MIDDLE EAST TECHNICAL UNIVERSITY

COMPUTER ENGINEERING DEPARTMENT

CENG 491 – Computer Engineering Design – I

SMART HOME PROJECT

SOFTWARE REQUIREMENTS SPECIFICATION

v1.1

TRANQUILLUM

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List of Changes

Date	Revision	Added/Changed
11/11/2012	1.0	Created
18/01/2013	1.1	User interface section added
18/01/2013	1.1	Section 4.1 Corrected
18/01/2013	1.1	Data description part added
18/01/2013	1.1	Security constraint added
18/01/2013	1.1	State of The Art added
18/01/2013	1.1	Description of Controller added

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1. Introduction

1.1 Purpose

This document details the software requirements specification for the SMARTHOME project. When explaining the details, the IEEE standards for software requirements specification documents are followed.

Home automation systems provide certain functionalities for variety of devices, but many of them cannot extend their ability to respond technology which changes very quickly. In order to achieve this, a generic set of functionality and support for various home appliances needs to be generated. An easy to use, easy to deploy system with an ability to learn and predict home owners' and residents' activities based on previous knowledge will provide a more intelligent way of handling our homes.

SMARTHOME project is intended to serve this purpose and project details will be provided in the following sections.

1.2 Document Conventions

SMARTHOME project's aims are currently not strictly defined. Many of the requirement specifications and use cases provided in the version 1.0 of this document are merely a starting point and will provide a perspective for the intended purpose of this project.

Technical details related to hardware and software systems and interfaces are not included in this document in detail. Regarding information and sources will be provided in the appendix sections at the end of the document.

1.3 Intended Audience and Reading Suggestions

This Software Requirements document is intended for:

− Developers who can review project’s capabilities and more easily understand where their efforts should be targeted to improve or add more features to it.

− Project testers who can use this document as a base for their testing strategy as some bugs are easier to find using a requirements document. This way testing becomes more methodically organized.

− End users of this application who wish to read about what this project can do.

1.4 Project Scope

SMARTHOME is a simple but quite versatile home automation system which consists of four tightly connected subsystems.

- Environment and device sensors collection
- Wireless network
- Coordinator Box
- User Interface

As home appliances provide various data from their own work conditions and status, sensor collection provided as a generic device analyzes the data and sends it through wireless network to coordinator box.

Receving the data through local wireless system, coordinator box collects and stores the data on an online server. Accordingto users’ choices or previous statistics, it can act as a smart agent to provide certain reflexes in case of emergencies and possible threats.

All scenarios of actions and status information can be viewed through internet (web server) in which statistical datas are accumulated. As well as viewing, user can send orders to the coordinator box in order to change home appliances’ activities in real time.

1.5 References

− Project’s development and distribution website at ceng.metu.edu.tr local repository. It provides the project’s source code, a bug reporting and tracking system, and all the available file downloads of the project.

− IEEE Software Requirement Specifications document.

2. Overall Description

2.1 Product Perspective

SMARTHOME is a generic solution for home automation enhanced with machine learning techniques. It uses a well-known wireless platform Zigbee for communication between devices and allows you to collect data and control home appliances from a single web interface. Main program running on Coordinator Box is open source with a GNU General Public License. In market, there are lots of home automation systems, but they lack the adaptability and generic way of application in variety of home appliances. Moreover, since SMARTHOME is open source; it allows collaboration of developers for new enhancements to the project.

2.2 Product Features

In our home automation system, the user indicates the person purchasing the product to take advantage of energy efficiency for his/her home. The user basically has rights to choose a device, turn it on & off, getting & updating the sensor info of the device and adjust it according to the configurations types of the device. Their main functionalities are shown by the below use case diagram.

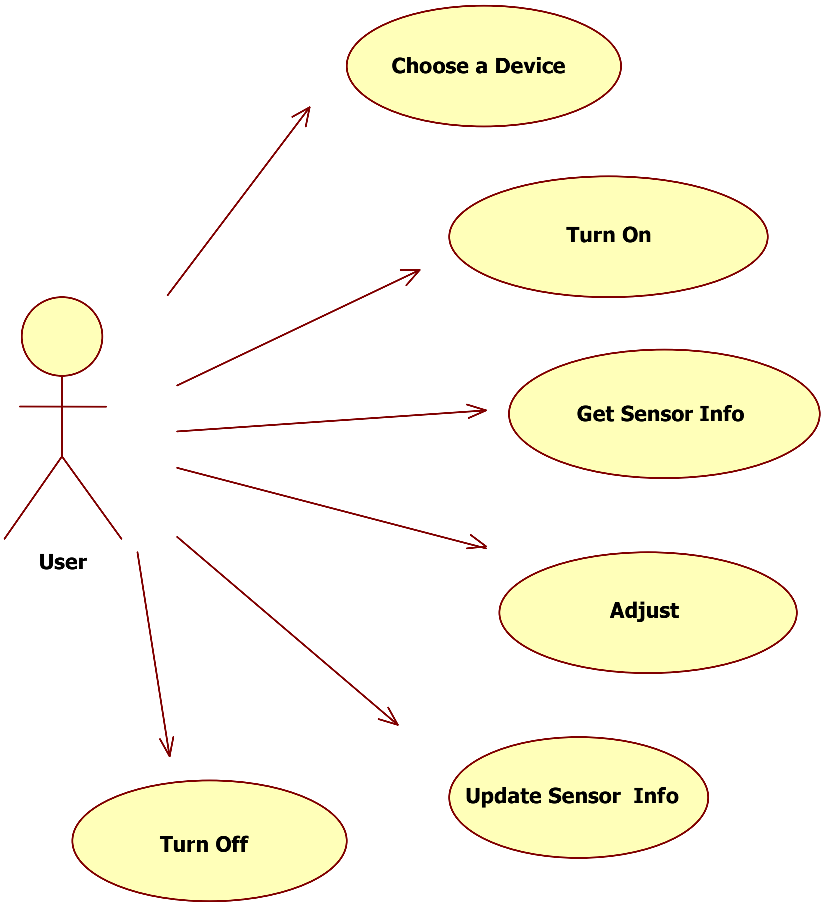


Figure 1: Block diagram

2.3 State of the Art

- We will use a wireless platform called Zigbee, for communication between devices (by using Xbee-pro devices) which allows us to collect data and control home appliances from a single web interface. ZigBee is an open WPAN (Wireless Personal Area Networks) standard based on the IEEE 802.15.4 protocol. The development of ZigBee/IEEE 802.15.4 is motivated to address those applications in which only low transfer data rate is involved. Compared to other wireless communication techniques, ZigBee/IEEE 802.15.4 possesses the following advantages:

  - Low power consumption;
  - Low cost;
  - Flexible reliable, and self-healing network;
  - Large number of nodes;
  - Fast, easy deployment;

- Security;
- Ability to be used globally;
- Product interoperability;
- Vendor independence.[12]

- We will use Raspberry Pi as a coordinator box. The Raspberry Pi is a credit-card sized computer that plugs into your TV and a keyboard. It’s a capable little PC which can be used for many of the things that a desktop PC does. Raspberry PI is cheap. The Model A will cost $25 and the Model B $35. It has an ARM11 on it (high performance). It is so powerful. The GPU provides Open GL ES 2.0, hardware-accelerated OpenVG, and 1080p30 H.264 high-profile decode. [13]

2.3 User Classes and Characteristics

This project is intended to be used by various of user classes. These classes can be listed as follows:

1. Home owners:

− User interface provided by SMARTHOME is easy-to-use and user friendly, in turn allows an average computer user to control home appliances they own.

2. Open source software developers and contributors:

− People with good knowledge of Python programming language can contribute to the main program which runs on Coordinator Box

- Also, network programmers and web designers can easily extend features provided by web interface.

3. Software Engineers & Computer Scientists involved in machine learning.

- Statistical data collected by coordinator box can be used in various cases of everyday situations in an efficient way. Although we implemented substantial concepts regarding an ordinary home, people who are experienced in machine learning can always provide new ways of adaptation for SMARTHOME.

2.4 Operating Environment

In this project, ZigBee network devices would be used to obtain a wireless communication between a master controller and home appliances as well as various sensors to collect data from home environment.

A master controller software working on ARM Based BeagleBoardwill be developed. In addition, adatabase deployed on web server would be needed to keep the data collected from home appliances on the web and show these data when required.

PIC Microcontroller Board would also be used to simulate home appliances within the development process by imitating the response of home devices.

2.5 Design and Implementation Constraints

- Smarthome system is a platform dependent. Embedded Linux working on a BeagleBoard device or PC with linux OS is a necessity.
- Work products such as documents will be in compliance with IEEE standards.

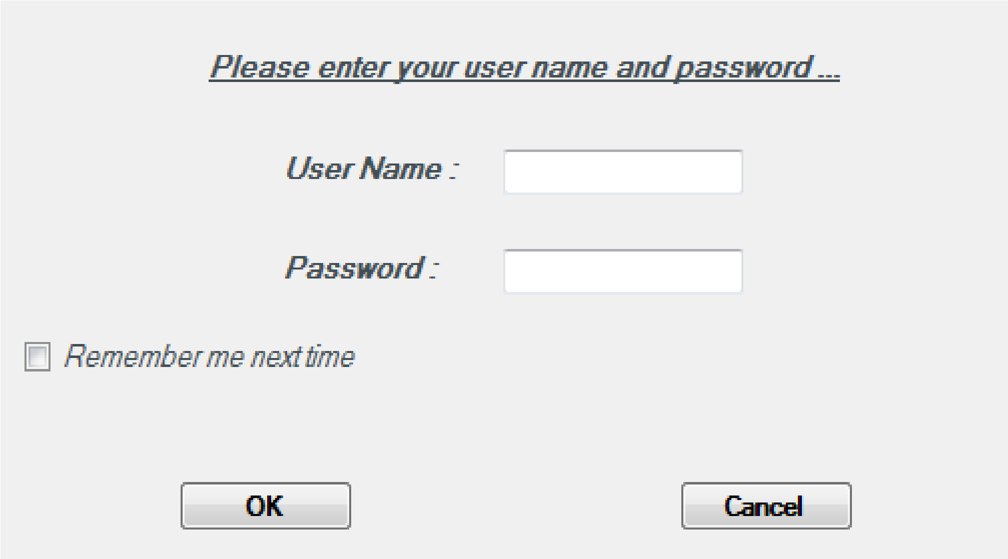
[Refer to 3.3.2 Design constraints]

3. Specific Requirements

3.1 Interface Requirements

At the beginning of the application, the system authorization is required for the users. This login process is same for all users. They will submit valid authorized username and password. In the below sections, user interface overview is described in a general manner.

3.1.1 Sign In

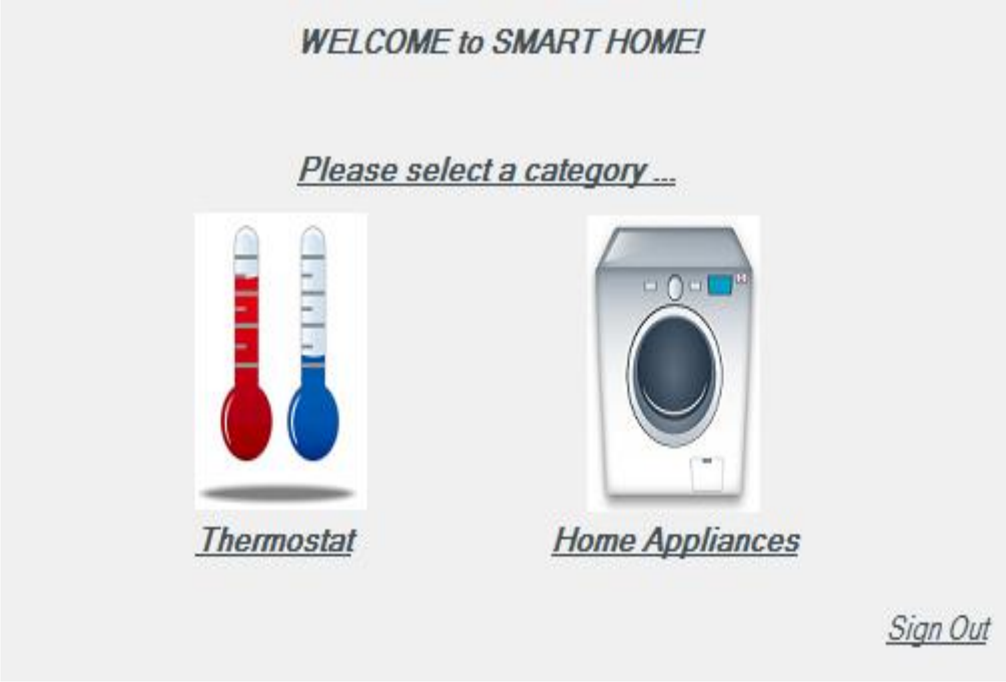


Please enter your user name and password ...

□ Remember me next time

When the Smart Home web page is opened, the user will face with the login screen. Previously authenticated users will login the system with their exact usernames and passwords.

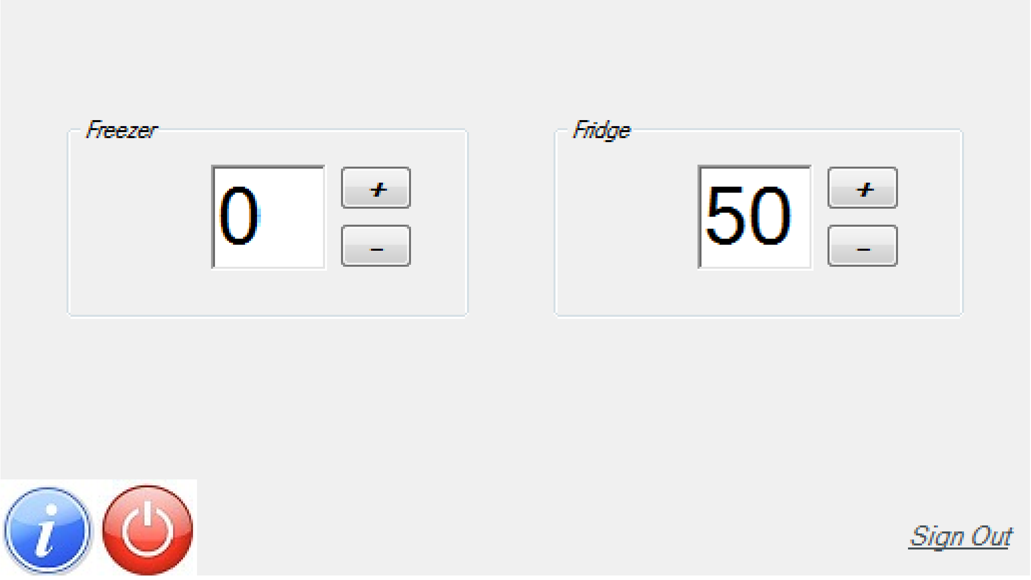
3.1.2 Select Category



WELCOME to SMART HOME!

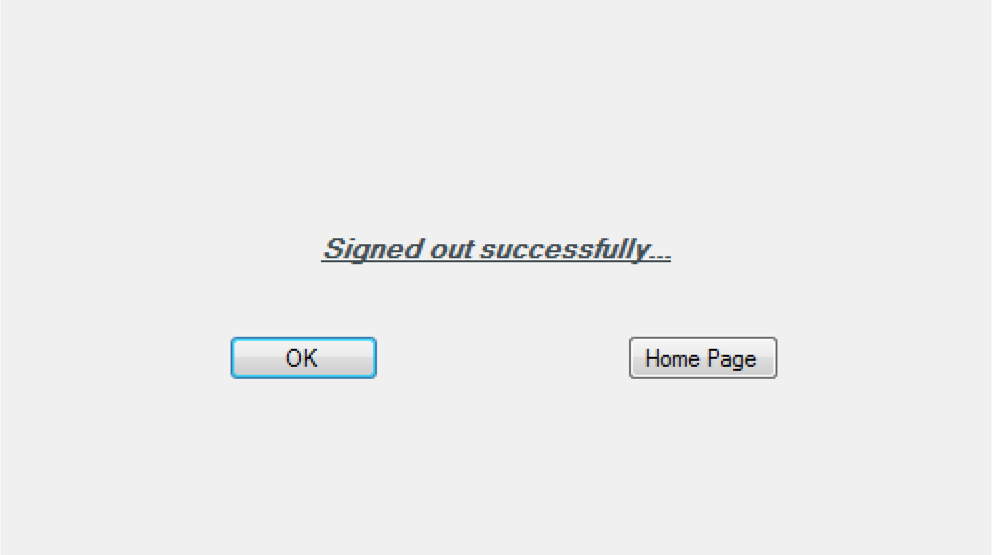
After the authentication process explained above, the user is waited for category selection. If the user clicks on one of the links below the icons, the user will be redirected to a new page related to the clicked category adjustments. There is also a sign out preference on the screen, which allows the user to log out from the system.

3.1.3 Adjust Configurations



For each appliance, it is required to have a configuration panel. For illustrative purposes, the above screenshot shows an example configuration panel of a refrigerator. There are two types of adjustments seen on the interface. One of them is the freezer temperature in Fahrenheits and the other one is the fridge temperature in Fahrenheits too. The user should be able to adjust them by clicking on the plus and minus buttons as increasing and decreasing functionalities relatively.

3.1.4 Sign Out



Signed out successfully...

It is also required to have a sign out window to provide continuity. If the user clicks on the sign out button seen on every page after signing in, s/he will be redirected to the page whose screenshot is shown on the above picture. There are two choices left after signing out: OK and Home Page. If the user clicks on the OK button, the window will be closed. If the user clicks on Home Page, the user should be redirected to login page previously described.

3.2 Non-functional Requirements

3.2.1 Performance requirements

The resulting home automation system should perform on home appliances and various sensors having the ability of compatibility more than the ones in the market. Additionally a more general communication protocol and wireless controller hardware should be used to make the system perform on much more devices. The system should access data in reasonable time. The data transfers between the devices such as actuators and sensors with master controller should not exceed the time limit of 3 seconds and lie under the throughput of 250 Kbps. Additionally, the system should service with the 7 days / 24 hours availability. The system should work smoothly with other existing connection networks at home.

3.2.2 Design constraints

The reporting of the project should be in IEEE standards and its diagrams should be drawn in UML standards. The interface between the system components should be well described to make the user control easier. As an environment constraint, master controller software should be developed on Linux system. Moreover, there is another constraint on wireless communication protocol. In this system, ZigBee wireless protocol should be used to make the devices communicate. The transmitted information between the devices should be carried in encrypted form, as a security constraint.

3.2.3 Security constraints

Security is another design constraint. The system should encrypt/decrypt the data transmitted between the Xbee-Pro devices.

3.3 Functional Requirements

In order to make the user manipulate the system, we need 5 general functions working on a home appliance included in the home automation system with the help of sensors and required connections. Each function is explained with the use cases below.

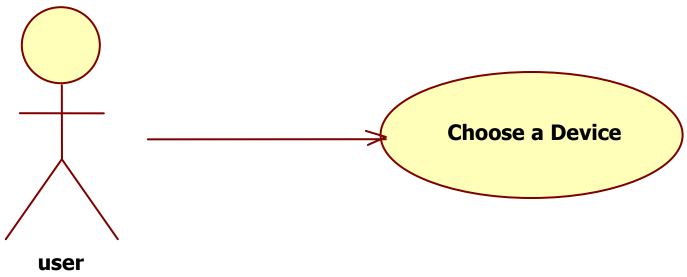
3.3.1 Choose a Device

3.3.1.1 Background Information

There will be different kinds of home appliances included in the home automation system.

3.3.1.2 Action/Response Sequences

3.3.1.2.1 Diagram



3.3.1.2.2 Description

Actor	User
Purpose	The aim of this function to enable the user to choose a device from the context.
Precondition	The system should be on mode and the user should start the application.
Trigger	The user should choose a device from the menu by clicking on it.

3.3.1.2.3 Normal Flow of Events

1. The user selects the device and sees its current condition.
2. The user can manipulate the appliance with given commands.

3.3.1.2.4 Alternative Flow of Events

1. The user tries to use other functions before choosing a device.
2. The system gives a warning message.

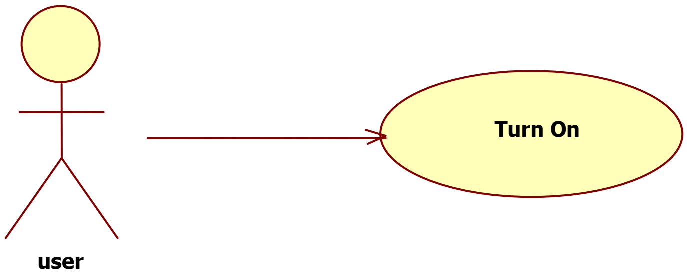
3.3.2 Turn On

3.3.2.1 Background Information

There will be a selected device to perform the action on before the user requests this action.

3.3.2.2 Action/Response Sequences

3.3.2.2.1 Diagram



3.3.2.2.2 Description

Actor	User
Purpose	The aim of this function to enable the user to turn on the chosen device.
Precondition	The user should select a device.
Trigger	The user should click on the turn on button.

3.3.2.2.3 Normal Flow of Events

1. The user clicks on the turn on button and waits for the system to start it.
2. The user turns on the appliance with the default adjustments.

3.3.2.2.4 Alternative Flow of Events

1. The user tries to turn off or wants to make adjustments on the device before using this functionality.
2. The system makes a request to make the user turn on the device, initially.

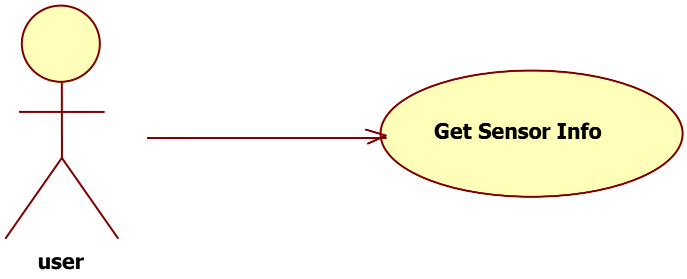
3.3.3 Get Sensor Info

3.3.3.1 Background Information

There will be sensors placed into the home appliances to perform this action.

3.3.3.2 Action/Response Sequences

3.3.2.3.1 Diagram



3.3.2.3.2 Description

Actor	User
Purpose	The aim of this function to enable the user to learn info about the device from the sensors.
Precondition	The device should have atruely working sensor connected to the system.
Trigger	The user should click on the'get the current condition' button.

3.3.2.3.3 Normal Flow of Events

1. After clicking on the above mentioned button, the system starts to communicate with the device.
2. A window appears on the screen to make the user learn the condition of the device.

3.3.2.3.4 Alternative Flow of Events

1. The sensor data may not be transferred properly.
2. A warning should appear on the screen indicating that the info could not be reached by the system and request the user to try again.

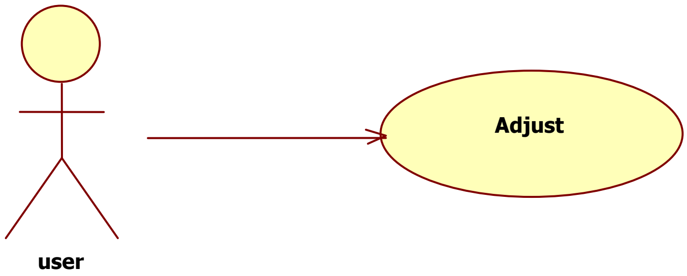
3.3.4 Adjust

3.3.4.1 Background Information

Well described adjustment panels on the interface will be provided for each device included in the system.

3.3.4.2 Action/Response Sequences

3.2.2.4.1 Diagram



3.3.2.4.2 Description

Actor	User
Purpose	The aim of this function is to enable the user to make the adjustments according to the device capabilities.
Precondition	The system should switch on the true adjustment menu according to the chosen device and make sure that sensor info is not obsolete by updating the sensor info.
Trigger	The user should enter the adjustment type and content into the adjustment panel.

3.3.2.4.3 Normal Flow of Events

1. This functionality is device dependent, so generally it can be stated that the user should click on the adjust button.
2. The device dependent adjustment panel appears on the screen.

3.3.2.4.4 Alternative Flow of Events

1. The user can enter ambiguous adjustments into the panel.
2. The system should give a warning, and continues with the previous adjustments.

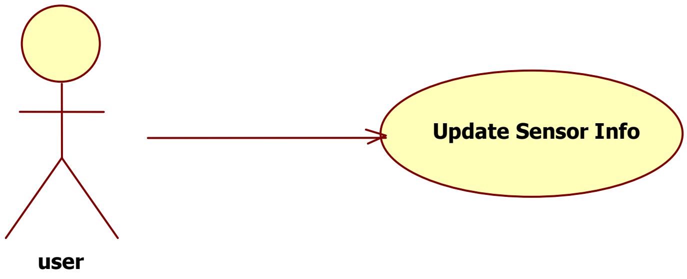
3.3.5 Update Sensor Info

3.3.4.1 Background Information

There will be sensors placed into the home appliances to perform this action.

3.3.4.2 Action/Response Sequences

3.3.2.4.1 Diagram



3.3.2.4.2 Description

Actor	User
Purpose	The aim of this function is to enable the user to update the sensor info anytime s/he wants.
Precondition	The device should have a truely working sensor connected to the system.
Trigger	The user should click on the update button.

3.3.2.4.3 Normal Flow of Events

1. The user clicks on the update button.
2. The system updates the sensor info beside the periodic updating times of the system.

3.3.2.4.4 Alternative Flow of Events

1. This command can conflict with the periodic update times.
2. The system continues with the periodic updating without making extra function call.

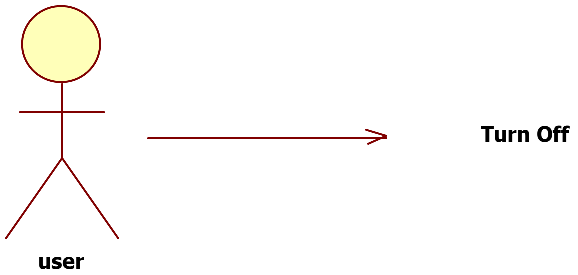
3.3.6 Turn Off

3.3.4.1 Background Information

There will be a selected and powered on device to perform the action on before the user requests this action.

3.3.4.2 Action/Response Sequences

3.3.2.4.1 Diagram



3.3.2.4.2 Description

Actor	User
Purpose	The aim of this function is to stop the working of the chosen home appliance.
Precondition	The device should be turned on.
Trigger	The user should click on the turn off button.

3.3.2.4.3 Normal Flow of Events

1. The user clicks on the turn off button after selecting the device.
2. The system powers the device down and inform the user.

3.3.2.4.4 Alternative Flow of Events

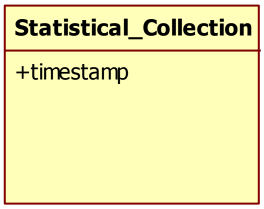
1. The user can try to turn off a device without turning on it before.
2. The system creates a warning message to display on the screen.

4. Data Model and Description

4.1. Data Objects

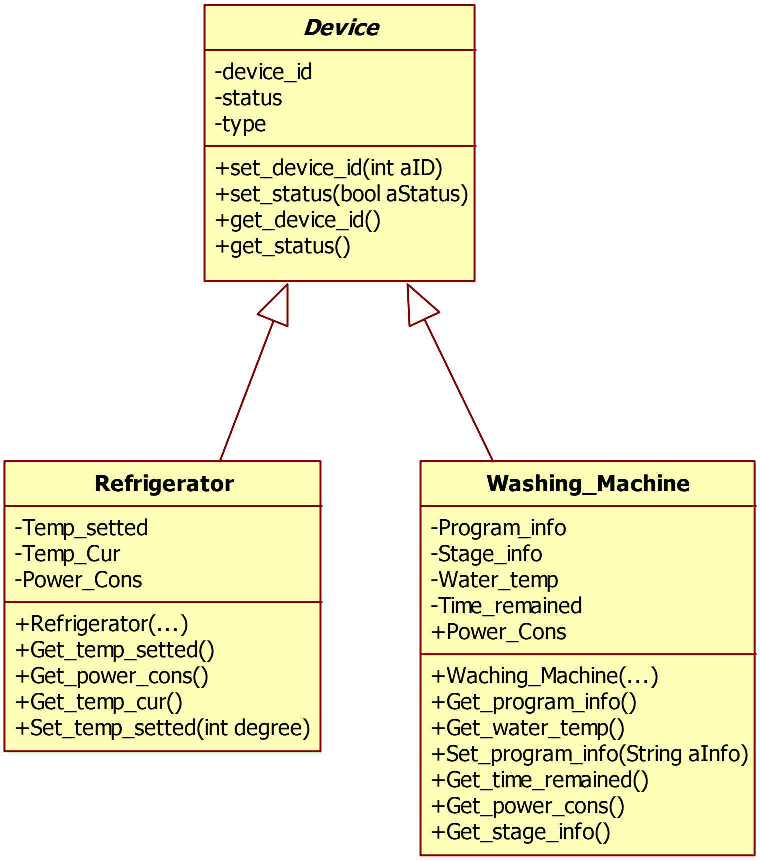
4.1.1. Statistical Collection

A relational database collection based on “Device” entity and “Sensor Data” associated with one another, attributed with a “timestamp” as a unique identifier. Logically, located on remote server accessed by user, through internet.



4.1.2. Device

Abstract entity of a home appliance.



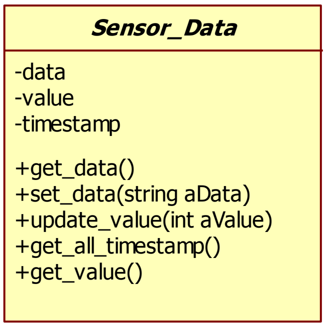
status: A flag variable containing current status of the appliance. May indicate a malfunction or problem in device, or proper workstate.

device_id: A unique id which is used when identification of the home appliance.

type: Type of home appliance; may be a lighting, thermostat, refrigerator etc.

4.1.3. Sensor Data

Abstract entity of a dictionary like data id and value mapping.



Contains the following attributes;

data: Identification (in type of string) of sensor data to be stored.

value: Corresponding value of the sensor data.

timestamp: Signifies issue time of a received statistical data.

4.1.4. Commands Collection

Another relational database collection based on device entity and “Adjustment”. Priority of those commands will be important when processing their communication orders in Zigbee network.

4.1.5. Adjustment Data

Real time issue regarding adjustable settings.

4.2. Relationships

For the sake of data consistency and safety, there will be two different databases built on two discrete components of the project.

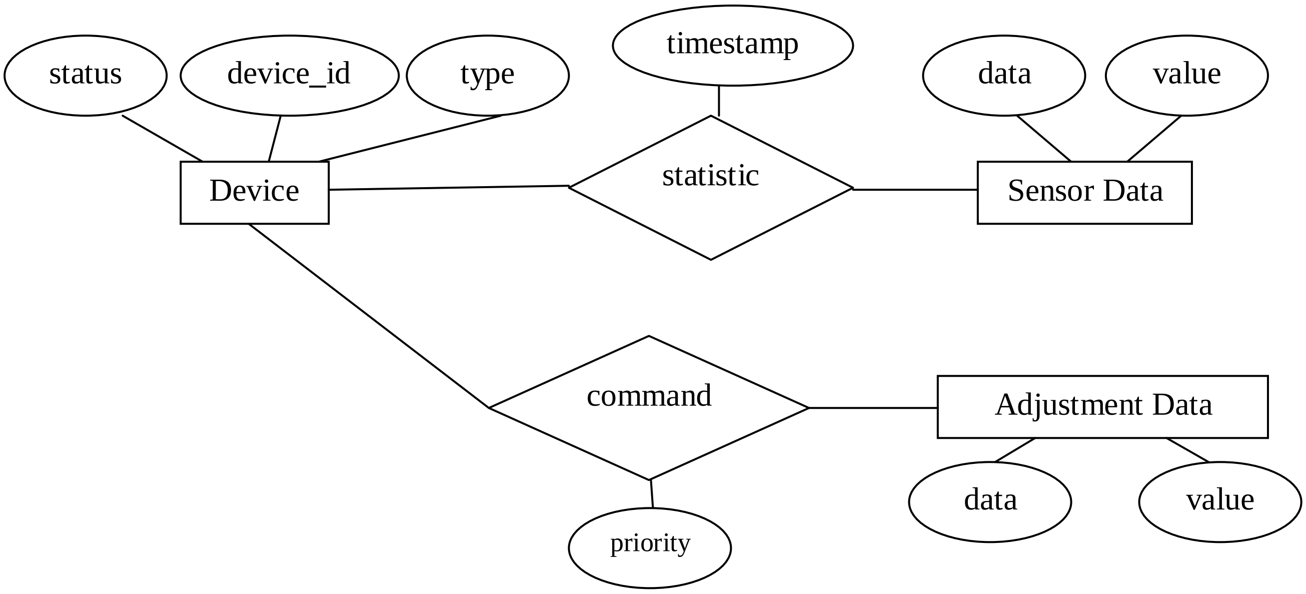


Figure: ER Diagram

First one of these databases will be working on server side ("statistic" relation above), which will be providing statistical data collection about home appliances and will serve as user interface (client) for remote control of home appliances. This database will hold time stamped data received from Coordinator Box at home and display this data to user through a web interface accessible through internet. Commands and adjustments of home appliances in remote connection will be done through this interface described previously.

Second database will be working on Coordinator Box ("command" relation above), holding a collection of adjustments, commands and control orders addressing home appliances. In case of internet connection loss and/or malfunction on Ethernet connection, coordinator device will continue remaining command items previously received from Server, provided by user interface.

5. Behavioral Model and Description

5.1. Description for Software Behavior

When user opens the Web based GUI from a browser window, he/she sees a main page with a list of devices connected to the coordinator box, with few limited details about their current status. From this list, user can select the device he/she wants to control or view and reach a detailed page for that specific device. Every home appliance has different features which can be controlled and monitored through this system, and all of these applicable information will be provided in the subpage of the selected device.

After a device is selected, user can see all features of that device that can be adjusted through web interface. After editing specific features user can use “Adjust” button to send report about these changed features to home appliances. After a reasonable time for data sending/receiving protocols (around 3 seconds in a fast network), the device to be controlled will respond to these changes and sensor information will be updated. User can also click on Update Sensor Info button to order these changes manually. Other than issuing feature changes for appliances, user can also use Turn Off and Turn On buttons in this page to control the device itself and start-stop its progress in real time.

5.2 State Transition Diagrams

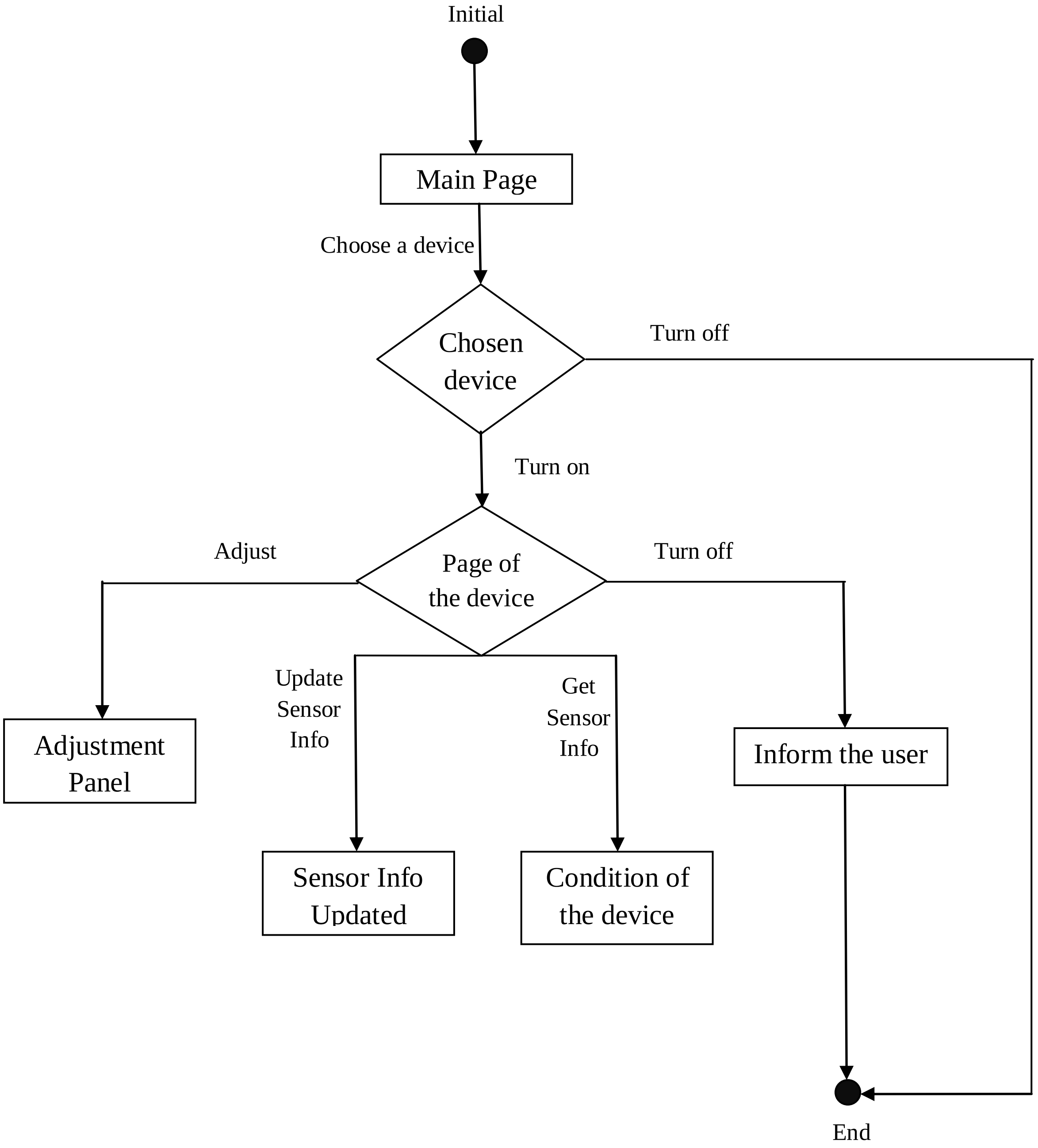


Figure 2: State Transition Diagram of the system

5.3. Description of Controller

As controller we are using PIC powered development board in order to control the appliances. On this control board you can adjust the appliances according to your needs. There are buttons in order to start or stop the appliances and an adjust button in order to adjust the temperature or the program information of the appliances. These adjustments can also be done using the application via Internet. After you adjust the configuration you want, it also sends the information to the system In order to protect the synchronization between the system and the controller.

6. Planning

6.1 Team Structure

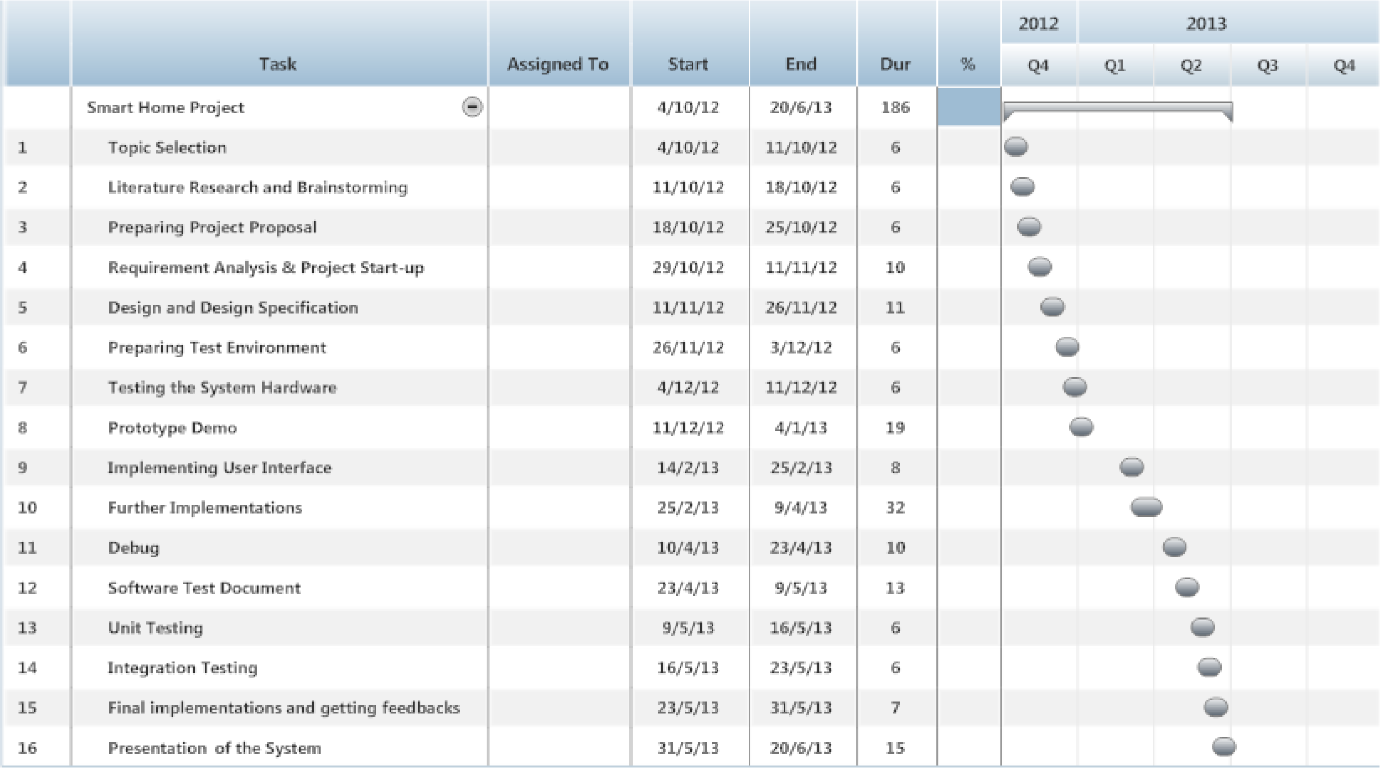
Our contact from the sponsor company Arcelik is İhsan Mert Özçelik with whom we discuss about our project process nearly once a week. Since project has interdependent hardware parts that can be combined after certain development phases, we decided to split our team into four. Team structure is listed below with their corresponding responsibilities.

- Abdullah Hasan Taher Bayrakdar - Web GUI Development and Server Base in Linux
- Anıl Ulutürk - Zigbee Wireless Networking and Data Modeling
- Zeynep Mavuş – Embedded Development with connection to Zigbee end devices
- Şerafettin Öztürk - Linux development with connection to Zigbee coordinator devices

Even though project has been split into two parts, each member will have information about each part of the project at the end of development cycles defined in next subsections.

6.2 Basic Schedule

The Gantt chart that shows the basic time schedule of the project is as follows with the tasks and dates included.



	Task	Assigned To	Start	End	Dur	%
	Smart Home Project		4/10/12	20/6/13	186	
1	Topic Selection		4/10/12	11/10/12	6	
2	Literature Research and Brainstorming		11/10/12	18/10/12	6	
3	Preparing Project Proposal		18/10/12	25/10/12	6	
4	Requirement Analysis & Project Start-up		29/10/12	11/11/12	10	
5	Design and Design Specification		11/11/12	26/11/12	11	
6	Preparing Test Environment		26/11/12	3/12/12	6	
7	Testing the System Hardware		4/12/12	11/12/12	6	
8	Prototype Demo		11/12/12	4/1/13	19	
9	Implementing User Interface		14/2/13	25/2/13	8	
10	Further Implementations		25/2/13	9/4/13	32	
11	Debug		10/4/13	23/4/13	10	
12	Software Test Document		23/4/13	9/5/13	13	
13	Unit Testing		9/5/13	16/5/13	6	
14	Integration Testing		16/5/13	23/5/13	6	
15	Final implementations and getting feedbacks		23/5/13	31/5/13	7	
16	Presentation of the System		31/5/13	20/6/13	15	

Figure3: Gantt chart

6.3 Process Model

Main model we will use in this project is Waterfall Lifecycle. First we have done research about market and currently developed home automation systems. Discussing their pros and cons, we decided on extra features we may add to come up with an interesting design. According to Waterfall model, Requirements Analysis and Specification was the next step. After the completion of the first version of this SRS document we came to end of second step and got started to design process. As many of the project's design choices were not clear, we decided to leave behavioral and data model definitions to be next step in our process model. After design phase, we will continue with implementation. When implementation of two subparts of the project becomes near completion, we will deal with combining, maintenance and testing of full set of requirements in this document.

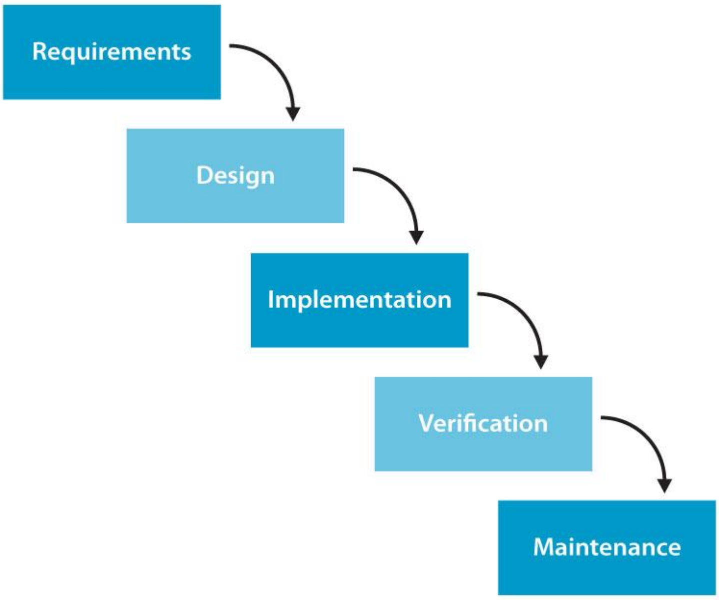


Figure4: Waterfall Model

7. Conclusion

This SRS document gives information about the SMARTHOME project which is an easy to deploy home automation system enhanced with machine learning features. At the beginning of this document, problem is defined and similar products in market are compared with our product. Afterwards, functionality of the application, requirements of the application, performance, attributes and design constraints are clarified in following subsections. In the overall description part, all of the functions that this application will perform are explained in detail for developers and future contributors. In the previous part, approximate plan of the project's progress is described tentatively. This document will hopefully constitute the base of design, development, and testing phases of the SMARTHOME project.