Ministry of Higher Education
University of Dammam
College of Computer Science & Information Technology - Computer Science Department
Dammam, Saudi Arabia

iTrack

Wireless Energy Consumption Monitoring System

Group #	09
Members' Names & IDs	Fatimah Jassim Al Shaer [redacted]
	Khadijah Ahmad Al Safwan [redacted]
	Khawla Eisa Aseeri [redacted]
	Lolah Mohammad Hakami [redacted]
	Masoumah Kadhem Al Jishi [redacted]
Supervisor's Name	Dr. Dilek Düştegör
Course Name	Project Implementation
Course Code	CS 521
Academic year	2014-2015 Term 2
Due Date	7th May 2015

For Evaluators' Use:	
Total Marks:	Obtained Marks:
Comments:	

Declaration Statement

We Fatimah, Khadijah, Khawla, Lolah, and Masoumah members of the senior project, declare that this report contains only work completed by members of our group except for information obtained in a legitimate way from literature, website, company, or university sources. All information from these other sources has been duly referenced.

Furthermore, we declare that in completing the project, the individual group members had the following roles and contributed in the final outcomes of the project:

Student Name	Student ID	Role	Signature
Fatimah Jassim Al Shaer	[redacted]	Member	
Khadijah Ahmad Al Safwan	[redacted]	Leader	
Khawla Eisa Aseeri	[redacted]	Member	
Lolah Mohammad Hakami	[redacted]	Member	
Masoumah Kadhem Al Jishi	[redacted]	Member	

Supervisor's Name	Dr. Dilek Düştegör
Signature	

Acknowledgment

Our senior project entitled “ITrack: Wireless energy monitoring System” was a great chance for learning and implementing the knowledge gained from the various courses taken in the college. We are blessed for having this chance of working in a project that provides support to real world problems.

We are using this opportunity to express our special thanks to **Dr. Dilek** who took from her time and provided help and advices. We are extremely grateful for her guidance and constant supervision. In addition, we would like to express our special gratitude and thanks to the **CSIT College Faculty** for educating us and developing our technical competency to the level that we can work in a project requiring deep understanding of computer science principles. Last but not least, we thank our **Families** whom we couldn’t accomplish this work without their support.

We mark this training as a milestone in our development. We will use gained skills and knowledge to implement the plan in hand to reach the goal of this project.

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Abbreviations Table

Abbreviation	Definition
AC	Alternating current
API	Application programming interface
CAPTCH	Completely Automated Public Turing test to tell Computers and Humans Apart
CO2	Carbon dioxide
CSS	Cascading Style Sheets
CT	Current transformer
ERD	Entity Relationship Diagram
HTML	Hypertext Markup Language
KSA	Kingdom of Saudi Arabia
kWh	kilowatt-hour
MVC	Model view controller
OOP	Object oriented programming
PHP	Hypertext Preprocessor
SDS	System design specifications
SPMP	System Project Management Plan
SRS	System requirement specifications
STP	System test plan
W	Watt
WiFi	Wireless Fidelity, wireless internet

Chapter 1 Introduction

"I can't decide which is worse, no electricity or unreliable electricity. I wonder if I'll ever have to decide which is worse, life as we're living is or no life at all".

Susan Beth Pfeffer

Electricity is essential in our way of life. People are using electricity 24 hours a day in residential and industrial areas. Electricity is indispensable in the modern day, enabling to save lives in hospitals, or contributing to economy through various industries. At home too, people are constantly using electricity, for cooking, heating/cooling, or simply lighting their environment. Despite this vital need for electricity, it is easily wasted.

Outline

1.1 Motivation

As much as electricity is important, it might also be quite harmful because of the way it is generated. As stated in [1], "the world's energy supply is largely based on fossil fuels". This usage of fossil fuels has led to several environmental issues such as global warming, air pollution, deforestation and several other environmental damages [2]. This is why scientists, engineers and governments all over the world are working on addressing this problem [3].

All agree that society needs to use existing electrical power more efficiently [4]. One way of making that happen in residential area is to inform the consumer about their energy usage. Currently, people only know their total monthly consumption, but a real-time load monitoring does not exist. There is a real need for a technology to visualize consumption, in other words a monitoring system.

1.2 Problem Statement

The Kingdom of Saudi Arabia (KSA) is blessed with an abundance of energy resources. It has the world's largest proven oil reserves; the world's fourth largest proven gas reserves, and is the world's 20th largest producer and consumer of electricity [5][6]. As stated in [7], on a per capita rate, Saudi Arabia has very high electricity consumption, mainly due to the improvement in living standards. Also, KSA is experiencing both population and industrial growth, causing a huge demand for power and especially electricity. Combined with these two local factors, the very high emission rate of CO_2 in the region makes it a National priority to reduce energy consumption.

We aspire to corporate in this goal to reduce this huge growth in energy consumption as soon as possible. To do that, Saudi citizens and residents need to be more aware of their power consumption. They need a real time system that measure the consumed power and provide this information to the user in an attractive way. The system need to be available all the time and accessible anywhere.

1.3 Aims and Objectives

This project aims to develop a home energy consumption monitoring system that communicate usage data to the customers in order to make them more aware of their power consumption habits. Real-time sensor measurements will be used to better educate the energy user, through a set of improved interfaces.

1.4 Proposed Solution

In order to solve the problem stated in section 1.2 Problem Statement, we propose to develop a monitoring system called iTrack for a smarter energy consumption management to be used in houses. The system will contain two parts: a software part and a hardware part. The software part will be a website. It will allow the user to watch their consumption habit. The website will provide the user with real time data that it will get from a wireless sensor network installed at the user's house. The system will also let the user set a limit for his/her consumption. When the user consumption reached 75% of the limit, the user is alerted. Since the system is meant to work in KSA, it will be available in two languages: English and Arabic.

1.4.1 Project Scope

As mentioned previously, the system contains two parts: software part and hardware part. This sub-section defines the scope of each part of the system.

1.4.1.1 The Software Scope

The development of the software part is the main goal of this project. The scope of the software covers the following:

- The correctness of the output provided by the software (eg. The user information, buildings, sensor readings).
- The ability of the software to notify the user about his/her consumption habit (e.g. Sending an alert message when the limit exceeds the 75% of the specified limit).
- The ability of the software to work in any size and any number of buildings.
- The usage of verification techniques to insure security and privacy of the data. (e.g. the captcha code that used to determent whether or not a user in human. Also, sending the verification email to make sure that the user entered his/her correct email address.)

1.4.1.2 The Hardware Scope

For the hardware part, an open source monitoring system will be used. The configuration of the hardware is the main challenge, whereas the design and building of the wireless sensor network is beyond the scope of this project. This could be considered as a future work.

1.4.2 Relevant Benefits/Advantages

The main advantage of this system is helping users to become more aware of their power consumption habits, and eventually they can take energy (and money) saving decisions. This system will enable customers to contribute in supporting the Nation's electrical energy saving.

1.4.3 Goals/Challenges

The goals of iTrack are:

- Provide real time data.
- Calculate the user's bill in any day of the month.
- Show the users their consumption in visual form.
- Alerting the user when 75% of the set limit is reached.

As an undergraduate capstone project, iTrack is a project that covers all the areas of computer science we studied throughout our Bachelor program. It covers programming, database, networking, and hardware. Thus, it is a complete project that requires high level of skills and knowledge.

In fact, developing iTrack requires even more than what we studied in the university. The iTrack system made us step out of our comfort zone. It is big step up for us to deal with hardware and sensor networks specifically. Also, it is our first time developing a system in Arabic. Although Arabs are over 380 million in world population [8], most of the world systems do not support Arabic. Developing Arabic system requires some excessive development work. Furthermore, developing a service to work with our system is new thing. Finally, we need to have background knowledge about how the home electricity is structured and how the electricity flows on it.

1.5 Project Methodology

This section describes the methodology that will be used to implement the iTrack system.

1.5.1 Methods and Techniques

The iTrack system needs to get some information from building's electricity circuit. It will gather this information using perception, then it will process these gathered information and it will display the processed result to the users.

1.5.1.1 Perception

The sensors in the hardware will take care of the perception process. The hardware mechanism of percept and calculate the power (w) and energy (kwh) is based on AC power theory. For more information about the hardware you can visit the hardware website and review building block section (http://openenergymonitor.org/emon/buildingblocks).

1.5.1.2 Processing

To accomplish the goals of this project, some processing operation will be done in the sense data. This operation will take place before displaying this information to the user.

1.5.1.3 Display

Finally, the system will display the processed information to the user through a set of improved interfaces in a very understandable way.

1.6 Summary

Section 1.1 Motivation

- The generation of the electricity based on fossil fuels leaded to many environmental issues.
- Scientists all over the world try to solve the problems caused by the current way of generating electricity.
- One way to contribute in solving this problem is by educating people about their usage of the electricity.

Section 1.2 Problem Statement

- The Kingdom of Saudi Arabia has the world's largest proven oil reserves. However, it has very high electricity consumption.
- A system should be developed to make people in Saudi Arabia more aware of their consumption.

Section 1.3 Aims and Objectives

- Developing a home energy consumption monitoring system is the aim of this project.

Section 1.4 Proposed Solution

- iTrack is a monitoring system for a smarter energy consumption management that will be used in houses.
- iTrack system contains two parts: software part and hardware part.
- iTrack will help the user to make energy (and money) saving decisions by providing them with real time data.
- The iTrack team has many challenges that they need to overcome in order to complete this project.

Section 1.5 Project Methodology

- Three methodology will be use to implement the iTrack system

Chapter 2 Background and Related Work

This Background and Related Work document describe some knowledge that the reader needs to have in order to understand the iTrack project. This is covered in the Background section. The Related Work section gives an overview of existing systems similar to the iTrack system.

Outline

2.1 Background

2.1.1 Power Sources

The breaker panel in our house is the connection point between utility company and home electricity circuit. The power flows through wires from the utility's power generators to the connection point at home. *Figure 1* shows the major parts of the home electrical circuit [9], the connection between the utility and our home circuitry.

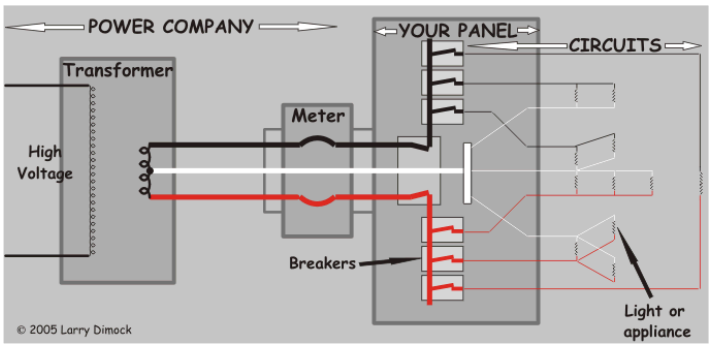


Figure 1: Home Electrical System.

The breaker panel contains number of switches, each switch control a separate circuit that will branch to sub-branches. The breaker panel directs the electricity through these separated circuits. The panel usually has a main switch that can shut down the power to all circuit as shown in *Figure 2* [9].

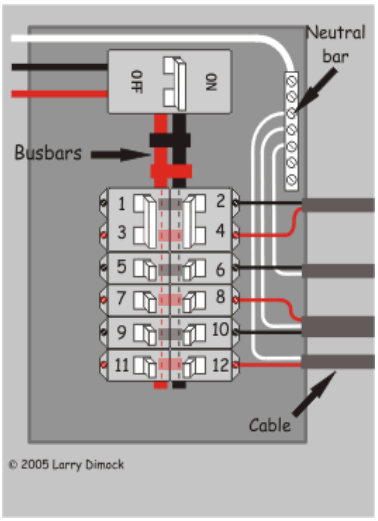


Figure 2: Switch in Home Breaker.

There are three different wires in the circuit: hot, neutral, and ground. The hot wire is one half of the wire that connects the electrical source and the operating item (appliance). The houses in old neighborhoods in KSA contain 110-volt and 220 volt, the other half in 110 circuits is the neutral wire. For 220-volt circuits the other half is a hot wire from the other phase. On the other hand, in new neighborhoods, houses contain only 220- volt, so the other half is the neutral wire. The hot wire is the only wire that is supposed to be switched [9].

2.1.2 Electrical Bills

As shown in *Figure 1*, there is a meter between the utility and the breaker panel. This meter calculates the amount of consumed power (kwh). Each month the electricity company subtracts the old reading (reading from previous month) from new reading (reading of this month). This subtraction will give us the consumed power for the current month. This consumed power will be divided to ranges. Each range has its own cost based on the building type as depicted in *Figure 3*.

Consumption Categories kwh	Residential (Halalah)	Commercial (Halalah)	Governmental (Halalah)	Agricultural (Halalah)	Charities (Halalah)
1-1000	5	12	26	5	5
1001-2000	5			5	5
2001-3000	10			10	10
3001-4000	10			10	10
4001-5000	12	20		10	10
5001-6000	12			12	12
6001-7000	15			12	12
7001-8000	20			12	12
8001-9000	22	26		12	12
9001-10000	24			12	12
More than 10000	26			12	12

Figure 3: Saudi Electricity Company Consumption Segments.

The monthly bill is the sum of the product of consumption (kwh) by its corresponding price (halala/100) for each segment.

2.2 Related Work

Many scientists, engineers and governments are trying to address the energy problems and related issues. As a result, many projects are emerging to contribute in finding new/ renewable energy sources and in reducing the energy consumption. In order to reduce the energy consumption, the first step is to monitor and study the consumption. Many systems are available for measuring and visualizing the energy consumption. The most important in the market are eGauge, EPI, Neurio, and efergy. However, theses systems are not available in Saudi Arabia and none of them is available in Arabic.

2.2.1 eGauge

eGauge is a web-based meter for electric energy and power. It is capable of measuring up to 12 circuits on up to 3 phases. It can be utilized to measure and record electrical consumption for either an entire building or individual circuits. [10].

2.2.2 EPI

EpiSensor is a platform that enables anyone, without any training or knowledge, to deploy, configure, and debug a whole range of wireless sensors. Through Gateway interface, sensors can be added and configured and quality-check the received data. Also, it can export the produced data automatically to any external system. Moreover, it can highlight inefficient areas, thus reducing the cost [11].

2.2.3 Neurio

Neurio is a system that enables you to monitor electrical consumption for each and every device in your house without the need for installing sensors on everyone. Through using a cloud, a Wi-Fi power sensor and smart pattern detection algorithms, Neurio turns your home into a smart more efficient one [12].

2.2.4 efergy

Through utilizing Engage, you can monitor your power consumption in real-time anywhere, anytime [13].

2.3 Summary

Section 2.1 Introduction

- This chapter introduces the background information needed by the reader to fully understand this report. Also, some examples of existing power monitoring systems are given.

Section 2.2 Background

- The utility company will connect with home electricity panel through the electricity meter.
- The home electricity panel contains number of switches, each switch control one circuit.
- Hot, neutral, and ground are the wires in each circuit.
- The calculation of electricity bill in Saudi Arabia depends on dividing the amount of consumed power to ranges.

Section 2.3 Related Work

- eGauge, EPI, Neurio, and efergy are some existing system that are similar to iTrack but none of them are available in Arabic language or in Saudi Arabia.

Chapter 3 System Project Management Plan

This Project Management Plan (PMP) document describes our senior project, the iTrack system, and management plan. The document starts by an introductory section about the project. After that, the project organization is stated. Then, the project managerial and technical and supporting processes' plans are given, followed by the summary.

Outline

3.1 Overview

3.1.1 Purpose, Scope, and Objectives

The main purpose of this document is to serve as guide for development of the iTrack system, which meets the requirements specified in next chapter within allocated time and budget. The SPMP will detail the major activities, resources, schedules and milestones for developing the iTrack system.

3.1.2 Assumptions, Dependencies, and Constraints

There are several assumptions and constraints that are of importance for the project and its team members.

3.1.2.1 Assumption and Dependencies

- The project hardware will be available at begin of the second semester and there is no electrical failure in the system.
- Every team member has knowledge of programming, software engineering, networking, electronics and database.
- The team member will be responsible to acquire tools and software needed for designing, implementing, testing and presenting the system.

3.1.2.2 Constraints

- Time (two semesters one for planning the project and the other one to implement it).
- Budget (funding sources are limited and full team member responsibility).
- Resources (team members' time is limited, 14 weeks each semester, besides their other courses work).

3.1.3 Project Deliverables

The iTrack team will produce a working system. That system will be compliant with the requirement that is mentioned in SRS chapter. This sub-section introduces the final deliverables of this project.

3.1.3.1 System Deliverables

By the completion of this senior project, first a small-scale prototype will be built, to showcase the hardware component of our system; then the software components will be developed, and both will be integrated for demonstration purpose. Finally, a larger scale electricity grid will be simulated for a close-to-real life demonstration.

3.1.3.2 Documents Deliverables

A number of documents will be delivered during the course of the project. *Table 1* shows the list of documents and their respective submission date. All documents will be submitted in soft and hard copy, several hard copies if necessary.

Table 1: Project Document Deliverables

Document Name	Due Date
Bi-weekly progress report	Every two weeks
Problem Statement	16 Oct 2014
Project Management Plan (PMP)	30 Oct 2014
System Requirements Specification (SRS)	13 Nov 2014
System Design Specification (SDS)	11 Dec 2014
System Test Plan (STP)	21 Dec 2014
Project Proposal Final Binder	21 Dec 2014
Project Proposal Oral Presentation in PDF format on CD	01 Jan 2015
Weekly progress report	Every week
Project Poster	5 May 2015
Senior Project Final Report	7 May 2015
Senior Project	7 May 2015

3.2 Project Organization

Definition of our internal project structure and roles and responsibilities for the project are available in this section.

3.2.1 Internal Structure

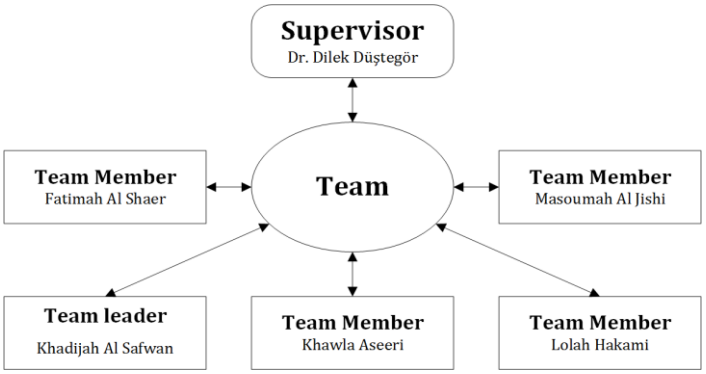


Figure 4: Internal Team Structure.

Figure 4 shows our project internal team structure. The team structure consists of project advisor, team leader, and four team members. The roles are assigned to the team leader and other members in turns. All team members are involved in more than one role and everyone is expected to contribute equally to the project. The members of the team are encouraged to provide input for the decisions that the team makes. Decisions are being made using a voting mechanism in which each team member's vote is counted equally. All the team's work are gathered and stored in a cloud storage (Google Drive) that all members and the advisor can access at any time.

3.2.2 Roles and Responsibilities

Most of the roles and responsibilities defined in *Table 2* are experienced by all team members.

Table 2: Roles and Responsibilities.

Role	Responsibilities

Supervisor	– Suggests topic(s) that is (are) within her area of expertise
	– Gives general description of the suggested topic.
	– Meets with student(s) regularly for efficient guidance and communication
	– Guide students for the purpose of efficient work in order to:
	  ○ Insure that student(s) meet(s) time schedule
	  ○ Maintain record of regular meetings with students
	– Evaluates work produced by student(s) based on the evaluation policies set by the CCSIT
	– Assigns grade to the work progress in accordance with the grading policies set by the CCSIT

Team leader	– Lead and facilitate constructive communication

Role	Responsibilities
	– Motivate and inspire team members – Monitor and manage the flow of day-to-day operations – Create reports to update the advisor on the team's progress – Distribute reports to the appropriate personnel – Point of contact
Technical writer	Write the documents according to specified reporting criteria (templates)
System analyst	– Specify the requirements – Compare the system with existing systems. – Identify actors and use cases – Identify the sequence diagrams
System designer	– Design the system structure and diagrams – Model the system architecture – Design the database – Design the interfaces
Developer	– Develop the software of the system – Configure the hardware of the system – Develop the database – Integrate the system
Tester	– Apply construction testing – Apply system testing

3.3 Managerial Process Plans

Specification of the project management processes including the project startup plan, project work plan, and project closeout plan are available in this section.

3.3.1 Project Start-Up Plan

The project start plan includes the following three plans: staffing, resource acquisition, and training plan.

3.3.1.1 Staffing Plan

The members of the team are introduced in sub-section 3.2.1.

3.3.1.2 Resource Acquisition Plan

This senior project needs some hardware and software. The following sections describe the plan for acquiring these resources.

Hardware Resources

Each team member should have a personal computer with Windows operating system for use during the project. Additionally there will be sensor network hardware components for constructing the project prototype. Refer to sub-section 3.3.2.2 (Budget Allocation *Table 4*) for details about the hardware resources that will be needed for the project.

Software Resources

Each team member is responsible for maintaining the required software resources including the development tools before the start of the development. Refer to sub-section 3.4.2 (Methods, Tools and Techniques) for details about the software resources needed for this project. Additionally, any other necessary software resources might be obtained in the time of need.

3.3.1.3 Project Staff Training Plan

There is no explicitly defined training plan for the project. The main training sources are the college curriculum courses taken before the project. The training is in following areas: methods of system development, system architecture, analysis of system requirement, management of system development, etc. Additionally, each team member is expected to familiarize herself with any other needed skills.

3.3.2 Project Work Plan

The project work plan includes identifying the work activities/schedule and budget allocation.

3.3.2.1 Work Activities and Schedule

The work activities' schedule shown in *Table 3* outlines the project phases' activities and milestones. The schedule for each phase tasks will be established once at the beginning of the phase. The team workload should be as balanced as possible.

Table 3: Work activities' schedule.

Phase activity/milestone	Start Date	End date
Project start	1st Sep 2014	
Phase 1: Feasibility study	4th Sep 2014	16th Oct 2014
Problem definition and idea formulation		
Problem Statement document submission	16 Oct 2014	
Project management plan establishment		
Phase 2: Requirements Analysis/ Specification	16th Oct 2014	13th Nov 2014
System users identification		
Hardware requirements specification		
Software requirements specification		
Project Management Plan document submission	30 Oct 2014	
Nonfunctional requirements specification		
Development methods and tools identification		
Test plan establishment		
System requirements specification document submission	13 Nov 2014	
Phase 3: Design	10th Nov 2014	11th Dec 2014
System architecture identification		
User interface design		
Data design		
System design specification document submission	11 Dec 2014	
Project documents submission	21 Dec 2014	
Project proposal presentation	1st Jan 2105	
Phase 4: Implementation	27thJan 2015	22nd Apr 2015
System software development		
Software interfaces design		
Software interfaces coding		
Database design		
System hardware prototype development		
hardware circuit construction		
Hardware configuration		

Hardware connection with the software database		
Phase 5: Testing	23th Apr 2015	4th May 2015
Construction testing		
Scenario based testing		
System test plan document submission	4 May 2015	
Phase 6: Delivery	5th May 2015	21st May 2015
Project showcase	5 May 2015	
Project documents submission	7 May 2015	
Source code submission	7 May 2015	
Project demo	21 May 2015	
Project evaluation presentation	21 May 2015	

3.3.2.2 Budget Allocation

A budget of 1157 SR will be needed for the project hardware and 167 SR for the international shipping. By adding the documentation printing cost, the electricity circuit, the house model and the logo the total budget of project is 4500 SR. We do not expect the budget to exceed 5000 SR. *Table 4* represents the hardware components and their estimated cost.

Table 4: Project budget.

Component	Estimated Cost	Count	Total
emonBase - Raspberry Pi web-connected base-station	524.5678 SR	1	524.5678 SR
emonTx V3 - Electricity Monitoring Transmitter Unit	386.043 SR	1	386.043 SR
AC-AC Power Supply Adapter - AC voltage sensor	49.219 SR	1	49.219 SR
100A max clip-on current sensor	47.44 SR	3	142.32 SR
Micro-USB cable	19.7469 SR	1	19.7469 SR
Programmer - USB to serial UART	34.5719 SR	1	34.5719 SR
Logo	100 SR	1	100 SR
Simple circuit Model	300 SR	1	300 SR
House Model	1200 SR	1	1200 SR
Shipping Costs	166.9295 SR	-	166.9295 SR
Translator	113 SR	-	113 SR
Online web server	338 SR	-	338 SR
Print Document	300SR	-	300 SR

3.3.3 Project Control Plan

The control plan is essential, and plays a critical role to the iTrack project to be successful. It consists of five plans: requirements control, schedule control, quality control, report, and monitoring plan.

3.3.3.1 Requirements Control

The requirement control plan of iTrack has two aspects: traceability and change control.

- Traceability: the output of iTrack can be traced back to all requirements that are specified in system requirement specification.
- Change control; there are no major changes on the requirements of iTrack, which have been specified in the system requirement specification.

3.3.3.2 Schedule Control Plan

The schedule for iTrack team must be maintained by separate documents as follows:

- Weekly task documents; each week one member is responsible of creating a weekly tasks and specifying a due date for each one. Once the status of the task has been changed the member who was assigned to this task shall update her task immediately.
- Project management document; at the beginning of the project one member is responsible for creating project management document which:
  - Divides the project into phases, each phase maintains several tasks.
  - These tasks are taken from the weekly task documents and update the information depending on these documents.
  - Contains all the tasks for each phase, the status of all these tasks, assigned resources (member/s), and the time duration for each task.
  - Project management document creator shall update this document periodically.
  - From this document iTrack team can see: late, critical, slipping, and complete tasks, and use it to generate a progress, milestone, resource overview and project overview reports.

iTrack team members use these documents to manage their time, see how the progress goes and speed up if necessary, make sure that the tasks are fairly distributed between all the members and none is working more the others.

3.3.3.3 Quality Control

At the beginning of the project iTrack team must put a standard for the quality of the project. So, all these standards must be reflected on the output of iTrack. The iTrack team members shall define several periodically tests for iTrack to make sure that all requirements reach the satisfied level of quality. These periodic tests from the early stage of iTrack to the last stage, give the team members the ability to detect any problem and solve it from the beginning.

3.3.3.4 Reporting Plan

The iTrack team shall have:

- An Informal reports between the team members, which include updating of the status of each tasks, faced problems, and suggesting solutions.
- Formal report between the team members and the project supervisor; at the end of each week one member shall be responsible for submitting a weekly status report to the supervisor which include updating of the status of the project, difficulties, attachments with references of all completed tasks, and weekly task document.

3.3.3.5 Monitoring Plan

The weekly task documents, and the project management document, which has been specified in section 4.4.3.2, are used for monitoring and keeping track of the project status.

3.3.4 Project Closeout Plan

The project will have an end, by the end of term 2 of year 2014-2015. At that time, the project team will submit all the project documents and poster, make a final presentation along with a demo, and present a poster.

3.4 Technical Process Plan

Specification of the development process model, technical models, tools and techniques that will be used to develop the system are available in this section.

3.4.1 Process Model

The project will follow the waterfall with feedback development model in *Figure 5* for its deliverables. The development will be done in several phases starting by System Requirement and ending with testing [14].

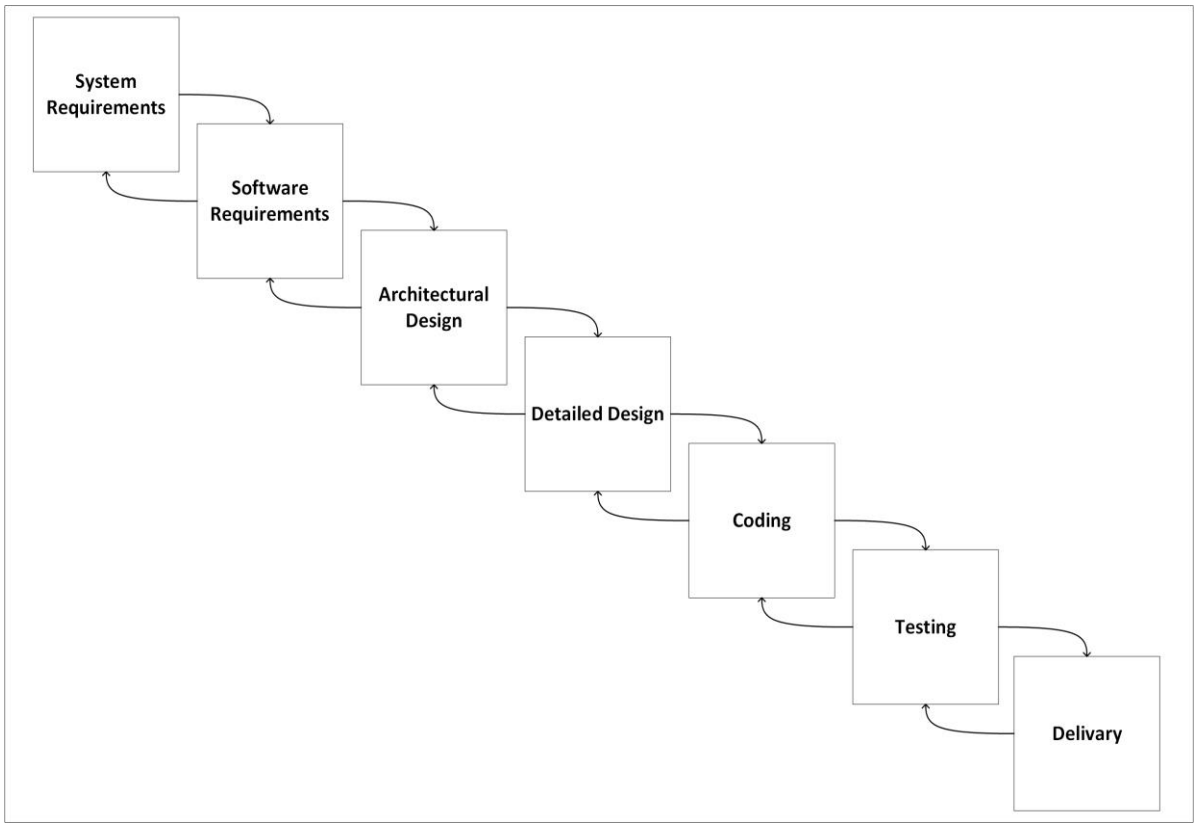


Figure 5: Waterfall Process Model.

The project phases, objectives and goals for each phase are outlined in *Table 5*.

Table 5: Project's Phases.

Project Phase	Objective	Outcome
System Requirements	Establish the components for building the system	Hardware requirements, software tools, and other necessary components.
Software Requirements	Establish the expectations for software functionality and identifies which system requirements the software affects.	Functional requirements and non- functional requirements.
Architectural design	Determine the system design by defining the major components and the interaction of those components, but the design does not define the structure of each component.	System architecture, Entity Relationship Diagram (ERD), and user interfaces layout.
Detailed design	Examine the system components by defining the design and produces for how each component will be implemented.	Database schema, class diagram, and sequence diagram.
Coding	Implements the detailed design specification	Running system
Testing	Determines whether the software meets the specified requirements and finds any errors present in the code	Home circuit prototype and simulation and test results
Delivery	Hand the project documentation and source code	Successful accomplishment of the project

3.4.2 Methods, Tools and Techniques

As mentioned in section 3.1.3 Project Deliverables, this project contains software, hardware and simulation. The project software will be developed using object-oriented methodology, PHP, HTML, CSS, java script (jQuery), MySQL, XAMPP Web Server, NetBeans software, Dreamweaver, Enterprise architect, Localizejs API, Test data generator, SQLyog and Xymon monitor.

For the hardware configuration an SD formatter, Win32 disk imager, putty, Wamp web server and Perl programming language will be used. The MatLab will be the simulation

tool for simulating the system. FileZilla will be the online server for iTrack system. For organizing the work iTrack team will use Google drive. Microsoft Office will be used for documentation. For recording the help tutorial the team will use Camtasia Studio.

3.5 Supporting Process Plans

The iTrack project will include the plans for the supporting processes that are part of the project. These plans are: verification and validation, system documentation and problem resolution [15].

3.5.1 Validation & Verification Plan

The verification and validation plan for the iTrack system contains one approach, which is Supervisor Review. Before submitting any document, the project supervisor checks the content appropriateness. Getting feedback or review from the project supervisor will improve the work qualities.

3.5.2 Documentation plan

There are many documents that will be produced during the lifetime of the project. All documents are responsibility of the project team members. The following table contains the documents that will be created:

Table 6: Project's documents.

Document Name	Document purpose
Introduction document	Defines the motivation, problem Statement, aim and objectives.
Background and Related Work Document.	Defines the needed background, mentions some existing similar projects.
System Project Management Plan	Defines the project management goals and plan of the project.
System Requirements Specification	Defines the system Requirements.
System Design Specification	Defines the design and structure of the system.
System Test Plan	Defines the testing phases and scenario of the system.
User manual	User guides that provide instructions and how to use iTrack system

3.5.3 Problem Resolution Plan

To solve the problems that will arise during the planning and implementing of the iTrack system, the team specifies the following plan. When one of the team members faces a problem, she should inform the rest of the team about that problem. Then, a meeting will be made to discuss that problem and find a solution

3.6 Requirements Gathering

For gathering the requirements of our iTrack system, the following techniques are used: studying documentation, brainstorming, and researching similar products. Each technique is discussed in the following subsection.

3.6.1 Studying Documentation:

The first step for us to establish our system idea and its requirements was getting educated about the field of our interest. We started by reading articles and documentations about: energy sources, energy usage, renewable energy, monitoring systems, wireless sensor networks, domestic electrical wiring, and domestic electricity accidents… These background studies were the base of our ideas for iTrack objectives and requirements.

3.6.2 Researching similar products

Some of iTrack requirements are gathered by observing and analyzing energy monitoring systems like: eGauge, EPI, Neurio, and efergy. These systems are briefly introduced in the Related Work section in the Background and Related Work chapter.

3.6.3 Brainstorming

Most of iTrack system requirements is gathered and defined by brainstorming. Group brainstorming sessions took place where all our team members shared all their ideas about the system. After that, sessions for organizing and prioritizing our ideas were conducted. The result of these sessions is a clear statement of the system objectives and functionalities. These requirements are presented in the following chapter.

3.7 Summary

Section 3.1 Overview

- This chapter is the guide for delivering the project in required time and budget.
- There are three assumption of this project: the availability of the hardware, the knowledge that the team members have, and availability of the needed software.
- Time and budget are the main constrains of this project.
- Hardware, software and simulation are the system's deliverables.

Section 3.2 Project Organization

- These project team members are: one supervisor, one team leader and four-team member.
- There are seven roles in this team. Each role has its own responsibilities.

Section 3.3 Managerial Process Plans

- The project start up plan contains all the planes needed before start working in this project. These plans include staffing plan, resources acquisition plan and staff training plan.
- The project work plan contains a tentative table of the phases' activity and the due date of them. Also, it contains the estimation needed budget.
- The project control plan section contains five plans, which are: requirements control, schedule control, quality control, reporting, and monitoring plan.

Section 3.4 Technical Process Plans

- The waterfall with feedback model will be the model that this project follows.
- In order to implement this project the team member will need to different tools and techniques.

Section 3.5 Supporting Process Plans

- The supervisor review is the only approach in validation and verification plans.
- The documentation plans section contains all the documents that will be provided as an outcome of this project.
- The problem resolution contains the plan to solve any problem occurs in the project lifetime.

Section 3.6 Requirements Gathering

- The iTrack team followed three techniques to gather the requirement of this project. Those techniques are: studying documentation, brainstorming, and researching similar products

Chapter 4 System Requirements Specification

This System Requirements Specification (SRS) document describes the requirements of a wireless energy consumption monitoring system, the iTrack. First, an introductory section clarifies what the iTrack system is, followed by an overall system description. Subsequently, system specific requirements are described in detail, followed by the functional requirement, behavioral requirement and non-functional requirement. At the end a summary of this chapter is given.

Outline

4.1 Purpose and Scope

4.1.1 Purpose

The purpose of this System Requirements Specification (SRS) document is to provide a complete description of both the purpose and functionality of the iTrack system that is to be developed.

The main intended audiences for this SRS are our potential customers that will install and use the system in their household. However, this document might also be of interest to developers, interested to learn about wireless energy consumption monitoring systems. Although the document is fairly technical, the goal is to provide a system description understandable by the developer as well as the customers. This document will also help project developers to implement a system satisfying all requirements..

4.1.2 Scope

The system described in this SRS document is the iTrack system. The iTrack is a monitoring system for a smarter energy consumption management to be used in houses. The system is composed of a hardware part, namely a sensor network, to aggregate power consumption data, and software to visualize the collected measurements data in an understandable and user-friendly way. Thus, customers will become more aware of their power consumption habits, and eventually they can take energy (and money) saving decisions. This system will enable customers to contribute in supporting Nation's electrical energy saving.

4.2 Overall Description

This section gives an overview of the system. The first two sections discuss the perspective of the system, how the system will interact with other systems and basic functionalities of the system. The third section describes the types of users who will interact with the system and the requirements of each user. At last, the fourth section presents the operating environment, constraints and assumptions for the system.

4.2.1 Product Perspective

There are two main parts to carry out in the system:

1. a hardware component,
2. a software component.

On one and, the hardware part will contain sensors and a router. The sensors will sense the current and voltage to calculate the consumed power from the circuitry providing electricity to various rooms or (appliances of choice) in a house. Then the measured data is sent to the system database remotely located, through the router. On the other hand, the software part will work on analyzing the data gathered from the sensors, and will provide a visual representation of the home electricity consumption for monitoring purpose, as a web base application.

In order to calculate the energy consumption, the iTrack system will need to communicate with the utility database and get the currently used consumption

segments (Halalah/kWH) [16], as consumption segments differ from one sector (e.g. governmental, agricultural, residential) to another. *Figure 3* shows the currently used consumption segments by the Saudi Electricity Company (Saudi utility). The utility API will be used to accomplish this communication. As previously mentioned, the iTrack system will use fully assembled wireless sensors network to get the power information from the prototype model.

An important feature of the iTrack system is the fact that it is bilingual (both English and Arabic). In order to ensure Arabic interface, iTrack will use localizejs to keep the Arabic phrases in the library and use that library in the iTrack website.

Another feature of the system, is that the user can set maximum consumption limit, and the system will send an alert message when the current consumption get close to the limit. Resalty.net will be use to sent the alarm messages.

In Figure 6 the context diagram shows, in high level, the external entities that contribute to the operation of the system.

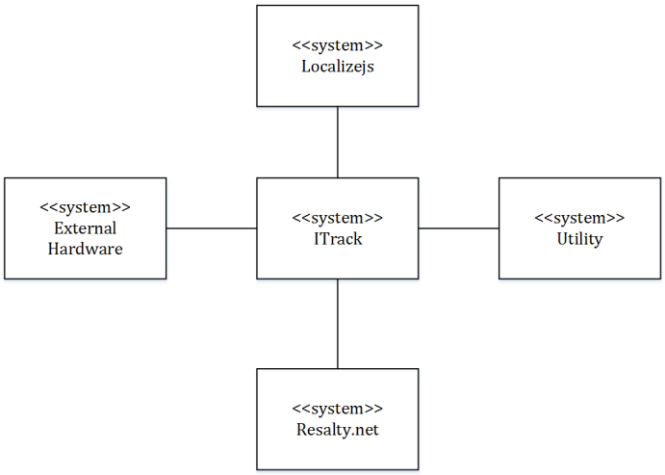


Figure 6: Context Diagram for the iTrack System.

4.2.2 Product Functionalities

The system will provide functionalities in three aspects:

1. admin aspect,
2. home-resident aspect and
3. guest aspect.

At the admin aspect, adding, deleting and/or editing on the features of his/her home are enabled for the system user. The admin has responsibility toward system functionalities to keep the system applicable at the home-resident aspect.

At the home-resident aspect, only the viewing functionalities are available. These viewing functionalities include accurate measurement of energy consumption and calculation of user electricity bill. The benefits of showing this information to the user

are to increase the awareness of the users and help them in monitoring the consumption of electricity in their home.

At the guest aspect, only browsing the website, discovering its functionality and sign up into the website are available.

Also, the system will provide the following additional functionalities to all aspects:

1. offering the system in two languages (English and Arabic),
2. showing useful information about the system and
3. presenting how to interact with the system through a user friendly website.

4.2.3 Users Characteristics

There are three types of users that interact with the system, each of them having different use of the system therefore having their own requirements:

1. Admin,
2. Home Resident and
3. Guest.

The Admin should have sensor network domain knowledge such as knowing about sensors information and energy consumption measuring, to be able to use the system functionalities correctly. Also, the admin should be able to write and read in order to enter the required information, and has a good level of computer skills. However, the Home Resident and the Guest should have at least reading ability and also a limited experience in computer skills.

There are some requirements to all types of users. They have to speak at least one of the available languages (English or Arabic). All users should be aware of using some desktop or portable devices.

4.2.4 System Considerations

4.2.4.1 Operating Environment

Since the system will be a web base system it will need a web server to work on. The iTrack website will work on any web server (online or local). On the other hand, the hardware will work in the electricity circuit in the buildings.

4.2.4.2 Assumptions and Dependencies

As mentioned previously, KSA is the targeted country for the system market. Since the utility company in KSA does not have an API as of today, the system will use an external database to get the consumption segment. This database will be replaced as soon as the utility company will provide an API, which to the best of our knowledge, is a project in progress.

4.2.4.3 Constraints

The iTrack system will be applicable in both national and international settings. However, the main targeted users of the system are in KSA. As mentioned in Problem

Statement section in chapter 1, the Kingdom of Saudi Arabia (KSA) is blessed with an abundance of energy resources. However, Saudi Arabia has very high electricity consumption, mainly due to the improvement in living standards. Also, KSA is experiencing both population and industrial growth, causing a huge demand for power and especially electricity. Combined with these two local factors, the very high emission rate of CO_2 in the region makes it a National priority to reduce energy consumption. We aspire to corporate in this goal to reduce this huge growth in energy consumption as soon as possible. In order to achieve this goal, the following constraints must be satisfied:

- The system must support Arabic language and
- The system must provide an update of various consumption segments of KSA.

4.2.4.4 Apportioning of Requirements

In the future, the system will:

- Be able to show to the user the room or devices that has the higher power consumption, and display tips for each device to reduce its power consumption.
- Provide a mean to easily input the blueprint of a building, and evaluate the latter to suggest a sensor deployment plan.

4.3 Specific Requirements

This section contains product features requirements including the user, hardware, software and communication interfaces.

4.3.1 User Interfaces

The user interfaces are the part of iTrack system that allow the users to interacts with the system. The iTrack system has several interfaces that can be accessed through a browser. The iTrack system is intended for everyone but especially for the Saudi population, from novices to expert in different ages. For that reason, iTrack interfaces should be clear, easy to use and friendly interfaces. Also, it should have colorful and attractive appearance that appeals and helps users to find their own needs in an easy and suitable way.

4.3.2 Hardware Interfaces

The hardware has three main components: the emonTX, the raspberry pi, and the regular home router. The emonTX interfaces with the electricity circuit using non-invasive clip on CT current sensors and an AC-AC Voltage adaptor to provide a voltage signal. The emonTX connects with the raspberry pi through RFM12Pi radio wireless adapter board. The raspberry pi connects to the Internet using the regular home router to transfer the data to the iTrack database.

4.3.3 Software Interfaces

The iTrack software will provide all the functionality mentioned in next section by using other software. For iTrack to work in the client devices, it will need a browser (e.g. Chrome, Firefox, Safari etc.). For sending a confirmation message PHP mailer will be used. There will be three PHP script running all the time in the server. One of these scripts will check the limit every 24 hours and send an alarm message whenever the limit reached 75% of the specified limit. The second script will synchronize the information from the utility database to iTrack database every year. The third script will synchronize the sensors data from the emon org database to the iTrack database every 10 seconds. Microsoft Excel will be acting as an interface between iTrack database and the simulation data; the data generated from the simulation software is exported to the Excel where the data format is changed to such a data format compatible with the iTrack database. For the Arabic version of the iTrack website, the localizejs API will be used. The Arabic phases will be stored in library in the localizejs website.

4.4 Functional Requirements

This section describes the functions of the iTrack system and assigns each function to its use case.

4.4.1 Classes Functions

4.4.1.1 Profile Class:

This class is responsible of processing user profile data and account management.

Table 7: Profile Use Cases

Function Name	Use Case
SignUp	Sign Up
SignIn	Sign In
ForgetPassword	Forget Password
ViewUserInformation	View Profile Information
ViewUserConnections	View Dependent Information
ViewUserConnections	View Connections Information
AddDependent	Add Dependent
DeleteDependent	Delete Dependent
ModifyGeneralInfo	Edit Profile Information
ChangeEmail	Change E-mail
ChangePassword	Change Password

4.4.1.2 Dashboard Class:

This class is responsible of processing dashboard data and building information management.

Table 8: Dashboard Use Cases

Function Name	Use Case
View_Building_information	View Building's Features
Add_Building_Information	Add Building
Edit_Building_Information	Edit Building's Features
Delete_Building_Information	Delete Building's Features
View_Room_information	View Room Features
Add_Room_Information	Add Room
Edit_Room_Information	Edit Room's Features
Delete_Room_Information	Delete Room's Features
ViewBillingRate	View Billing Rate
View_General	View Sensor's Reading
getGeneralLimit	View Consumption Limit
getbill_Calculation	View Electricity Bill

view_tips	View Awareness Tips

4.4.1.3 Verify Email Class:

This class is responsible of verifying the email of the user after him/her signup.

Table 9: Verify Email Use Case

Function Name	Use Case
verifyEmail	Sign Up

4.4.1.4 Change Email Class:

This class is responsible of processing change email requested by the user.

Table 10: Change Email Use Case

Function Name	Use Case
ChangeEmail	Change E-mail

4.4.1.5 Continue Registration Class:

This class is responsible of processing create dependent account initiated by an admin.

Table 11: Continue Registration Case

Function Name	Use Case
ContinueRegistration	Add Dependent

4.4.1.6 Reset Password Class:

This class is responsible of processing reset password initiated by use forget password request.

Table 12: Reset Password Use Case

Function Name	Use Case
ChangePassword	Forget Password

4.4.1.7 Alarm Message Script:

This class is responsible of processing the system database and finding the users whom exceeded 75% of their consumption limit for alarm message initiation.

Table 13: Alarm Message Use Case

Function Name	Use Case
The whole script	Receive Alarm Message

4.5 Behavioral Requirement

This section describes the use case of the system. It contains two parts. The first part contains a use case diagram. The second part contains the tabular description of each case of the use case diagram.

4.5.1 Use Case Diagram

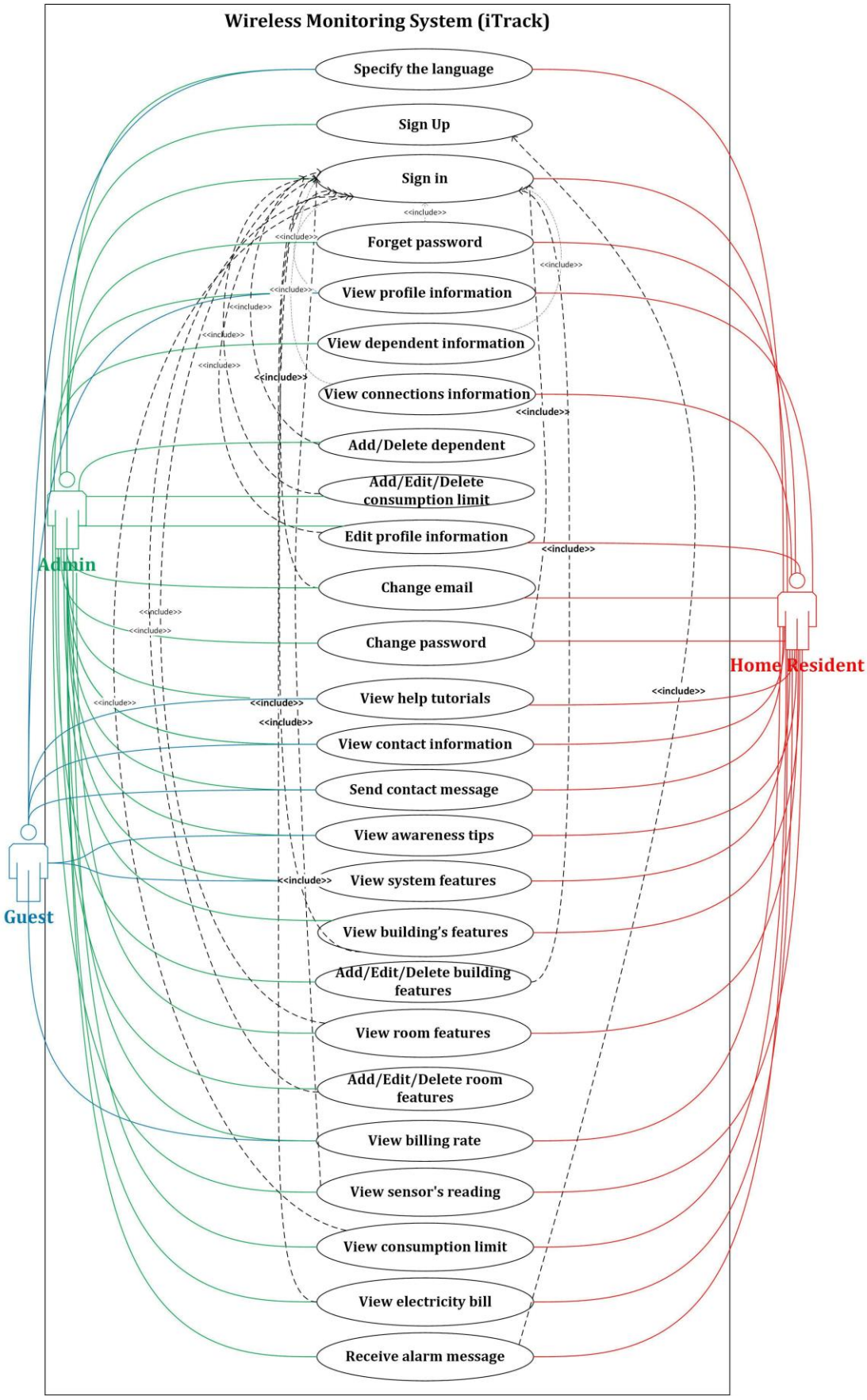


Figure 7: iTrack Use Case Diagram.

4.5.2 Use-Cases Description

4.5.2.1 Specify the Language

Table 14: Tabular Description of the ' Specify The Language ' Use Case.

Actor	Admin, Home Resident, Guest.
Description	The Admin, the Home Resident or the guest may specify the suitable language (English / Arabic), where is the English language is the default language.
Data	System language.
Stimulus	Admin, Home Resident or the guest command to change language.
Respond	Change system's language to the specified language.

4.5.2.2 Sign Up

Table 15: Tabular Description of the 'Sign Up' Use Case.

Actor	Admin.
Description	Admin may sign up to the system.
Data	Profile picture, full name, birth date, phone number, email, and password.
Stimulus	Admin command to sign up.
Respond	Admin account created and a confirmation message received.

4.5.2.3 Sign In

Table 16: Tabular Description of the ' Sign In ' Use Case.

Actor	Admin, Home Resident.
Description	Admin or Home Resident may sign in to the system.
Data	E-mail, password.
Stimulus	Admin or Home Resident command to sign in.
Respond	Display the main page.

4.5.2.4 Forget Password

Table 17: Tabular Description of the ' Forget Password ' Use Case.

Actor	Admin, Home Resident.
Description	Admin or Home Resident may be able to request for reset his/her forgotten password.
Data	E-mail.
Stimulus	Admin or Home Resident command to reset his password.
Respond	Change password email message received with reset password link.

4.5.2.5 View Profile Information

Table 18: Tabular Description of the ' View Profile Information' Use Case.

Actor	Admin, Home Resident.
Description	Admin or Home Resident may view his profile information.
Data	No data input.
Stimulus	Admin or Home Resident command to view his profile.
Respond	Displays user type, email, birthdate, and phone number.

4.5.2.6 View Dependent Information

Table 19: Tabular Description of the 'View Dependent Information' Use Case.

Actor	Admin.
Description	Admin may view his dependents information.
Data	No data input.
Stimulus	Admin command to view his dependents.
Respond	Displays user dependents information: type, email, birthdate, and phone number.

4.5.2.7 View Connections Information

Table 20: Tabular Description of the 'View Connections Information' Use Case.

Actor	Home Resident.
Description	Home Resident may view his connections information.
Data	No data input.
Stimulus	Home Resident command to view his connections.
Respond	Displays user connections information: type, email, birthdate, and phone number.

4.5.2.8 Add /Delete Dependent

Table 21: Tabular Description of the 'Add/ Delete User Account' Use Case.

Actor	Admin.	
Description	Admin may command to add or delete dependent account.	
Data	Add Dependent Account: full name, email, phone number.	Delete Dependent Account: user id
Stimulus	Admin command to add dependent account.	Admin command to delete dependent account.
Respond	Dependent account created and continue registration email received.	Dependent account deleted and a confirmation message display.

4.5.2.9 Edit Profile Information

Table 22: Tabular Description of the 'Edit Profile Information' Use Case.

Actor	Admin, Home Resident.
Description	Admin or Home Resident may edit his/her general profile information.
Data	Profile picture, full name, birth date, phone number.
Stimulus	Admin or Home Resident command to edit profile information.
Respond	Admin or Home Resident general information updated.

4.5.2.10 Change E-Mail

Table 23: Tabular Description of the ' Change E-Mail ' Use Case.

Actor	Admin, Home Resident.
Description	Admin or Home Resident may change the e-mail of his account.
Data	New e-mail.
Stimulus	Admin or Home Resident command to change the e-mail.
Respond	Change e-mail confirmation.

4.5.2.11 Change Password

Table 24: Tabular Description of the ' Change Password ' Use Case.

Actor	Admin, Home Resident.
Description	Admin or Home Resident may change the password of his/her account.
Data	Old and new password.
Stimulus	Admin or Home Resident command to change the password.
Respond	Change password confirmation message.

4.5.2.12 View Help Tutorials

Table 25: Tabular Description of the ' View Help Tutorial ' Use Case.

Actor	Admin, Home Resident, Guest.
Description	Admin, Home Resident or Guest may navigate help tutorials.
Data	No data input.
Stimulus	Admin, Home Resident or Guest command to view helps tutorials.
Respond	Displays help tutorials.

4.5.2.13 View Contact Information

Table 26: Tabular Description of the 'View Contact Information' Use Case.

Actor	Admin, Home Resident, Guest.
Description	Admin, Home Resident or Guest may view contact information.
Data	No data input.
Stimulus	Admin, Home Resident or Guest command to contact with system's developers.
Respond	Display contacts information: E-mail, LinkedIn and Twitter accounts.

4.5.2.14 Send Contact Message

Table 27: Tabular Description of the ' Send Contact Message ' Use Case.

Actor	Admin, Home Resident, Guest.
Description	Admin, Home Resident or Guest may send contact message.
Data	Message.
Stimulus	Admin, Home Resident or Guest command to send contact message.
Respond	User message sent.

4.5.2.15 View Awareness Tips

Table 28: Tabular Description of the ' View Awareness Tips ' Use Case.

Actor	Admin, Home Resident, Guest.
Description	Admin, Home Resident or Guest may view awareness tips that will increase their awareness of the system.
Data	No data input.
Stimulus	Admin, Home Resident or Guest command to view tips.
Respond	Display awareness tips.

4.5.2.16 View System Features

Table 29: Tabular Description of the ' View System Features ' Use Case.

Actor	Admin, Home Resident, Guest.
Description	Admin, Home Resident or Guest may view system features.
Data	No data input.
Stimulus	Admin, Home Resident or Guest command to view system features.
Respond	Display system features.

4.5.2.17 View Building's Features

Table 30: Tabular Description of the 'View Building's Features ' Use Case.

Actor	Admin, Home Resident.
Description	The Admin or the Home Resident may view building's features.
Data	Building's name.
Stimulus	The Admin and the Home Resident command to view building's features.
Respond	Display building's features.

4.5.2.18 Add /Edit/ Delete Building's Features

Table 31: Tabular Description of the ' Add/ Edit/ Delete Building's Features ' Uses Case.

Actor	Admin.		
Description	Admin may add, edit or delete building's features.		
Data	Add: Building's type, building's name and activation key.	Edit: Building's type, and building's name	Delete: Building id
Stimulus	Admin command to add building's features.	Admin command to edit building's features.	Admin command to delete building's features.
Respond	Building's features added and confirmation message display.	Building's features added and confirmation message display.	Building's features deleted and confirmation message display.

4.5.2.19 View Room Features

Table 32: Tabular Description of the ' View Room Features ' Use Case.

Actor	Admin, Home Resident.
Description	The Admin or the Home Resident may view room's features.
Data	Room's name.
Stimulus	The Admin and the Home Resident command to view room's features.
Respond	Display room's features.

4.5.2.20 Add/ Edit/ Delete Room's Features

Table 33: Tabular Description of the 'Add/ Edit/ Delete Room's Features ' Use Case.

Actor	Admin.		
Description	Admin may add, edit, or delete any room.		
Data	Add: Room's name, description, sensor's name, consumption limit, is the sensor the main sensor or not.	Edit: Room's name, description, sensor's name, consumption limit, is the sensor the main sensor or not.	Delete: Room's name, sensor's name
Stimulus	Admin commands to add a room.	Admin commands to edit a room.	Admin commands to delete a room.
Respond	Room features added and confirmation message display.	Room features edited and confirmation message display.	Room features deleted and confirmation message display.

4.5.2.21 View Billing Rate

Table 34: Tabular Description of the ' View Billing Rate ' Use Case.

Actor	Admin, Home Resident, Guest.
Description	Admin, Home Resident or Guest may view the billing rate of any building type.
Data	Building type.
Stimulus	Admin, Home Resident or Guest command to view billing rate.
Respond	Display the billing rate cost.

4.5.2.22 View Sensor's Reading

Table 35: Tabular Description of the ' View Sensor's Reading ' Use Case.

Actor	Admin, Home Resident.
Description	The Admin or the Home Resident may view main sensor's or any other sensor's reading ,or display comparison between the readings of two or multiple sensors.
Data	The Admin or the Home Resident choice of the number of sensors (single or multiple sensors).
Stimulus	Home Resident command to view only one sensor or muliple sensors' reading .
Respond	Display main sensor's or any other sensor's reading.

4.5.2.23 View Consumption Limit

Table 36: Tabular Description of the ' View Consumption Limit ' Use Case.

Actor	Admin, Home Resident.
Description	The Admin or the Home Resident may view consumption limit of the main sensor or any other sensor.
Data	Room's name.
Stimulus	The Admin or the Home Resident command to view consumption limit.
Respond	Display consumption limit.

4.5.2.24 View Electricity Bill

Table 37: Tabular Description of the 'Request Bill's Calculation' Use Case

Actor	Admin, Home Resident.
Description	Admin or Home Resident may see bill's calculation whenever they want, in 24 hours per day.
Data	Building name.
Stimulus	Admin or Home Resident command to make a request for bill's calculation.
Respond	Display bill's calculation.

4.5.2.25 Receive Alarm Message

Table 38: Tabular Description of the ' Receive Alarm Message ' Use Case.

Actor	Admin, Home Resident.
Description	Admin or Home Resident may receive a message of approximately reaching the consumption limit.
Data	No data input.
Stimulus	Exceeding 75% of the consumption limit.
Respond	Receive e-mail whenever they approximately reached 70% of the specified limit.

4.6 Non-Functional Requirements

This section presents the non-functional requirements of iTrack system. The non-functional requirements are those functions that are not directly concerned with the specific service delivered to the user.

4.6.1 Performance Requirements

- The system must have general storage space available for data and sensors' reading for 1 year.
- The system interfaces shall have acceptable response time to the user maximum few seconds.

4.6.2 Safety and Security Requirements

- The system should provide data security that will prevent direct and unauthorized access (add, update, delete) to underlying tables.
- The system shall authenticate the users by providing email verification and the CAPTCHA (letters and numbers) verification code.
- The system shall protect user's personal information like password by encryption.

4.6.3 Software Quality Attributes

4.6.3.1 Reliability

In case of error occurring, the system will handle this error and display error messages.

4.6.3.2 Availability

The system must be available all the time (24 hours per day) and provide real time information, so the user can make a request for bill's calculation whenever they want.

4.6.3.3 Maintainability

The original developers, and other developers who have technical skills can maintain the system.

4.6.3.4 Look and Feel

The system shall:

- Have clear, easy to use, and user-friendly interfaces.
- Use a graphical user interface with colorful, and attractive appearance that appeals and helps users to find their own needs in an easy and suitable way.
- Use bright and attractive colors.
- Provide two languages Arabic and English.
- Use symbols and words that are naturally understandable by the user community.
- Show error messages when wrong inputs have entered by the user or required fields were empties.

4.7 Summary

Section 4.1 Purpose and Scope

- The purpose of this document is to define the purpose and functionality of the iTrack system.
- Potential customers and developers are the audience of this document.
- The system is consisting of two parts: hardware and software.

Section 4.2 Overall Description

- The hardware part will be used to measure the consumed energy and to send these data to the database.
- The software will get the data coming from the hardware manipulate it and present it to the user.
- The iTrack system will use services from four different external systems.
- The system will provide functionality to three different aspects.
- There are three kinds of users of iTrack system: Admin, Home Resident and Guest.
- The iTrack system is a web base system.
- In order for the iTrack system to fulfill the needs of the people in KSA, it should be available in two languages (Arabic/ English).

Section 4.3 Specific Requirements

- iTrack interfaces should be clear, easy to use and friendly interfaces.
- There are three different interfaces between the hardware components.

Section 5.4 Functional Requirements

- The functional requirement section discussed all the system functions. Also, it assigns each function to the corresponding use case.

Section 4.5 Behavioral Requirement

- The behavioral requirement presented the use case of the iTrack system.

Section 4.6 Non-Functional Requirements

- The iTrack system should contain some non-functional requirements in order to judge the operation of the system

Chapter 5 System Design Specification

This System Design Specification (SDS) document describes the design of a wireless energy consumption monitoring system, the iTrack. First, it starts with an introductory section which clarifies what the iTrack system is, followed by the design considerations. Subsequently, system architecture, data designs, user interface, and detailed design are described in detail, followed by the summary.

Outline

5.1 Design Mapping and System Overview

5.1.1 Design Map

The purpose of this System Design Specification (SDS) document is to provide a complete description of the iTrack system designs. These are the system architecture, the user interface, and the data designs.

The main intended audiences for this SDS are the software developers that will implement or extend the iTrack system. Also, this document might also be of interest to developers, interested to learn about wireless energy consumption monitoring systems. Although the document is fairly technical, our potential customers that will install and use the system in their household can benefit from it to understand how the system is constructed.

5.1.2 System Overview

The system designs in this SDS document are for the iTrack system. The iTrack is a monitoring system for a smarter energy consumption management to be used in houses. The system is composed of a hardware part, a sensor network, to aggregate power consumption data, and software to visualize the collected measurements data in an understandable and user-friendly way. Thus, customers will become more aware of their power consumption habits, and eventually they can take energy (and money) saving decisions. This system will enable customers to contribute in supporting Nation's electrical energy saving. Therefore, the iTrack system design will consider its own energy consumption, and seek to minimize it. Also, the system will be designed to be reliable.

5.2 Design Considerations

This section presents the design considerations. First the general constraints are given, followed by the assumptions and dependencies.

5.2.1 General constrains

In order to fulfill requirements defined in the SRS, the design team considers developing a web-based system because this type of applications uses a web browser to provide access to the system. Therefore, this enables the user to access to the system anytime, from any device that contains a browser [17, 18].

MySQL will be used to develop the database; as it supports coding in Arabic and English, can save sensor reading and is compatible with PHP programming language [19, 20].

PHP is the choice, as the web-based application programming language to achieve the visualization related required of the monitoring system. It's a common preferable language used by developers. Compared to other web languages (e.g. Ruby, Python and ASP.net), it provides extensive database support, works on almost every operating system and platform, and is easy to learn. Although PHP is considered to be less secured compared with the other programming languages, we still think that the advantages are very important; in fact the security can be handled by the programmers [21, 22].

HTML, CSS JavaScript and jQuery will be used for developing the system, as these languages are the best languages for developing web-based systems [21].

5.2.2 Assumption and dependencies

Object-oriented methodology will be adopted, as it is a system development approach that encourages and facilitates re-using of software components. With this methodology, the system may be developed on a component basis, which enables the effective re-use of existing components and facilitates the sharing of its components with other systems [23].

MatLab will be used as a simulation tool for simulating a close-to real life system, as it is shown from studies that this is the best simulation tool when simulating electrical circuit in general and home circuitry in particular [24, 25].

5.3 System Architecture

This section gives a high level overview of how the system processes flow. The section first represents the considered architecture design approach. After that, the utilization of the design approach in specifying the architecture of our system is presented.

5.3.1 Architectural Design Approach

Since it is decided that the iTrack system is a web-based system, the architecture that is going to be used has to be a web-based architecture. There are several web-based architectures that can be utilized. For example, there are layered architecture, message bus architecture, N-tier architecture, object-oriented architecture, and service-oriented (client-server) architecture [26]. For our system only two architectures are preferred: client server and N tier architectures.

Client server architecture is computing model where one or more computers act as a clients and one computer acts like server. All the clients request services from the server [27]. The server hosts the software system and the system database as well. Many users in different places, will access the server using different devices at the same time, and the system security should be high, since the user information will be saved in centralized database. Therefore, the client server architecture is proper architecture for our system.

N-tier architecture is a computing architecture where the system is scattered into many tiers. Each tier represents one part of the system that is located on physically independent device [26, 27]. Because the components of our system will be in different places (the hardware will be in the house and the software and the data will be on the server), the N tier architecture is the best choice. It allows them to communicate with each other [26].

5.3.2 Architectural Design

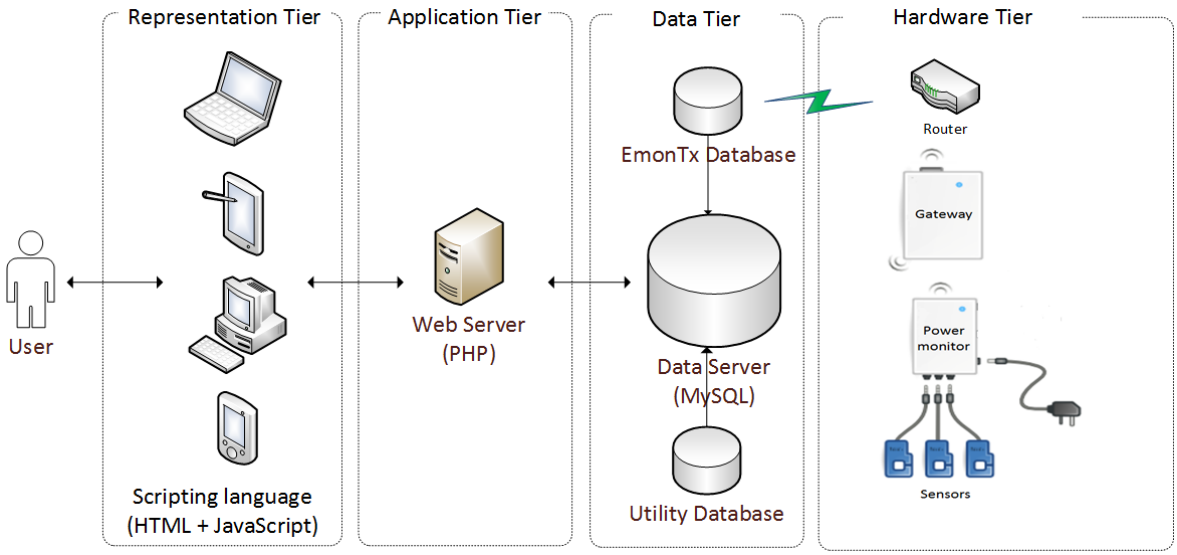


Figure 8: Architectural Design of the iTrack System.

Figure 8 represents the architecture of iTrack system. The system architecture consists of 4-tiers: representation tier, application tier, data tier, and hardware tier. First, the presentation tier is the website of the system working on the web browser in the user device. Second, the application tier is the web server that is hosting the system website. Third, the data tier is the data server that is storing the system databases. Finally, the hardware tier is the hardware components that sense the needed information for calculating the power consumption and sends them to the EminTx database in the previous data tier.

5.3.2.1 System Hardware Architecture

The hardware utilized by iTrack (Figure 9) is open source monitoring product provided by openenergymonitor.com. EmonTx (wireless sensor nodes) and Raspberry Pi (base-station) are the two main hardware components of iTrack system.

Figure 9: Hardware Architecture

EmonTx V3

Figure 10 EmonTx; Power Monitor

The EmonTx is designed to monitor AC electrical power on up to four separate house circuits through non-invasive clip to measure current and voltage (Figure 10). The device uses low power wireless energy monitoring node for monitoring voltage signal for full real power data. The varieties of information that can be produced by EmonTx V3 are Real Power, Apparent Power, Power Factor, Root Mean Square Voltage, and current [28].

Raspberry Pi

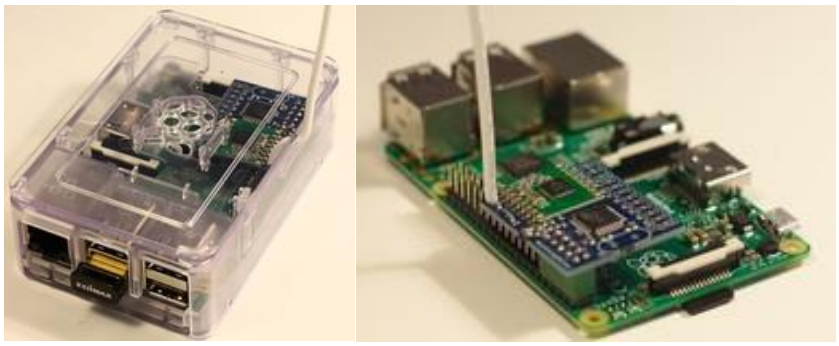


Figure 11 Raspberry Pi; EmonBase

The Raspberry Pi (RPi) is "credit-card sized Linux computer developed by the Raspberry Pi Foundation. The device has many applications both in the developed and the developing world" [29].

Raspberry Pi is used as a base-station to log data generated from EmonTx locally. It is equipped with RFM12Pi wireless adaptor board to forward the data to a remote database over the Internet in a server [30].

The iTrack system continuously updates its remote database with the hardware database.

5.3.2.2 System Software Architecture (subsystems architecture)

As mentioned before, iTrack website will be developed using MVC architecture. So, it will have three kinds of files; the view files that contain all the interfaces' code (HTML, CSS, JavaScript, jQuery); the controllers file which contains all the PHP code that connect

the interfaces with the Model classes; the Model files which contain classes to hold the information coming from the database. All these classes and its function mentioned in details in section 5.5 User Interfaces Design.

iTrack has three background processes for: checking the consumption limit, synchronization between hardware database and iTrack database, and synchronization between the utility database and iTrack database. These three processes run in the server automatically. Configuring the processes to run is done using Cron jobs.

5.4 Database Design

Data design is a common process for generating a description of the data model of any database in details. Data model consists of all required choices of physical and logical design for producing the proper design by using a data definition language, and then this can be used to develop a database. Our data design consists of data description and data dictionary for both the internal and the external database.

5.4.1 Data Description

As shown in Figure 12, the system consists of eight entities, eight binary relationships; called binary because each relationship is associated with two entities only, and the associated attributes with each one of them (each entity and each relationship) which are illustrated by oval shape. The line under some attributes means that these are the primary attributes (the primary keys). Each entity is illustrated by rectangular shape, which are (Account, User, Role, Building Type, Building, Consumption Range, Room, and Room Power), and each relationship is illustrated by diamond shape, which are (four 'Has' relationships, "Contain", "Create", "Own", and "billing rate "relationships).
Each user has only one account; which includes the ID, user email and the password of the user this means that each account is for a single user only. Each user has exactly one role; includes the ID and the name of the role, while each role may have a wide range of users from one to many. Each user may own from zero to many buildings while each building should be owned by one to many users, the admin and the home resident. Each building has an ID, an activation key and a name and exactly one type, which includes the ID and name, while each type is for zero to many buildings. Each building's type has one to many consumption ranges with the corresponding price for that range while each consumption range is for one to many buildings. Each consumption range has an ID a start range and an end range. Each building contains from one to many rooms while definitely each room is contained in exactly one building. Each room has its ID, name, description, isMain, to identify that the room is utility room or not, and limit. Each room has one to many rooms energy while each room energy is for one room only. Each room energy has a power and time.

As shown in Figure 13, each building's type has one to many consumption ranges with the corresponding price for that range while each consumption range is for one to many buildings. Each consumption range has an ID a start range and an end range.

5.4.2 Entity Relationship Diagram

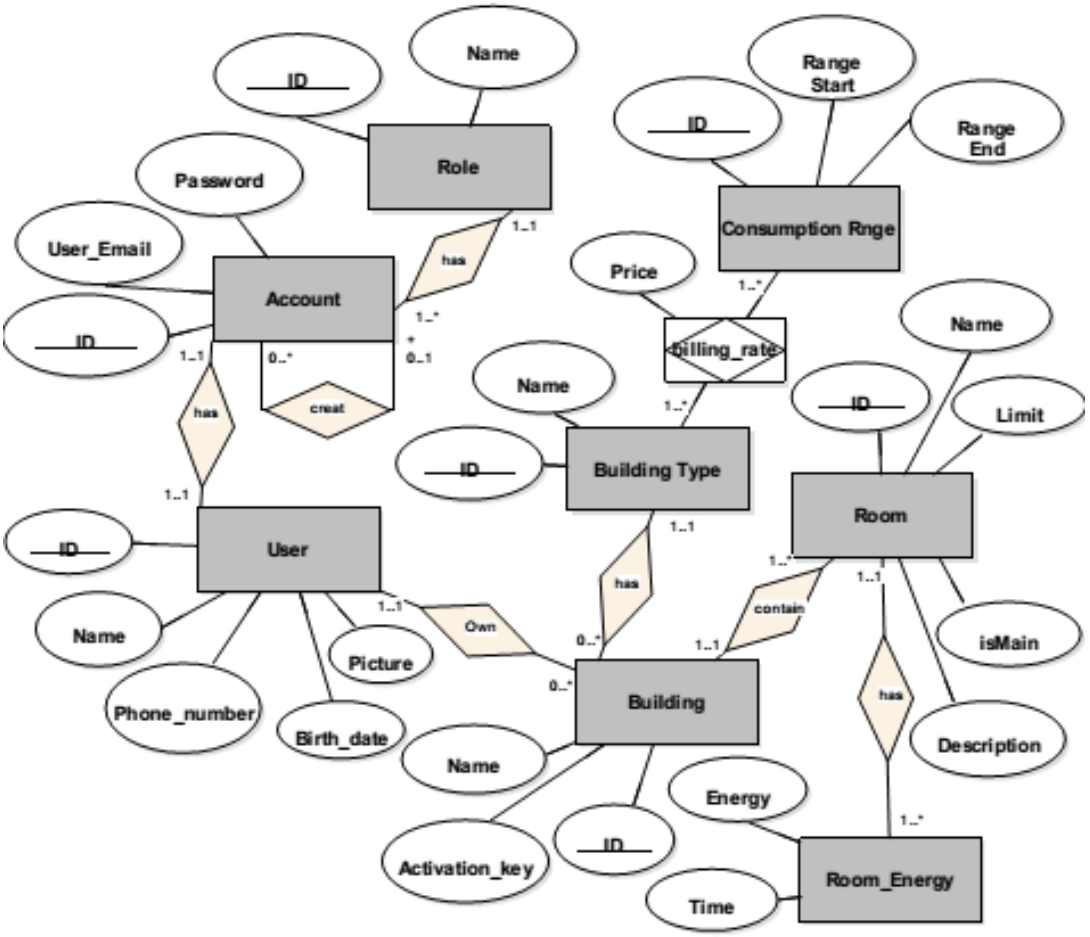


Figure 12: ER Diagram of the System's Database.

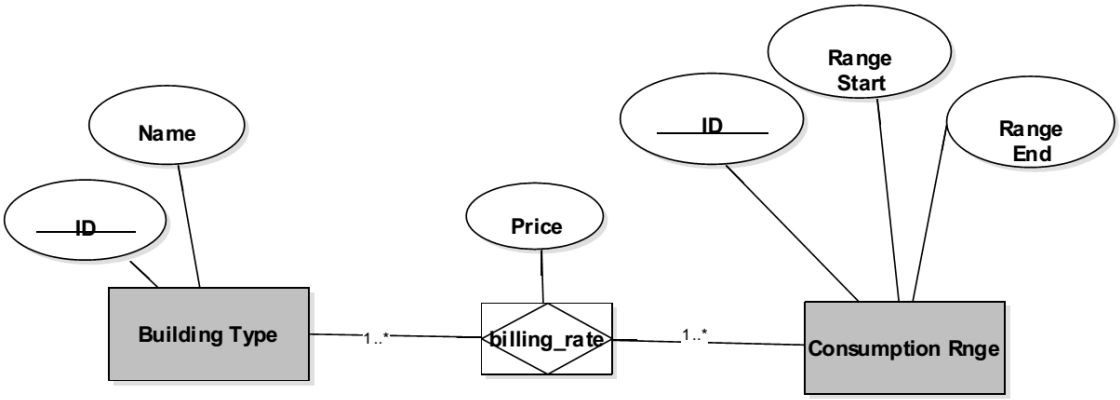


Figure 13: ER Diagram of the External Database.

5.4.3 Database Tables Specifications

5.4.3.1 account

#	Name	Type	Collation	Attributes	Null	Default	Extra	Action
1	ID	int(11)			No	None	AUTO_INCREMENT	Change Drop Browse distinct values Primary More
2	User_name	varchar(250)	utf8_unicode_ci		No	None		Change Drop Browse distinct values Primary More
3	Password	varchar(32)	utf8_unicode_ci		No	None		Change Drop Browse distinct values Primary More
4	Role_ID	int(11)			No	None		Change Drop Browse distinct values Primary More
5	User_ID	int(11)			No	None		Change Drop Browse distinct values Primary More
6	Temp	int(11)			No	1		Change Drop Browse distinct values Primary More

Figure 14: Account Table Specifications.

5.4.3.2 account_creator

#	Name	Type	Collation	Attributes	Null	Default	Extra	Action
1	Creator_ID	int(11)			No	None		Change Drop Browse distinct values Primary Unique Index Spatial Fulltext
2	Created_ID	int(11)			No	None		Change Drop Browse distinct values Primary Unique Index Spatial Fulltext

Figure 15: Account Creator Table Specifications.

5.4.3.3 billing_rate

#	Name	Type	Collation	Attributes	Null	Default	Extra	Action
1	Building_type_ID	int(11)			No	None		Change Drop Browse distinct values Primary Unique Index More
2	Consump_range_ID	int(11)			No	None		Change Drop Browse distinct values Primary Unique Index More
3	Price	double			Yes	NULL		Change Drop Browse distinct values Primary Unique Index More

Figure 16: Billing Rate Table Specifications.

5.4.3.4 building

#	Name	Type	Collation	Attributes	Null	Default	Extra	Action
1	User_ID	int(11)			No	None		Change Drop Browse distinct values Primary More
2	ID	int(11)			No	None	AUTO_INCREMENT	Change Drop Browse distinct values Primary More
3	Name	varchar(64)	utf8_general_ci		No	None		Change Drop Browse distinct values Primary More
4	Activation_key	varchar(25)	latin1_swedish_ci		No	None		Change Drop Browse distinct values Primary More
5	Building_type_ID	int(11)			No	None		Change Drop Browse distinct values Primary More

Figure 17: Building Table Specifications.

5.4.3.5 building_activation_key

#	Name	Type	Collation	Attributes	Null	Default	Extra	Action
1	ID	int(11)			No	None	AUTO_INCREMENT	Change Drop Browse distinct values Primary More
2	Activation_key	varchar(25)	latin1_swedish_ci		No	None		Change Drop Browse distinct values Primary More

Figure 18: Building Activation Key Table Specifications.

5.4.3.6 building_type

#	Name	Type	Collation	Attributes	Null	Default	Extra	Action
1	ID	int(11)			No	None	AUTO_INCREMENT	Change Drop Browse distinct values Primary Unique More
2	Name	varchar(64)	utf8_general_ci		No	None		Change Drop Browse distinct values Primary Unique More

Figure 19: Building Type Table Specifications.

5.4.3.7 consumption_range

#	Name	Type	Collation	Attributes	Null	Default	Extra	Action
1	ID	int(11)			No	None	AUTO_INCREMENT	Change Drop Browse distinct values Primary Unique More
2	Started_range	double			No	None		Change Drop Browse distinct values Primary Unique More
3	End_range	double			No	None		Change Drop Browse distinct values Primary Unique More

Figure 20: Consumption Range Table Specifications.

5.4.3.8 role

#	Name	Type	Collation	Attributes	Null	Default	Extra	Action
1	ID	int(11)			No	None		Change Drop Browse distinct values Primary Unique Index Spatial More
2	Name	varchar(30)	utf8_general_ci		No	None		Change Drop Browse distinct values Primary Unique Index Spatial More

Figure 21: Role Table Specifications.

5.4.3.9 room

#	Name	Type	Collation	Attributes	Null	Default	Extra	Action
1	Building_ID	int(11)			No	None		Change Drop Browse distinct values Primary Unique More
2	ID	int(11)			No	None	AUTO_INCREMENT	Change Drop Browse distinct values Primary Unique More
3	Name	varchar(64)	utf8_general_ci		No	None		Change Drop Browse distinct values Primary Unique More
4	Description	varchar(64)	utf8_general_ci		Yes	NULL		Change Drop Browse distinct values Primary Unique More
5	Limit	double			Yes	NULL		Change Drop Browse distinct values Primary Unique More
6	isMain	binary(1)			No	None		Change Drop Browse distinct values Primary Unique More

Figure 22: Room Table Specifications.

5.4.3.10 room_power

#	Name	Type	Collation	Attributes	Null	Default	Extra	Action
1	Room_ID	int(11)			No	None		Change Drop Browse distinct values Primary Unique Index Spatial Fulltext
2	Power	double			No	None		Change Drop Browse distinct values Primary Unique Index Spatial Fulltext
3	Time	datetime			No	None		Change Drop Browse distinct values Primary Unique Index Spatial Fulltext

Figure 23: Room Power Table Specifications.

5.4.3.11 temp_account

#	Name	Type	Collation	Attributes	Null	Default	Extra	Action
1	ID	int(11)			No	None	AUTO_INCREMENT	Change Drop Browse distinct values Primary More
2	User_name	varchar(256)	utf8_unicode_ci		No	None		Change Drop Browse distinct values Primary More
3	Confirmation_Code	varchar(32)	utf8_unicode_ci		No	None		Change Drop Browse distinct values Primary More
4	Account_ID	int(11)			No	None		Change Drop Browse distinct values Primary More

Figure 24: Temp Account Table Specifications.

5.4.3.12 user

#	Name	Type	Collation	Attributes	Null	Default	Extra	Action
1	**ID**	int(11)			No	*None*	AUTO_INCREMENT	Change Drop Browse distinct values Primary More
2	**Name**	varchar(64)	utf8_general_ci		No	*None*		Change Drop Browse distinct values Primary More
3	**Birth_date**	varchar(10)	utf8_unicode_ci		Yes	*NULL*		Change Drop Browse distinct values Primary More
4	**Phone_number**	varchar(15)	utf8_unicode_ci		Yes	*NULL*		Change Drop Browse distinct values Primary More
5	**Picture**	blob			Yes	*NULL*		Change Drop Browse distinct values Primary More

Figure 25: User Table Specifications.

5.4.4 Relational Database Schema

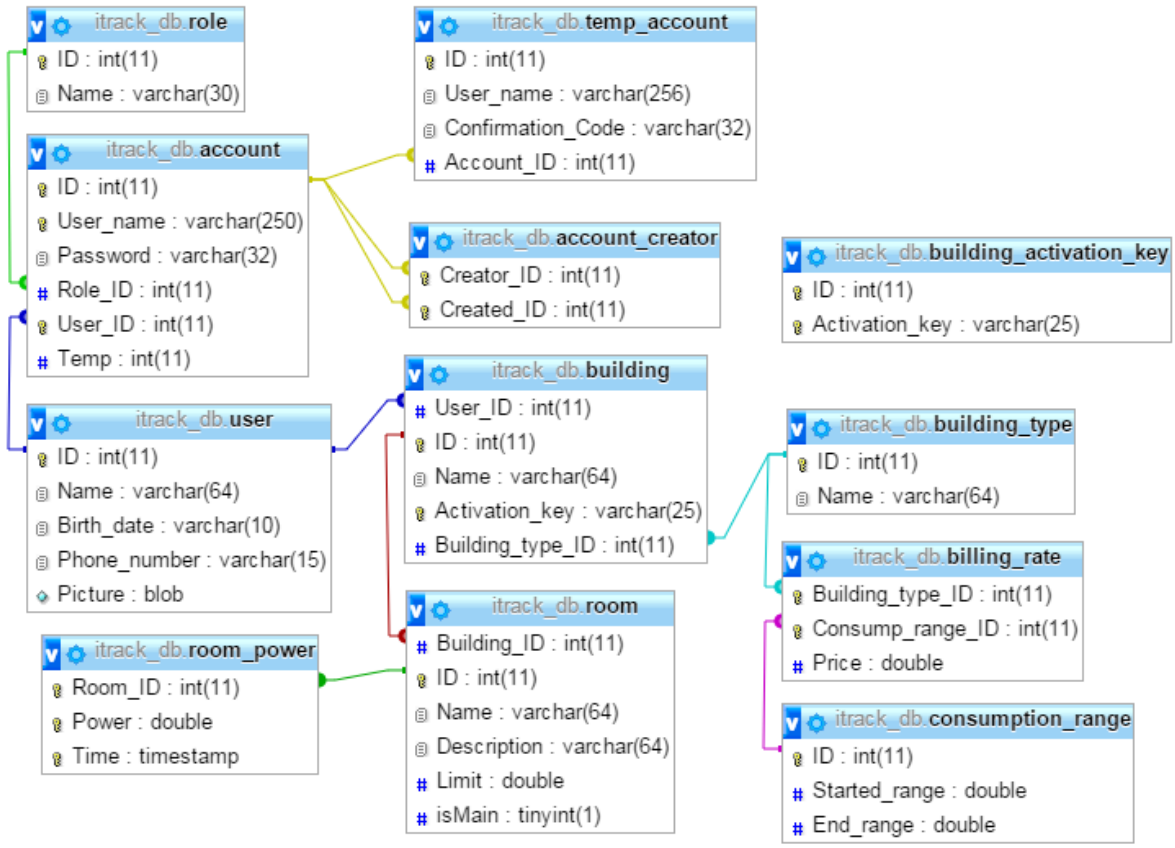


Figure 26: Relational Database Schema.

5.5 User Interfaces Design

This section discusses the design of the user interfaces. It starts with an overview about the interfaces. Then, it mentions the rules of the interfaces design. After that, interfaces images, interfaces objects and actions are described.

5.5.1 Overview of User Interfaces

To design the iTrack interfaces ready template was used. The INSPINIA - Responsive Admin Theme is the chosen theme. The iTrack system has 12 interfaces: home, about, awareness tips, change email, continue registration, dashboard, forget password, help tutorial, profile, reset password, system features and verify email. The functionality of some of these interfaces differs according to the user type: Admin, home resident and Guest.

For all system user:

- The user should be able to navigate to other interfaces from the home interface. Also, the user should be able to see advertisement area.
- The user should be able to see the iTrack team members contact information on the about interface.
- The user should be able to send email to iTrack website on the about interface.
- The user should be able to see the general, safety and saving energy tips on the awareness tips interface.
- The user should be able to see the system features on the system feature interface.
- The user should be able to watch help videos on the help tutorial interface.
- The user should be able to see the consumption range coming from the utility database on the dashboard interface (electricity bill tab)

For the guest of iTrack website:

- The guest should be able to see dummy dashboard to demonstrate what the system will provides to him/her if he/she become a member.

For the admin of iTrack website:

- The admin should be able to sign up to the system on the sign up interface.
- The admin should be able to manage his/her profile by:
  - View his/her information
  - Add/delete his/her dependent
  - Modify his/her information like: profile picture, full name, birth date, phone number, change password and change email.
- The admin should be able to manage his/her building information on the dashboard interface by:
  - Add building information (building type, name and activation key), edit building information and delete building information.
  - Add room information (room name, room description, room limit and main sensor), edit room information and delete room information.

- View the consumption information (graph that show the consumption habit, the percentage of the consumed limit, bill calculation).

For the home resident:

- The home resident should be able to continue registration after his/her admin added him/her on the continue registration interface.
- The home resident should be able to manage his/her profile by:
  - View his/her information
  - View his/her connections.
  - Modify his/her information like: profile picture, full name, birth date, phone number, change password and change email.
- The home resident should be able to View the consumption information (graph that show the consumption habit, the percentage of the consumed limit, bill calculation).

5.5.2 Interface Design Rules

As mentioned before the interfaces of iTrack system should be clear, user-friendly and attractive. In order to achieve that the design of iTrack interfaces will be based on the eight golden rules:

Strive for consistency: all the interfaces components like colors, fonts, layout, menus, should be consistent.
Cater to universal usability: recognize the user characteristic of iTrack system like novice or expert, education and age range.
Offer informative feedback: provide a system feedback after each interaction between the iTrack users and the system.
Design dialogs to yield closure: give an indication about user action if it is completed or failed.
Prevent errors: design the system in a way that users should not be able to make major error by minimizing the typing input and making the user to choose from menu, gray out the unneeded field, give clear messages and instructions.

Permit easy reversal of actions: give the user the ability of undoing actions.

Support internal locus of control: design the system in a way that makes the user feels like he/she is controlling the action.

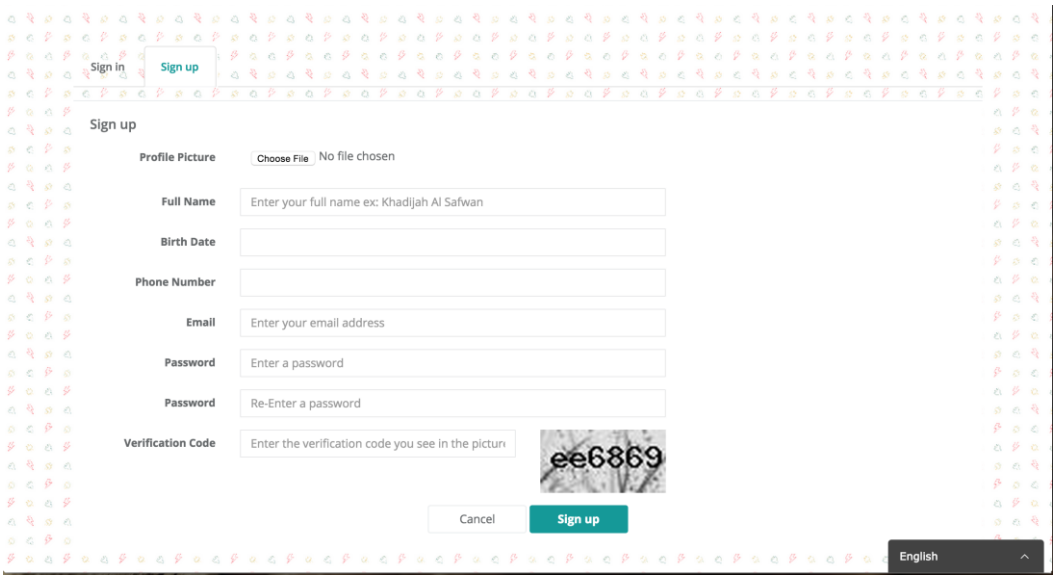
Reduce short-term memory load: design the system in a way that does not requires the user to recall information from previous interface.

5.5.3 Interfaces Images, Object and Actions

5.5.3.1 Admin Interfaces

Profile/Sign Up Interface

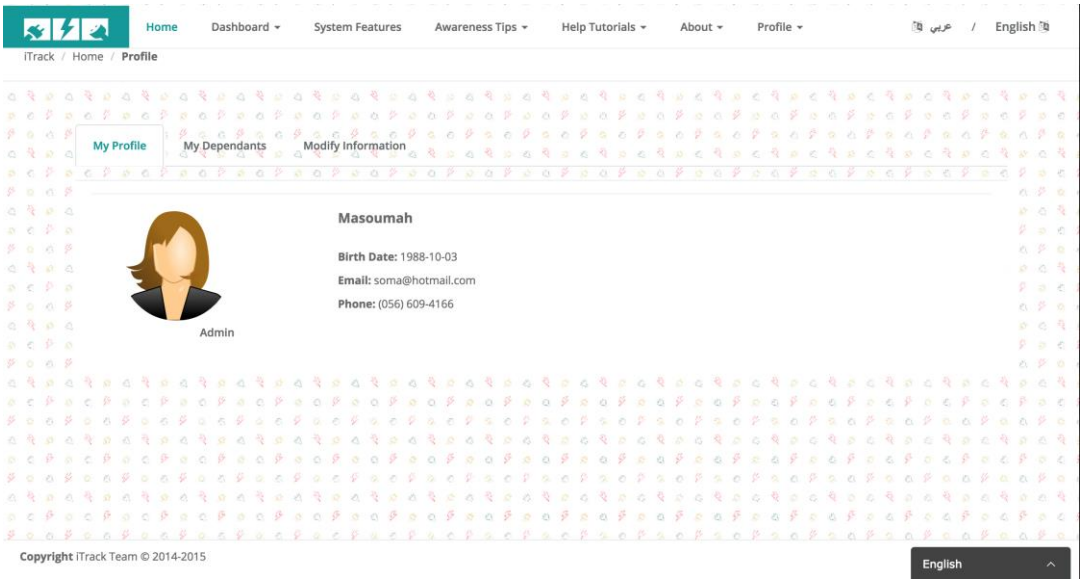
Table 39: Sign Up Interface Specifications

Screen	 *Figure 27: Sign Up Interface.*
Purpose	Enables the user to create a new account.
Screen Object	**Actions**
Sign Up (Tab)	Displays to the user the information that is necessary to enter.
Profile Picture (Button)	Requires the user to choose his/her profile picture.
Full Name (Text field)	Requires the user to enter his/her full name.
Birth Date (Text field)	Requires the user to enter his/her birth date.
Phone Number (Text field)	Requires the user to enter his/her Phone number.
Email (Text field)	Requires the user to enter his/her email.
Password (Text field-password)	Requires the user to enter password.
Password (Text field-password)	Requires the user to re-enter the password.
Verification code (Image)	A Captcha code that determines the user is human or not.

Enter the code (Text field)	Requires the user to enter the shown code.
Cancel (Button)	Enables the user to cancel signing up process.
Submit (Button)	Checking the previous fields if they are empty or they have incorrect input. It will display an error message; else it will save the user information.

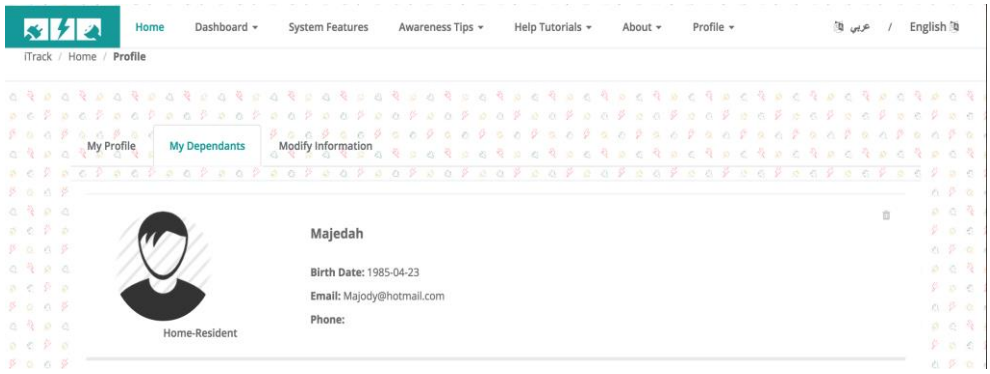
Profile/My Profile Interface

Table 40: My Profile Specifications.

Screen	 *Figure 28: My Profile Interface.*
Purpose	Enables the user to view his/her profile information.
Screen Object	**Actions**
Profile picture (div)	View the user his/her profile picture.
User information (paragraph)	Show the user his/her profile information.

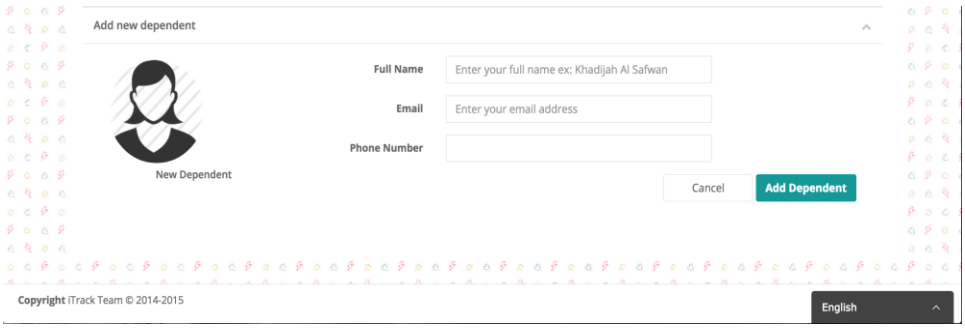
Profile/ My Dependents Interface

Table 41: My Dependent Specifications.

Screen	 *Figure 29: My Dependents Interface.*
Purpose	Enables the user to view his/her dependents.
Screen Object	**Actions**
Profile picture (div)	View the user his/her dependent profile picture.
User information (paragraph)	Show the user his/her dependent profile information.
Trash icon	Enables the user to delete his/her dependent.

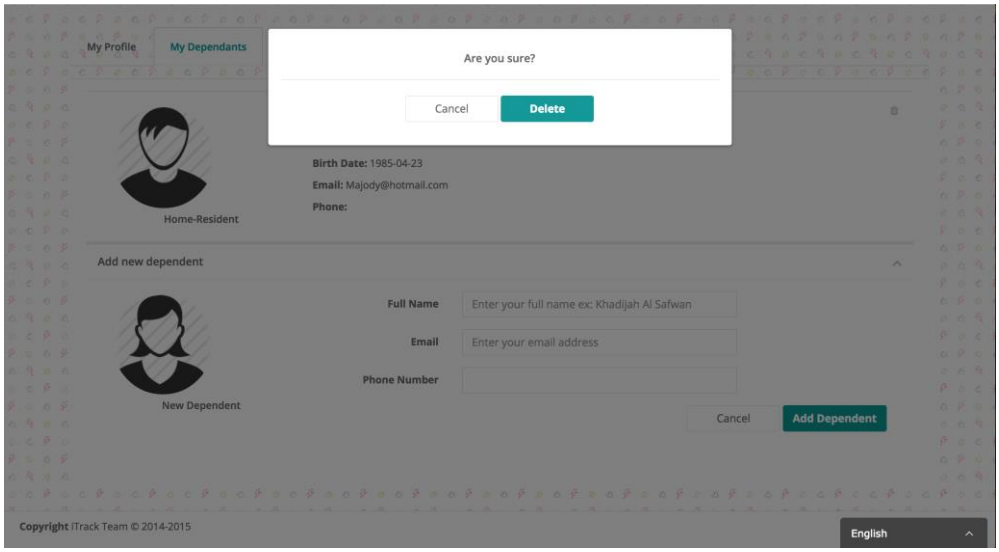
Profile/ Add New Dependent Interface

Table 42: Add New Dependent Specifications.

Screen	 *Figure 30: Add New Dependent Interface.*
Purpose	Enables the user to add new dependent.
Screen Object	**Actions**
Up Arrow	Enables the user to hide add new dependent area.
Profile picture (div)	View the user the default picture of his/her dependent.
Full Name (Text field)	Requires the user to enter dependent's full name.
Email (Text field)	Requires the user to enter dependent's email.
Phone Number (Text field)	Requires the user to enter dependent's Phone number.
Cancel (Button)	Enables the user to cancel adding new dependent process.
Add dependent (Button)	Enables the user to Add his/her dependent.

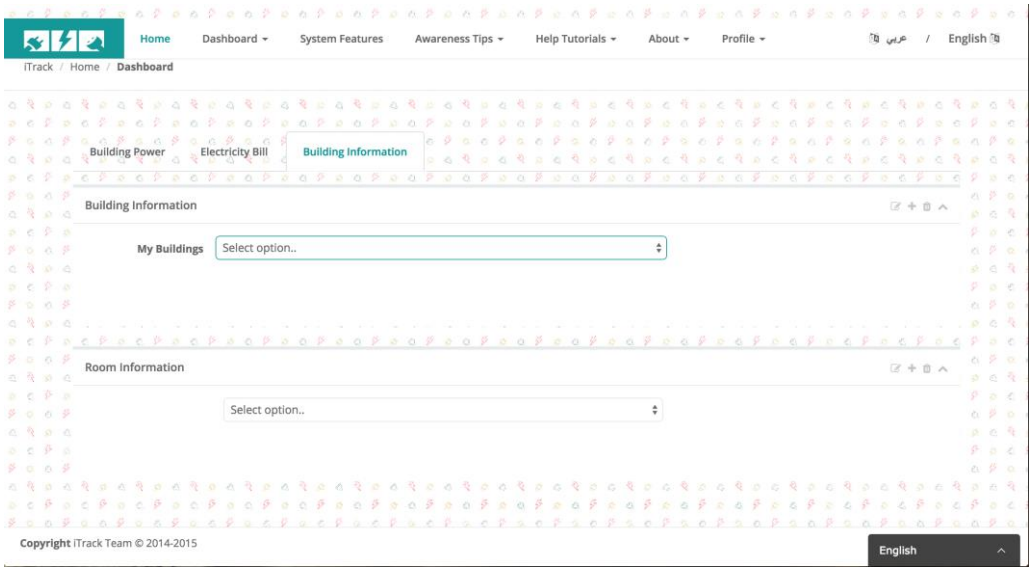
Profile/ Delete Dependents Interface

Table 43: Delete Dependent Specifications.

Screen	 *Figure 31: Delete My Dependent Interface.*
Purpose	Enables the user to delete his/her dependents.
Screen Object	**Actions**
Confirmation message (paragraph)	Display a confirmation message to the user.
Cancel (Button)	Enables the user to cancel deleting his/her dependent process.
Delete (Button)	Enables the user to delete his/her dependent.

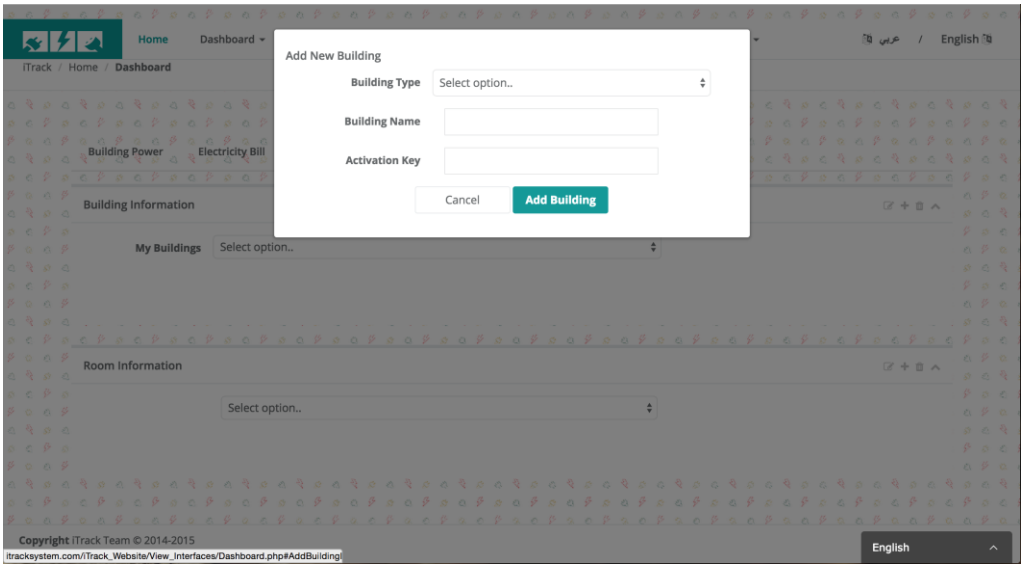
Dashboard/ Building/Room Information Interface

Table 44: Building/Room Information Specification.

Screen	 *Figure 32: Building/Room Information Interface.*
Purpose	Enables the user to view his/her building information.
Screen Object	**Actions**
My Building (dropdown list)	Requires the user to choose his/her building.
Room Information (dropdown list)	Requires the user to choose his/her room.
Edit icon	Enables the user to edit his/her building/room.
Plus icon	Enables the user to add new his/her building/room.
Trash icon	Enables the user to delete his/her building/ room.
Up Arrow	Enables the user to hide building/room information area.

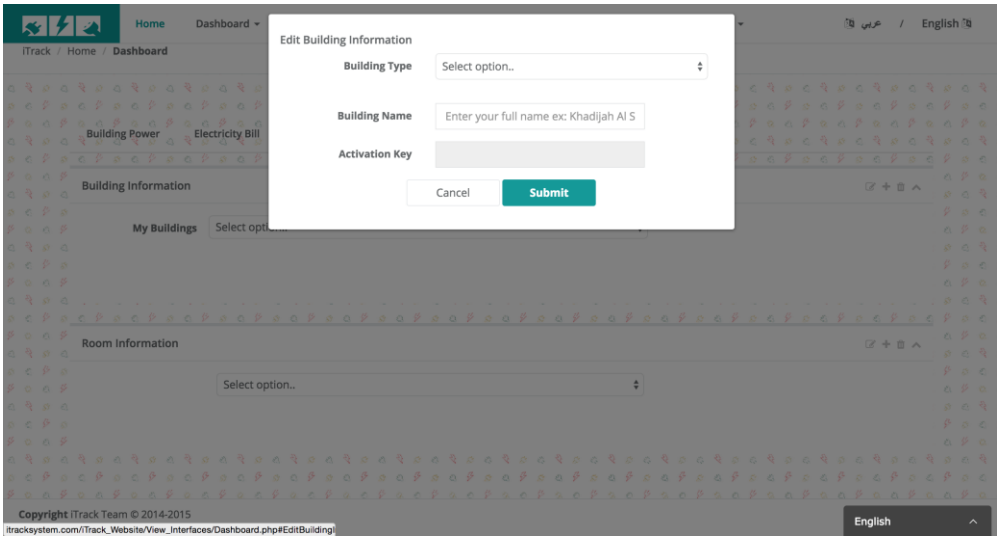
Dashboard/ Add New Building Interface

Table 45: Add New Building Specifications.

Screen	 *Figure 33: Add New Building Interface.*
Purpose	Enables the user to add new building.
Screen Object	**Actions**
Building Type (Drop down list)	Requires the user to choose his/her building type to specify consumption value.
Building Name (Text Field)	Requires the user to enter his/her building name.
Activation Key (Text Field)	Requires the user to enter his/her activation key.
Cancel (Button)	Enables the user to cancel adding new building process.
Save changes (Button)	Enables the user to save his/her changes.

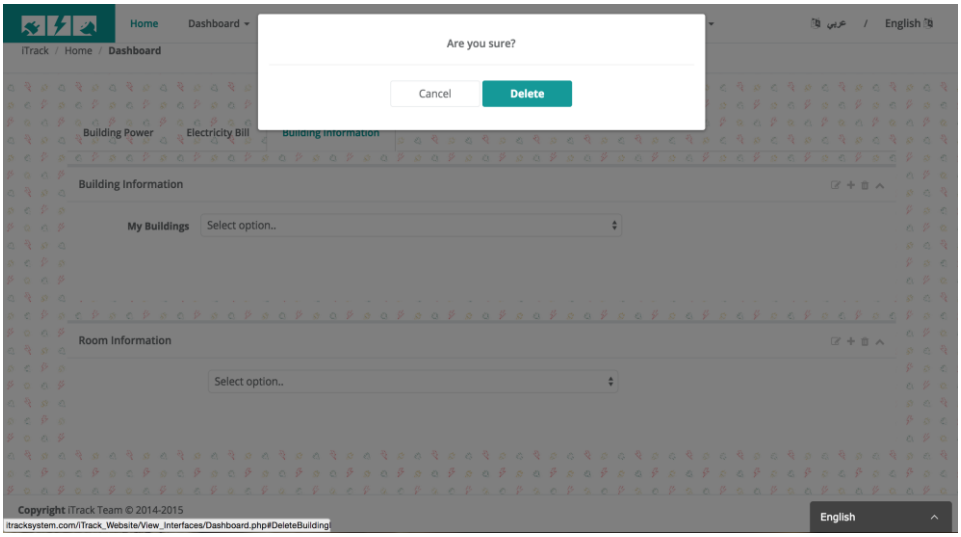
Dashboard/ Edit Building Information Interface

Table 46: Edit Building Information Specifications.

Screen	 *Figure 34: Edit Building Information Interface.*
Purpose	Enables the user to edit his/her building information.
Screen Object	**Actions**
Building Type (Drop down list)	Enables the user to edit his/her building type.
Building Name (Text Field)	Enables the user to edit his/her building name.
Activation Key (Text Field)	Show the user his/her activation key.
Cancel (Button)	Enables the user to cancel editing building information process.
Submit (Button)	Enables the user to save his/her changes.

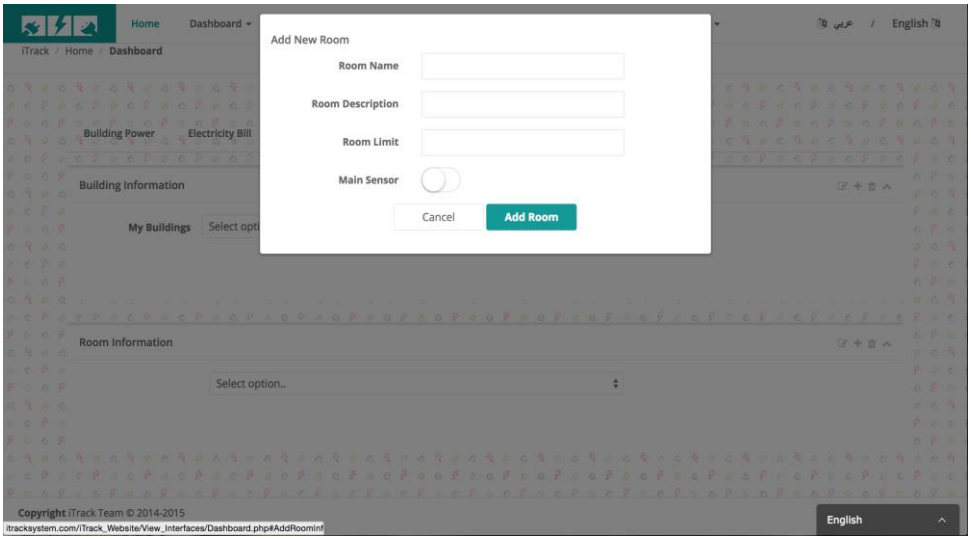
Dashboard/ Delete Building Information Interface

Table 47: Delete Building Information Specification.

Screen	 *Figure 35: Delete Building Information Interface.*
Purpose	Enables the user to delete his/her building.
Screen Object	**Actions**
Cancel (Button)	Enables the user to cancel deleting building information.
Delete (Button)	Enables the user to delete his/her building.

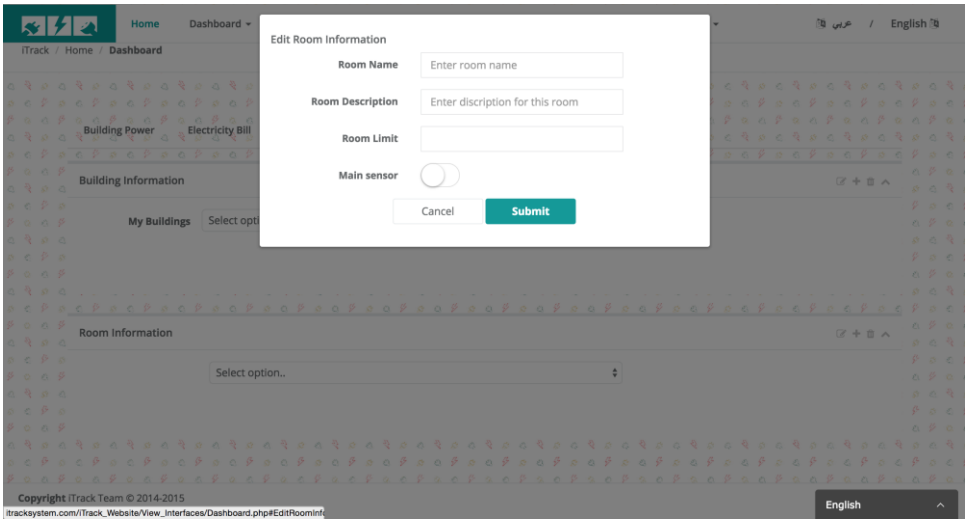
Dashboard/ Add New Room Interface

Table 48: Add New Room Specifications.

Screen	 *Figure 36: Add New Room Interface.*
Purpose	Enables the user to add new room in his/her building.
Screen Object	**Actions**
Room Name (Text Field)	Requires the user to enter his/her room name.
Room Description (Text Field)	Requires the user to enter his/her room description.
Room Limit (Text Field)	Requires the user to specify room's limit.
Main Sensor (Checkbox)	Requires the user to specify if this room has the main sensor or not.
Cancel (Button)	Enables the user to cancel adding room process.
Add Room (Button)	Enables the user to complete adding room process.

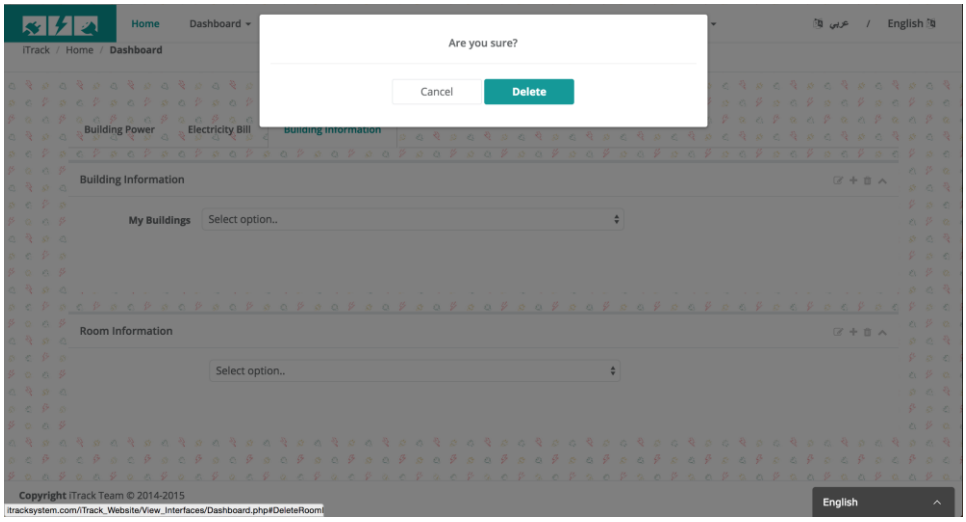
Dashboard/ Edit Room Information Interface

Table 49: Edit Room Information Specifications.

Screen	 *Figure 37: Edit Room Information Interface.*
Purpose	Enables the user to edit room information.
Screen Object	**Actions**
Room Name (Text Field)	Enables the user to edit room's name.
Room Description (Text Field)	Enables the user to edit room's description.
Room Limit (Text Field)	Enables the user to edit room's limit.
Main Sensor (Checkbox)	Enables the user to edit the status of the room's sensor.
Cancel (Button)	Enables the user to cancel editing room information process.
Submit (Button)	Enables the user to complete editing room information process.

Dashboard/ Delete Room Interface

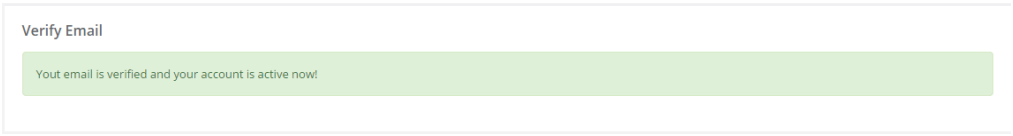
Table 50: Delete Room Specifications.

Screen	 *Figure 38: Delete Room Interface.*
Purpose	Enables the user to delete room.
Screen Object	**Actions**
Cancel (Button)	Enables the user to cancel deleting room process.
Submit (Button)	Enables the user to complete deleting room process.

5.5.3.2 Admin & Home Resident Interfaces

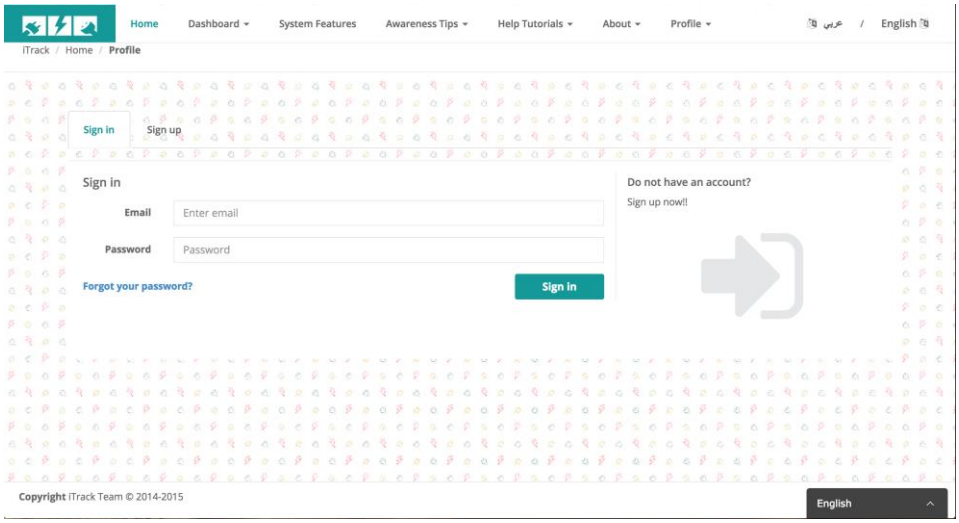
Profile/ Verify Email Interface

Table 51: Verify Email Specifications.

Screen	 *Figure 39: Verify Email Interface.*
Purpose	Notify the user if his/her account has been verify or not.
Screen Object	**Actions**
Confirmation message (div)	Show the confirmation message of verifying email.

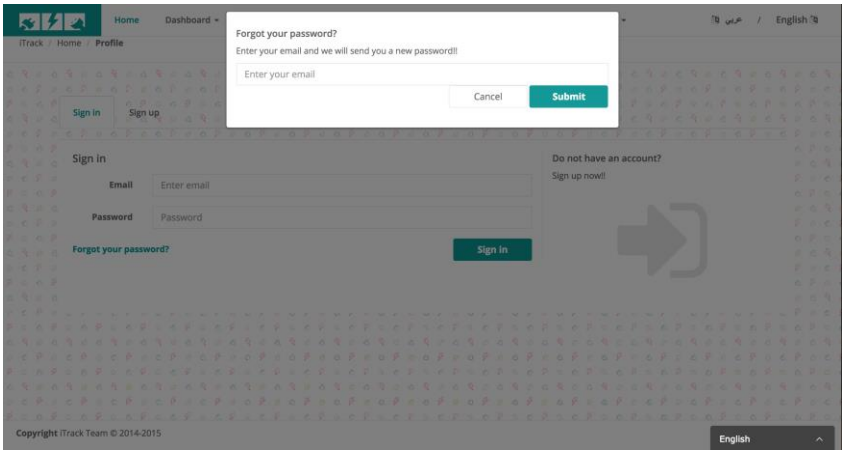
Profile/ Sign in Interface

Table 52: Sign In Specifications.

Screen	 *Figure 40: Sign in Interface.*
Purpose	Enables the user to sign in to the system.
Screen Object	**Actions**
Sign in (Tab)	Displays to the user the information that is necessary to enter.
Email (Text field)	Requires the user to enter his/her email.
Password (Text field-password)	Requires the user to enter his/her password.
Sign in (Button)	Checking the previous fields if they are empty or they have incorrect input it will displays an error message, else it will lead user to enter to the system.
Forget Password (Link)	Enables the user to request new password in case he/she forget his/her password.
Sign Up (Link)	Redirect the user to the sign up tab.

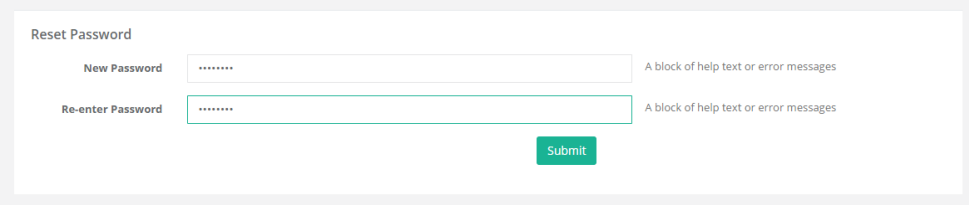
Profile/ Forget Password

Table 53: Forget Password Specifications.

Screen	 *Figure 41: Forget Password Interface.*
Purpose	Enables the user to change his/her password in case he/she forgot it.
Screen Object	**Actions**
E-mail (Text field)	Requires the user to enter his/her e-mail.
Cancel (Button)	Enables the user to cancel forgetting e-mail process.
Submit (Button)	Enables the user to complete forgetting e-mail process.

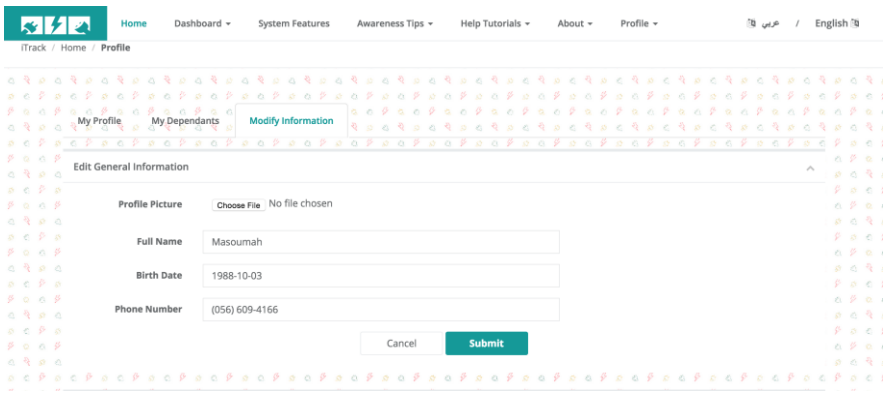
Profile/ Reset Password

Table 54: Reset Password Specifications.

Screen	 *Figure 42: Reset Password Interface.*
Purpose	Enables the user to reset his/her password.
Screen Object	**Actions**
New Password (Text field-password)	Requires the user to enter his/her new password.
Re-Enter Password (Text field-password)	Requires the user to re-enter his/her new password.
Submit (Button)	Enables the user to complete reset password process.

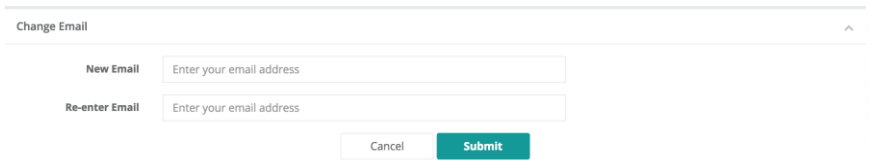
Profile/ Edit General Information

Table 55: Edit General Information Specifications.

Screen	 *Figure 43: Edit General Information Interface.*
Purpose	Enables the user to edit his/her general information.
Screen Object	**Actions**
Profile Picture (Button)	Enables the user to edit his/her profile picture.
Full Name (Text field)	Enables the user to edit his/her full name.
Birth Date (Text field)	Enables the user to edit his/her birth date.
Phone Number (Text field)	Enables the user to edit his/her Phone number.
Cancel (Button)	Enables the user to cancel editing process.
Submit (Button)	Checking the previous fields if they are empty or they have incorrect input. It will display an error message; else it will save the user information.

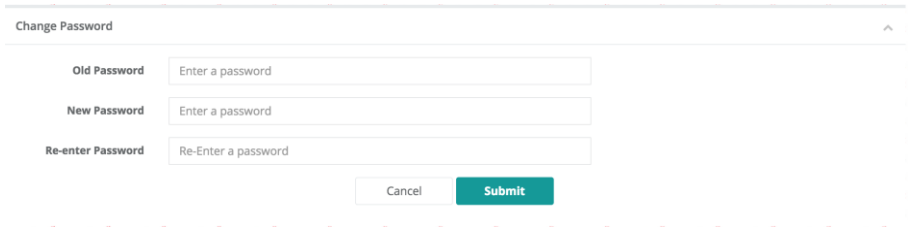
Profile/ Change Email

Table 56: Change Email Specifications.

Screen	 *Figure 44: Change Email Interface*
Purpose	Enables the user to change his/her e-mail.
Screen Object	**Actions**
New E-mail (Text field)	Requires the user to enter his/her new e-mail.
Re-Enter Email (Text field)	Requires the user to re-enter his/her new e-mail.
Cancel (Button)	Enables the user to cancel changing password process.
Submit (Button)	Enables the user to save his/her changes.

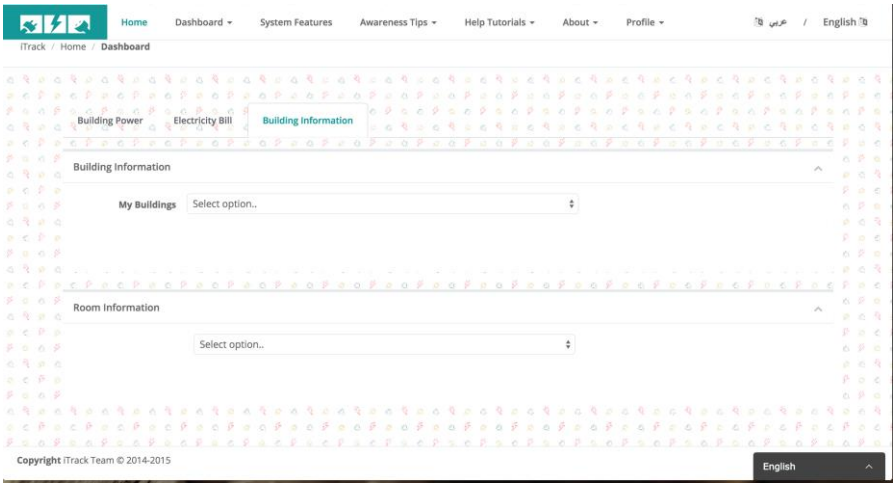
Profile/ Change Password

Table 57: Change Password Specifications.

Screen	 *Figure 45: change Password Interface.*
Purpose	Enables the user to change his/her password.
Screen Object	**Actions**
Old Password (Text field- password)	Requires the user to enter his/her old password.
New Password (Text field- password)	Requires the user to enter his/her new password.
Re-Enter Password (Text field- password)	Requires the user to re-enter his/her new password.
Cancel (Button)	Enables the user to cancel changing password process.
Submit (Button)	Enables the user to save his/her changes.

Dashboard/Building information

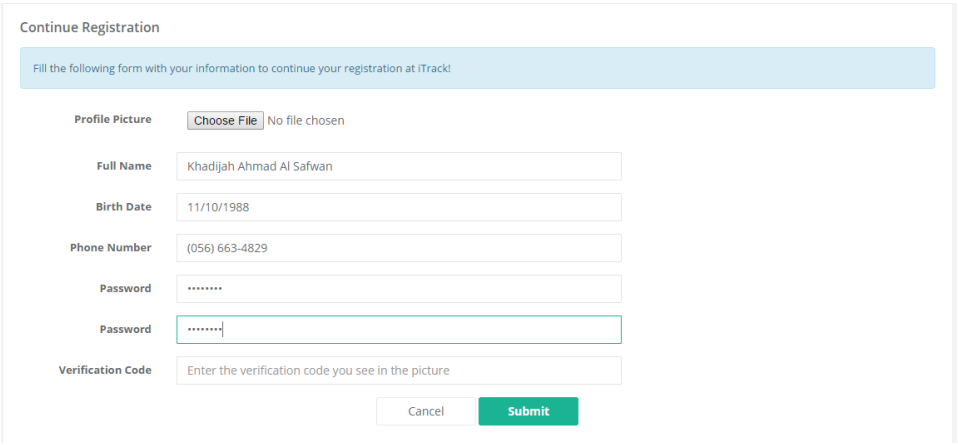
Table 58: Building Information Specifications

Screen	 *Figure 46: Building Information Interface.*
Purpose	Enables user to see the information of his/her building and room.
Screen Object	**Actions**
My Building (Drop down list)	Enables the user to specify his/her building name to see the information associated with the chosen building.
Room (Drop down list)	Enables the user to specify his/her room name to see the information associated with the chosen room.
Building/room information (paragraph)	Show the building/ room information for the selected one.
Up Arrow	Enables the user to hide his/her building/ room information.

5.5.3.3 Home Resident Interface

Profile/ Continue Registration Interface

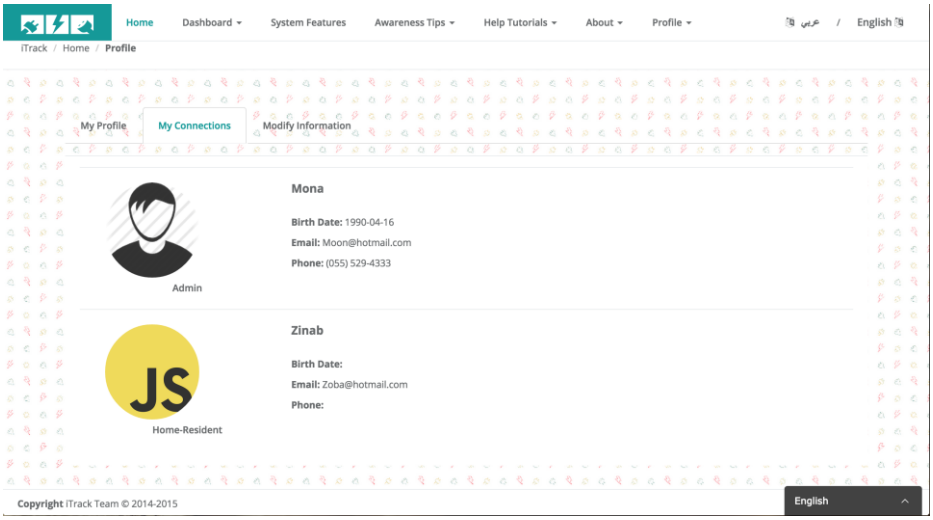
Table 59: Continue Registration Specifications.

Screen	 *Figure 47: Continue Registration Interface.*
Purpose	Enables the use to continue his/her registration.
Screen Object	**Actions**
Profile Picture (Button)	Requires the user to choose his/her profile picture.
Full Name (Text field)	Requires the user to enter his/her full name.
Birth Date (Text field)	Requires the user to enter his/her birth date.
Phone Number (Text field)	Requires the user to enter his/her Phone number.
Password (Text field-password)	Requires the user to enter password.
Password (Text field-password)	Requires the user to re-enter the password.
Verification code (Image)	A Captcha code that determines the user is human or not.
Enter the code (Text field)	Requires the user to enter the shown code.
Cancel	Enables the user to cancel signing up process.

(Button)	
Submit (Button)	Checking the previous fields if they are empty or they have incorrect input. It will display an error message; else it will save the user information.

Profile/ My Connections Interface

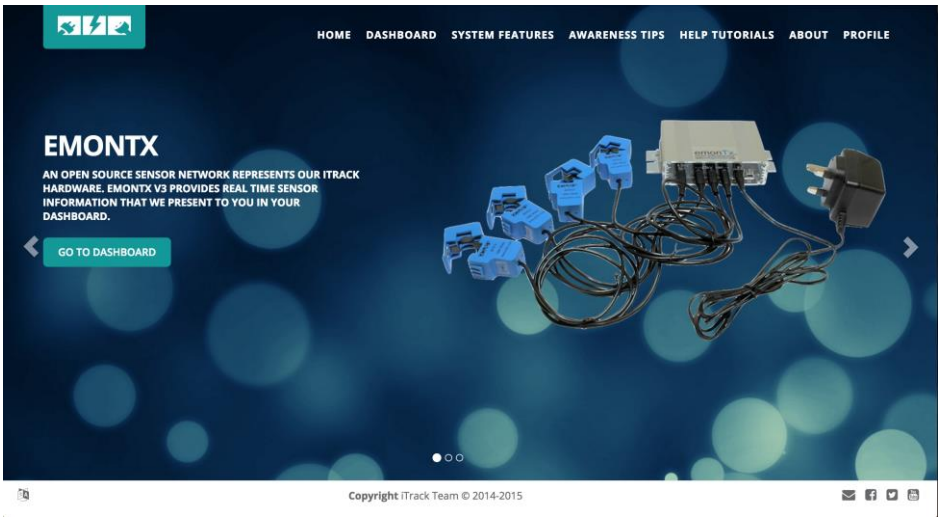
Table 60: My Connections Specifications.

Screen	 *Figure 48: My Connections Interface.*
Purpose	Enables the user to view his/her dependents.
Screen Object	**Actions**
Profile picture (div)	View the user his/her dependent profile picture.
User information (paragraph)	Show the user his/her dependent profile information.
Trash icon	Enables the user to delete his/her dependent.

5.5.3.4 Home Resident & Admin &Guest Interfaces

Home Interface

Table 61: Home Specifications.

Scree	 *Figure 49: Home Interface.*
Purpose	Entrance gate of iTrack that have links to all system interfaces.
Screen Object	**Actions**
Logo	Enable the user to go to the home page from any page.
Dashboard (Tab)	Enables the user to go to the dashboard interface.
System Features (Tab)	Enables the user to go to the system features interface.
Awareness Tips (Tab)	Enables the user to go to the awareness tips interface.
Help tutorials (Tab)	Enables the user to go to the help tutorial interface.
About (Tab)	Enables the user to go to the about interface.
Profile (Tab)	Enables the user to go to the profile interface.
Advertisement area.	Show some advertisement to the user.

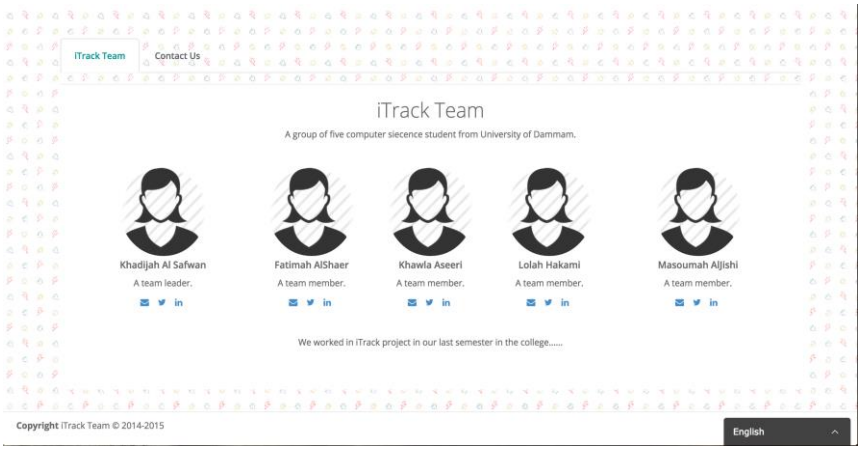
Help Tutorial

Table 62: Help Tutorial Specifications.

Screen	 *Figure 50: Help Tutorial Interface.*
Purpose	Guide the user how to use the system.
Screen Object	**Actions**
Get Started (Tab)	Provides to the user videos of how to start using the system.
Dashboard Tutorials (Tab)	Provides to the user videos of how to use the dashboard of the system.
Profile Tutorials (Tab)	Provides to the user videos of how manage his/her profile.

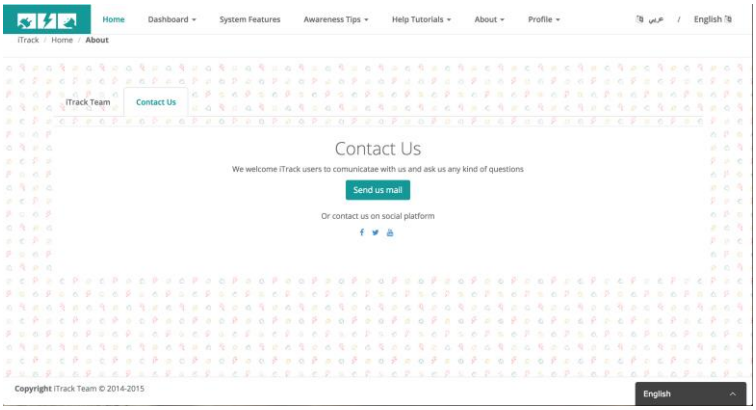
About/iTrack Team

Table 63: iTrack Team Specifications.

Screen	 *Figure 51: iTrack Team Interface.*
Purpose	Provide the iTrack team members information to the user.
Screen Object	**Actions**
ITrack Team (Tab)	Displays the development tram's contact information.

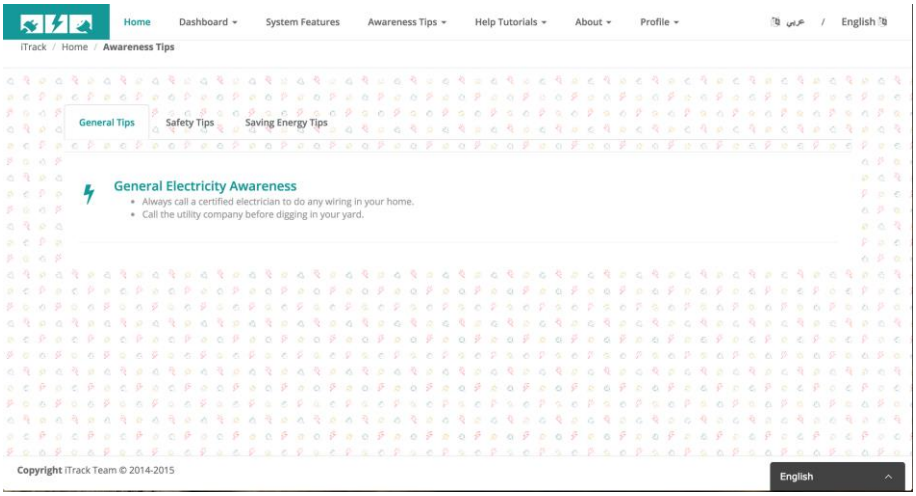
About/ Contact us

Table 64: Contact Us Specifications.

Screen	 *Figure 52: Contact Us Interface.*
Purpose	Enables the user to send email to iTrack website.
Screen Object	**Actions**
Contact Us (Tab)	Displays the iTrack contact information.
Send us mail (Button)	Enables the user to send an e-mail to iTrack.

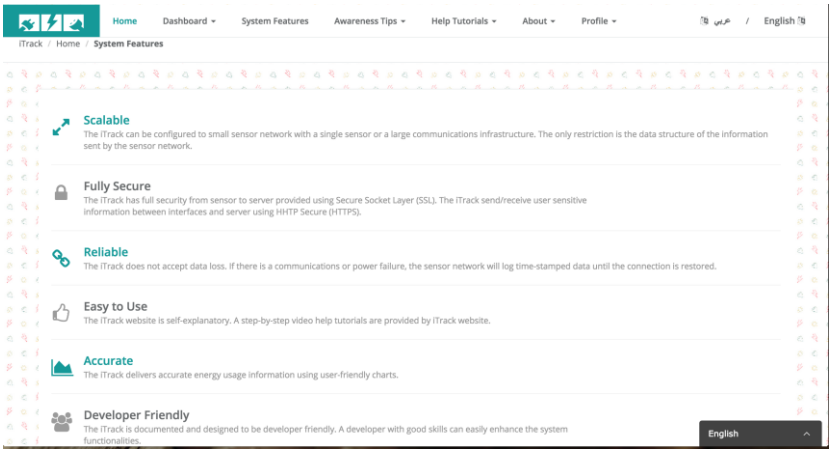
Awareness Tips

Table 65: Awareness Tips Specifications.

Screen	 *Figure 53: Awareness Tips Interface.*
Purpose	Give the user some devices to increase his/her awareness.
Screen Object	**Actions**
General Tips (Tab)	Displays General tips to the user.
Safety Tips (Tab)	Displays Safety tips to the user.
Saving Energy Tips (Tab)	Displays saving energy tips to the user.

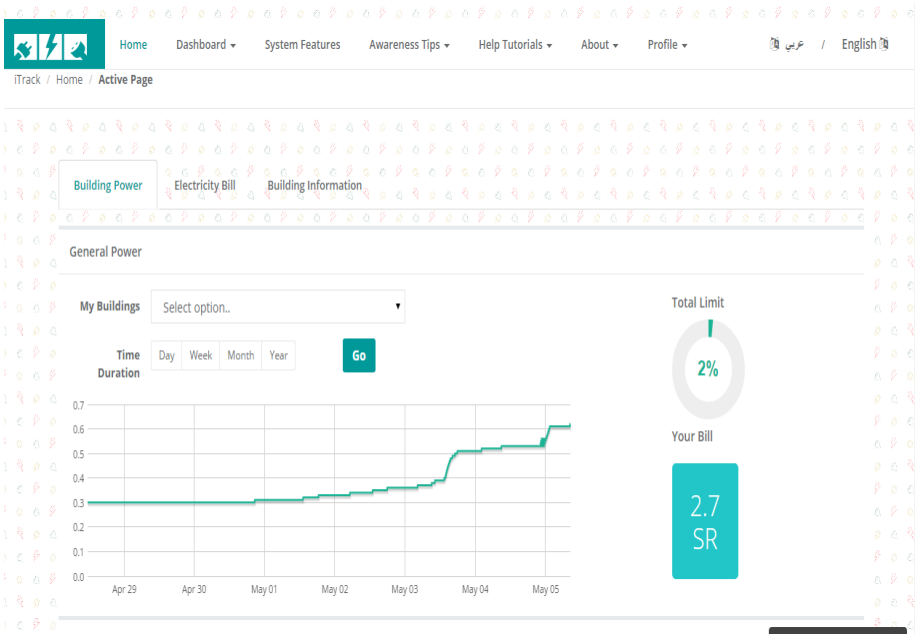
System Features

Table 66: System Features Specifications.

Screen	 *Figure 54: System Features Interface.*
Purpose	Enables the user to know about ITrack system features.
Screen Object	**Actions**
System features (Tab)	Displays to the user the information of the system features.

Dashboard/Building Power (General Power)

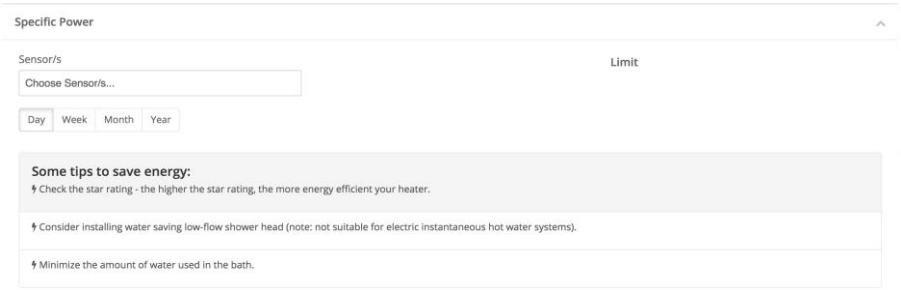
Table 67: Building Power (General Power) Specifications

Screen	 *Figure 55: Building Power (General Power) Interface.*
Purpose	Enables the user to see the power consumption of his/her building.
Screen Object	**Actions**
My Building (Drop down list)	Enables the user to choose his/her building.
Time Duration (Radio button)	Enables the user to specify the time duration for displaying the consumption in the graph.
Go (button)	Show the user his/her consumption in the graph and the consumed limit, and calculate the user bill.
Graph	Displaying the user's consumption habit based on selected building and the specified time duration.
Total Limit (Pointer)	Displays the limit of the building's main sensor according to selected building (Drop down list).
Your Bill	Displays the bill of the building according to selected building (Drop

(Pointer)	down list).

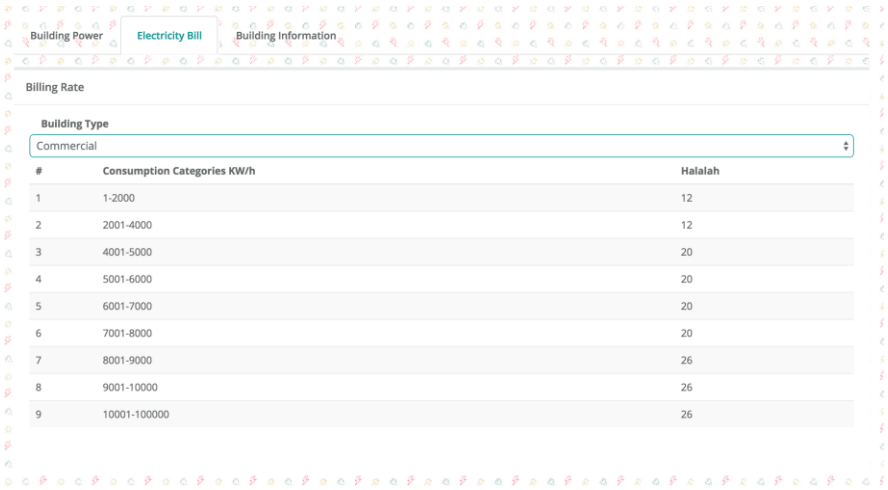
Dashboard/Building Power (Specific Power)

Table 68: Building Power (Specific Power) Specifications.

Screen	 *Figure 56: Building Power (Specific Power) Interface.*
Purpose	Enables the user to see the power consumption of specific sensor.
Screen Object	**Actions**
Sensor/s (Drop down list)	Enables the user to choose sensor/s.
Time Duration (Radio button)	Enables the user to specify the time duration for displaying the consumption in the graph.
Go (button)	Show the user his/her consumption in the graph and the consumed limit, and calculate the user bill.
Graph	Displaying the user's consumption based on selected building and the specified time duration.
Limit (Pointer)	Displays the limit of specific sensor.
Tips (Text Area)	Displays tips to the user according to limit reading.

Dashboard/Electricity Bill

Table 69: Electricity Bill Specifications

Screen	 *Figure 57: Electricity Bill Interface.*
Purpose	Enables user to see the billing rate.
Screen Object	**Actions**
Building Type (Dropdown list)	Enables the user to specify building's type to see the billing rate associated with the chosen building type.
Billing rate table	Show the user the consumption range and the amount of required money for that range according to the selected type.

5.6 Detailed Design

This section is divided to three sub sections. First, design of system component that represents the class diagram of iTrack system. Then, sequence diagram sub-section that shows the sequence of user action in each use case. After that, an interface objects and action section discusses the error messages and confirmation messages of the iTrack system.

5.6.1 Design of System

iTrack software is developed using Model View Controller (MVC) architecture. The view interfaces were described in details on 5.5 User Interface Design. In this section, detailed design of the model and controller is presented. Also, iTrack has three background processes that will be described in this section.

5.6.1.1 Model Classes

The Model classes are used to hold and encapsulate the data coming from iTrack database. The use of model classes eases the access and transfer of objects between pages. The design of the model classes is a match to the database mapping presented on section 5.4.4 Relational Database Schema Figure 58 below show the model classes of iTrack.

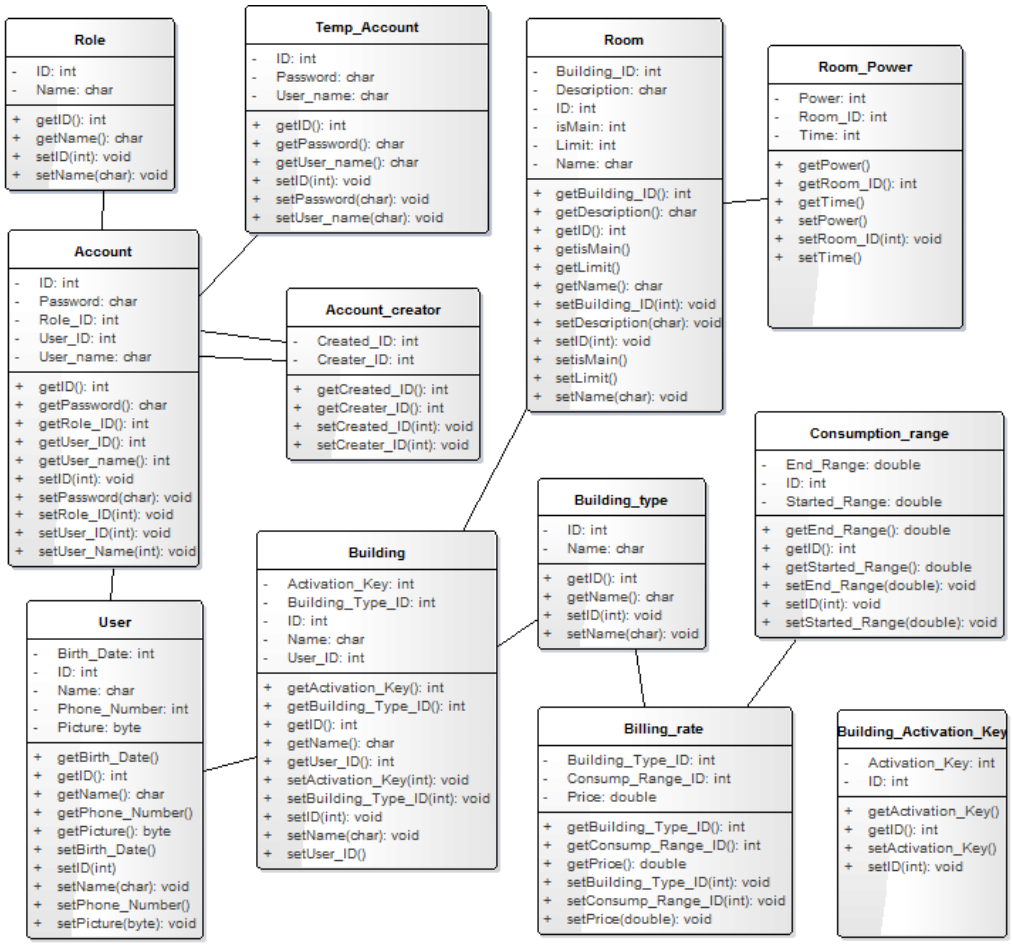


Figure 58: Model Classes Diagram

5.6.1.2 Control Classes

The control classes are the heart of iTrack. They are the place where all the functionalities are implemented. iTrack control classes houses the logic and control the flow of information from/to view interfaces. The following figures show the internal structure of the individual control classes of iTrack.

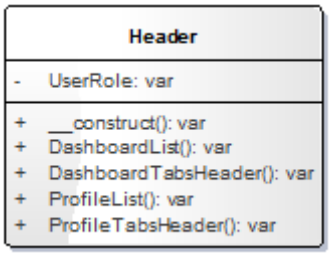


Figure 59: Heder Control Class Diagram

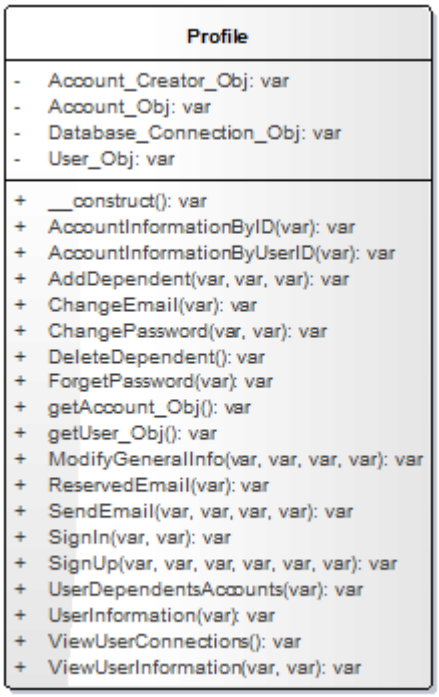


Figure 60: Profile Control Class Diagram

Figure 61: Dashboard Control Class Diagram

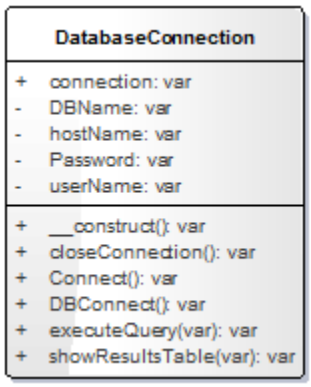


Figure ٦٢ : Database Connection Control Class Diagram

Figure 63: Re-set Password Control Class Diagram

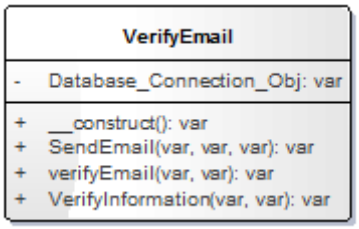


Figure 64: Verify Email Control Class Diagram

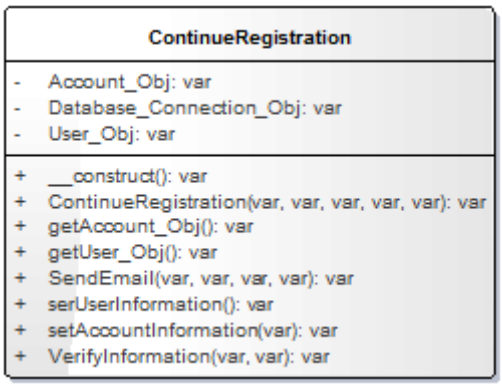


Figure 65: Continue Registration Control Class Diagram

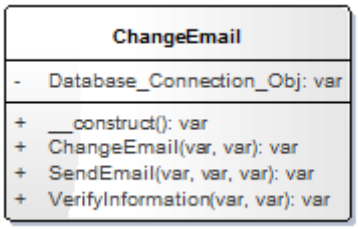


Figure 66: Change Email Control Class Diagram

5.6.2 Sequence Diagrams

5.6.2.1 Validate Verify Input

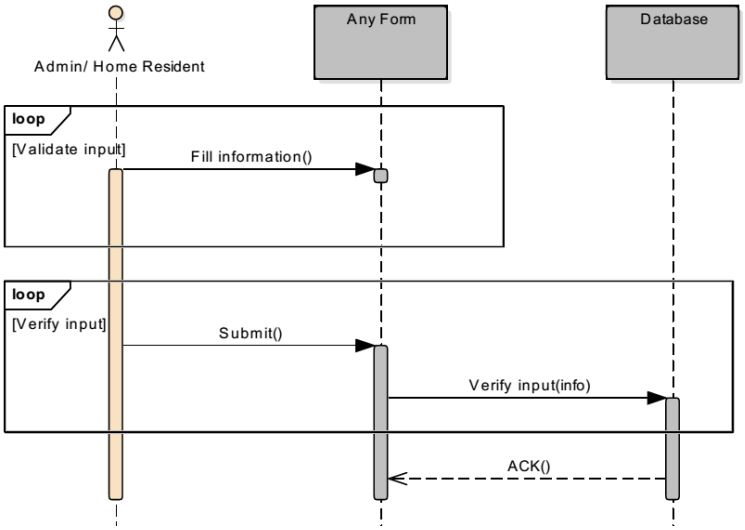


Figure 67: Validate Verify Input sequence diagram.

5.6.2.2 Specify Language

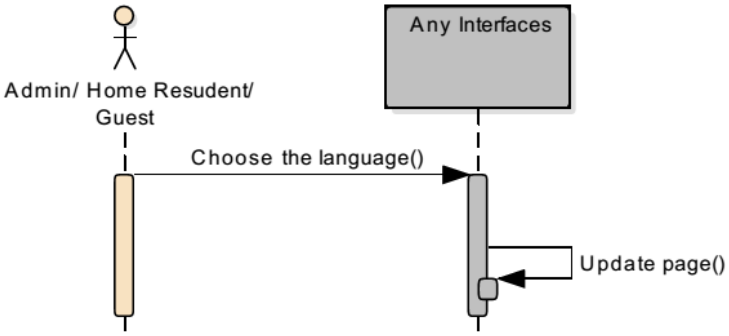


Figure 68: Specify Language Sequence Diagram.

5.6.2.3 Sign Up

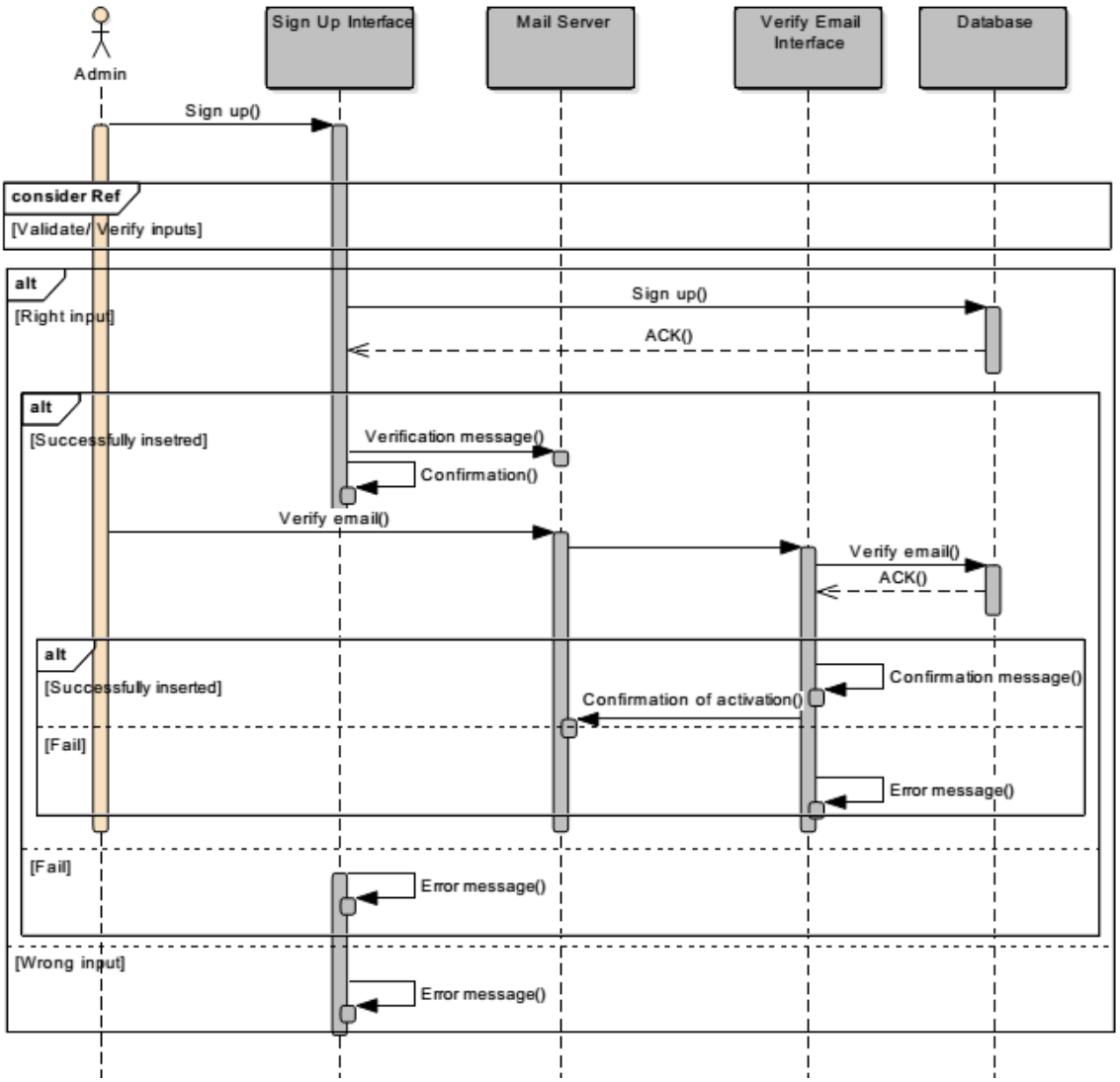


Figure 69: Sign Up Sequence Diagram.

5.6.2.4 Sign In

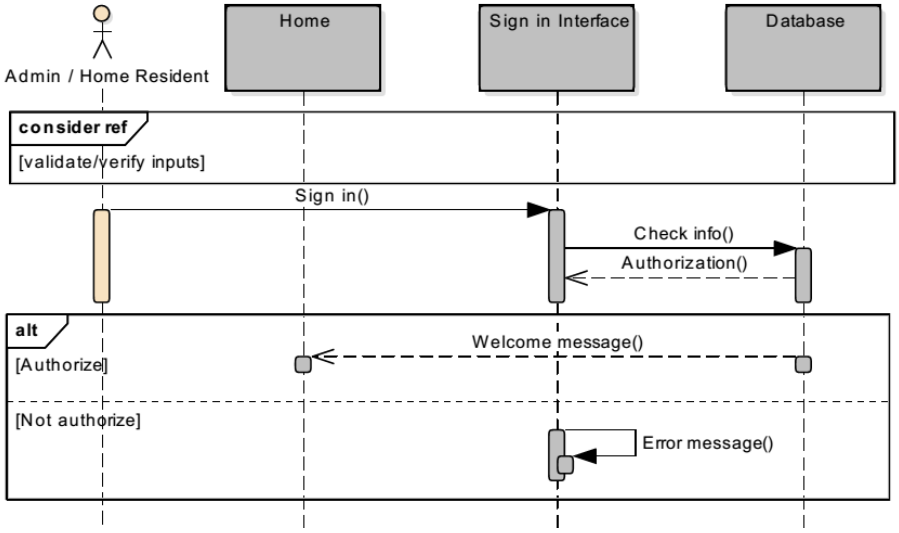


Figure 70: Sign In Sequence Diagram

5.6.2.5 Forget Password

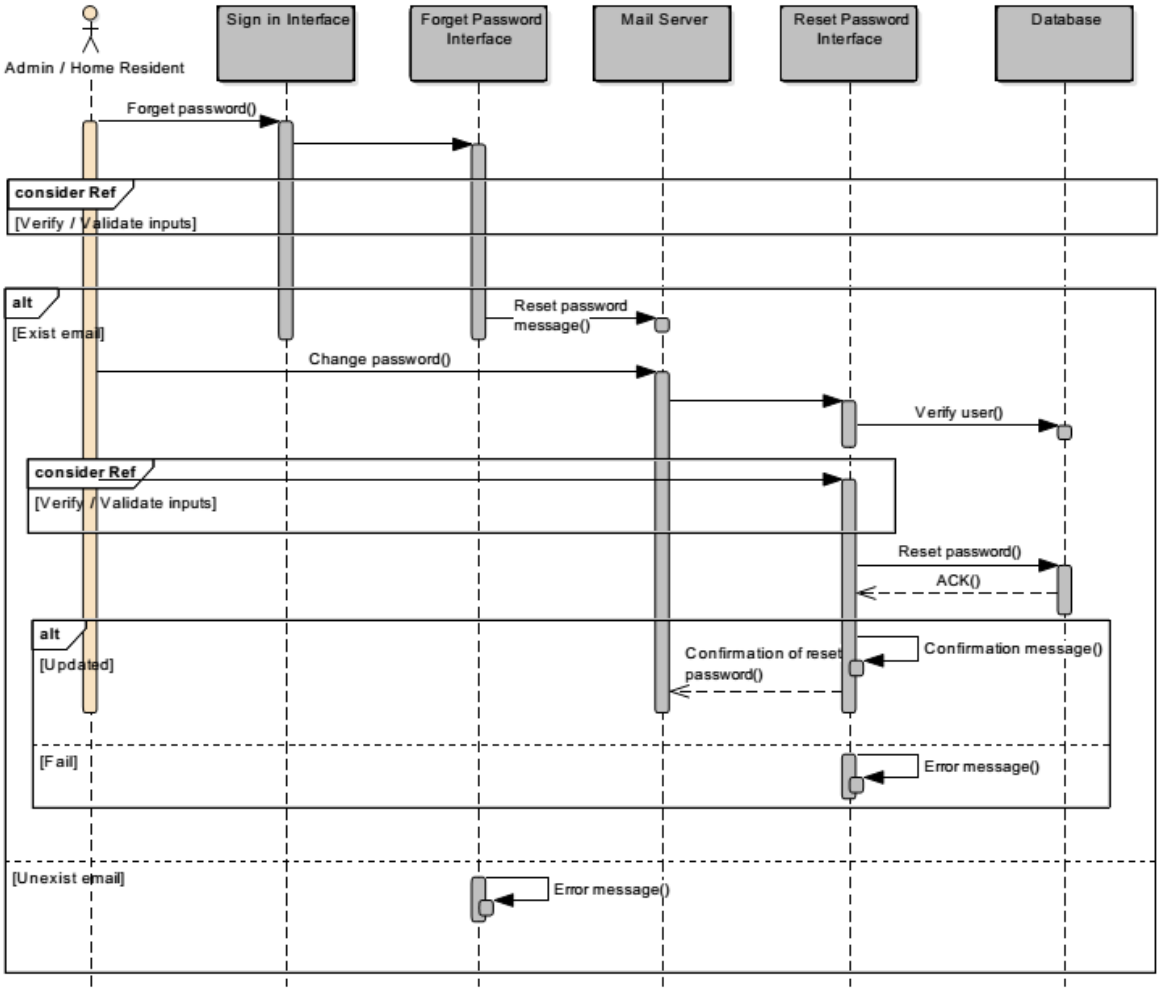


Figure 71: Forget Password Sequence Diagram.

5.6.2.6 View Profile Information

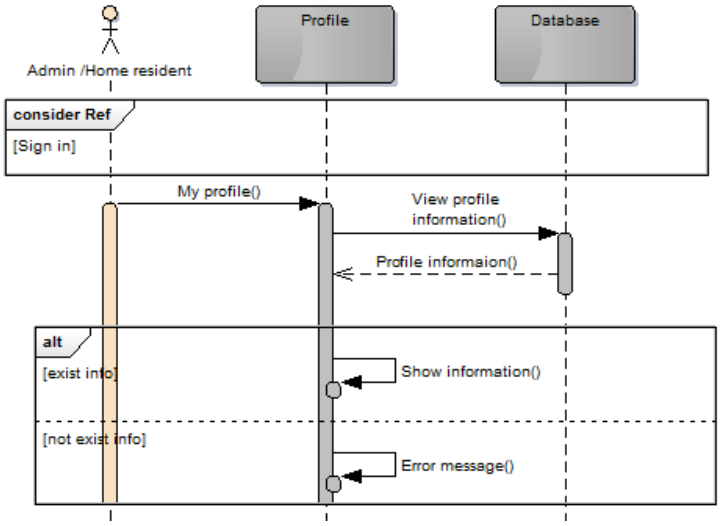


Figure 72: View Profile Information Sequence Diagram.

5.6.2.7 Add New Dependent

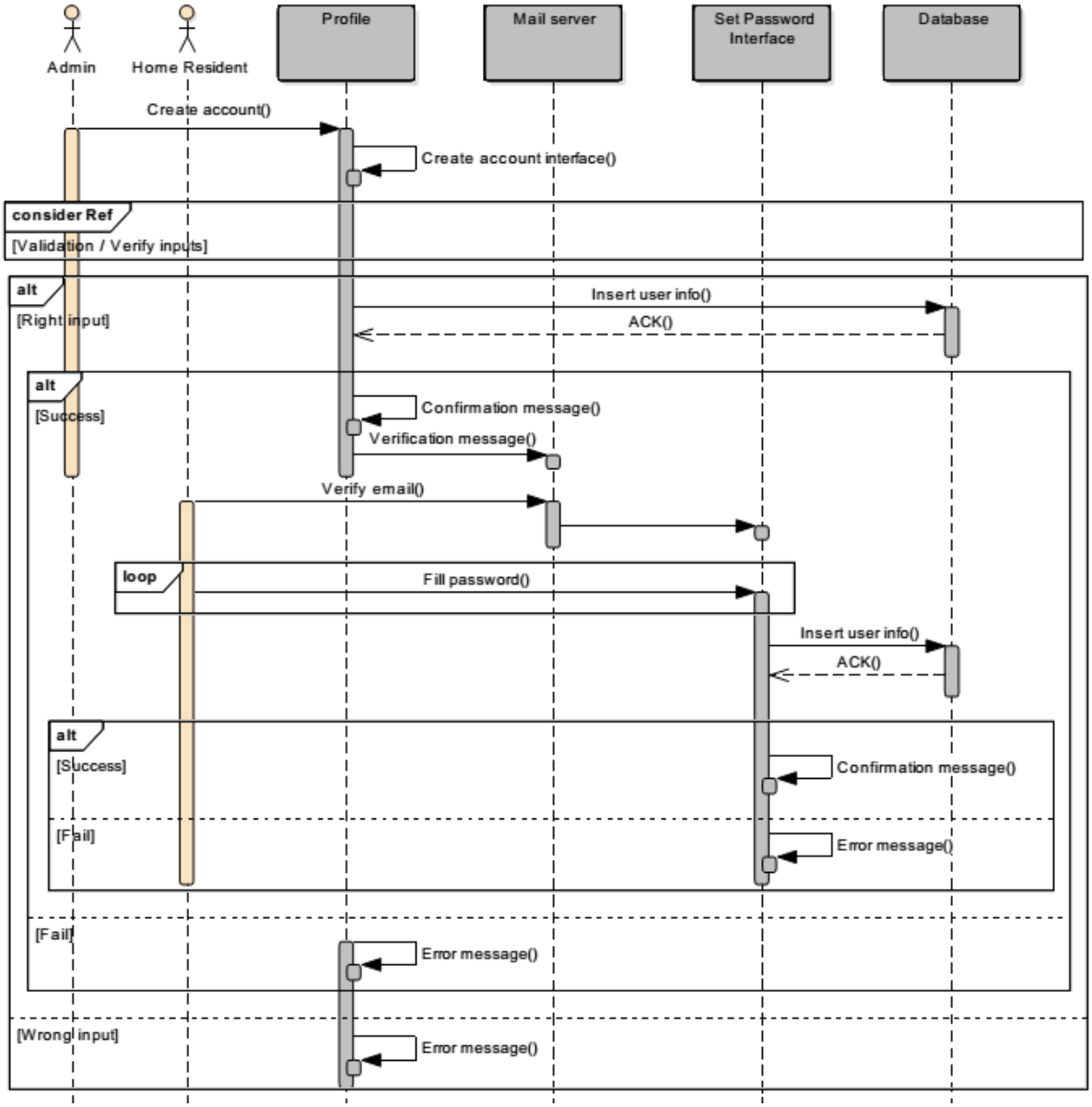


Figure 73: Add New Dependent Sequence Diagram.

5.6.2.8 View/Delete Dependent

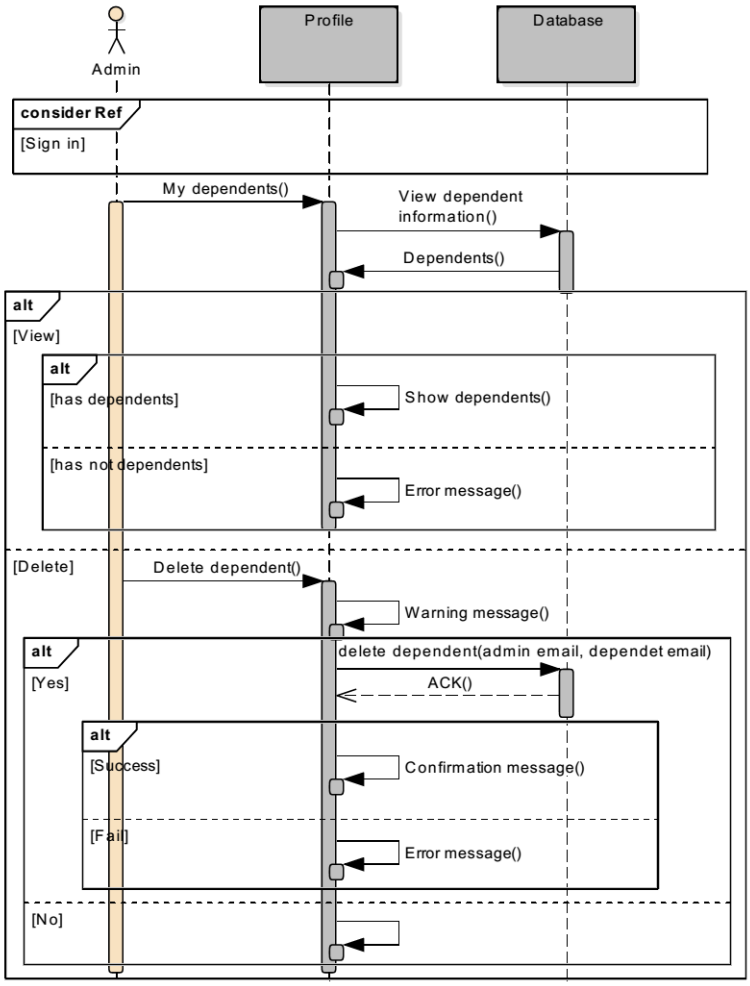


Figure 74: View/Delete Dependent Sequence Diagram.

5.6.2.9 Edit Profile Information

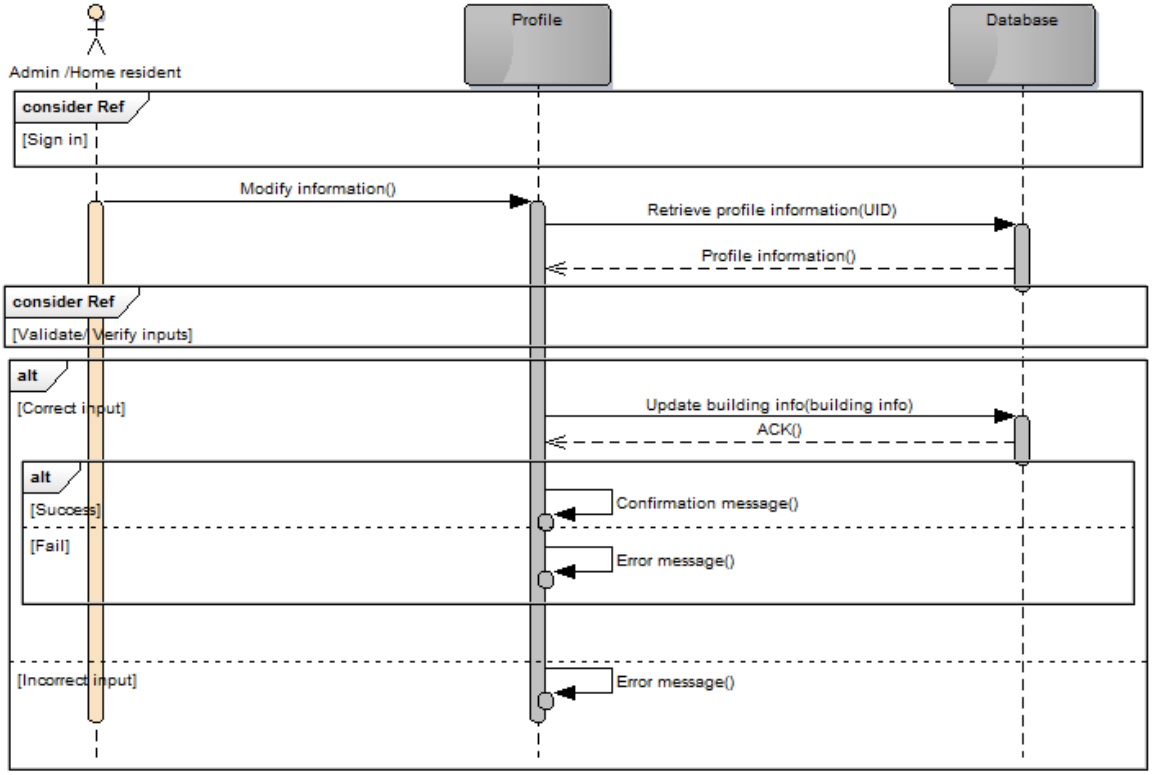


Figure 75: Edit Profile Information Sequence Diagram.

5.6.2.10 Change Email

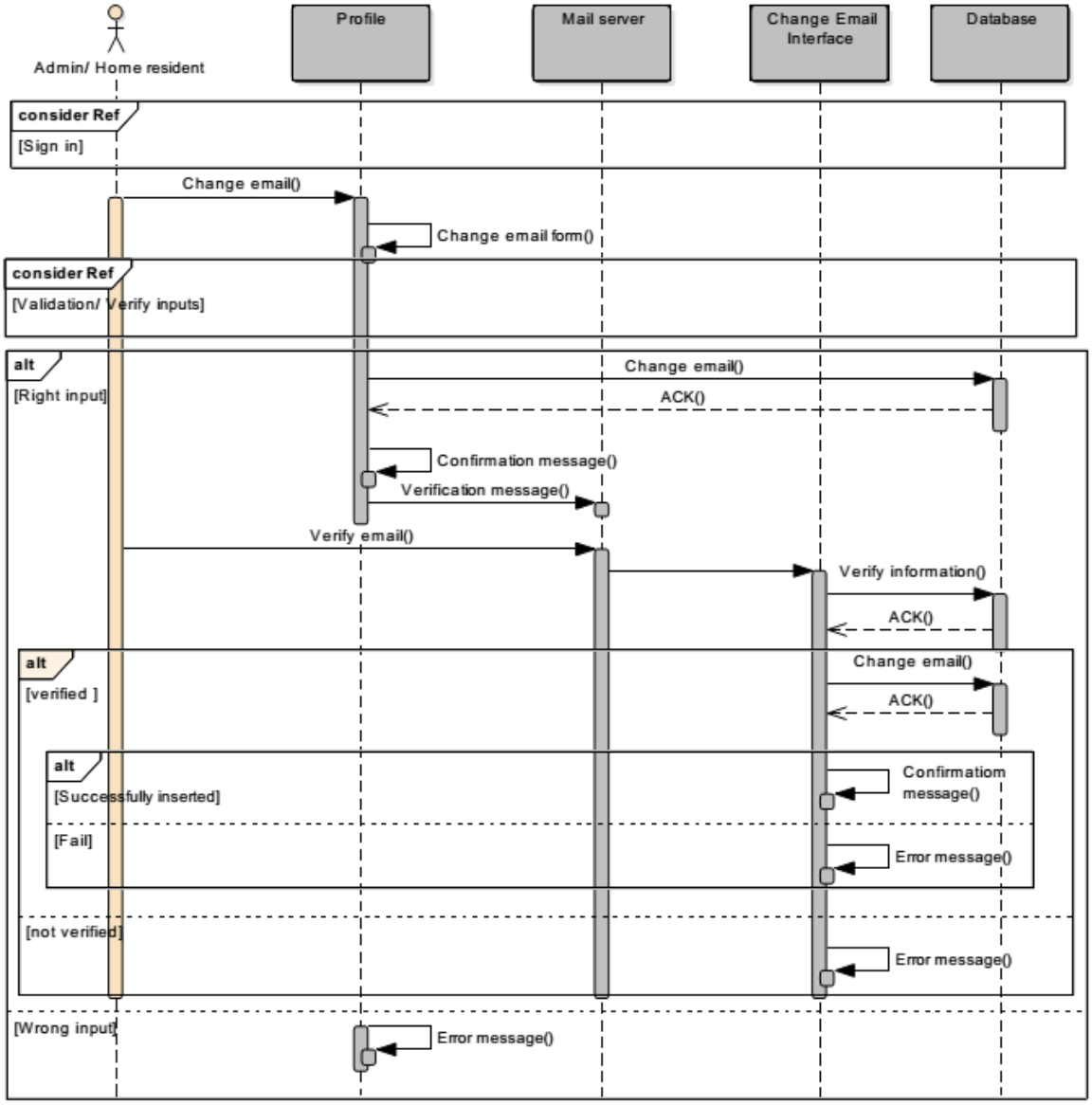


Figure 76: Change Email Sequence Diagram.

5.6.2.11 Change Password

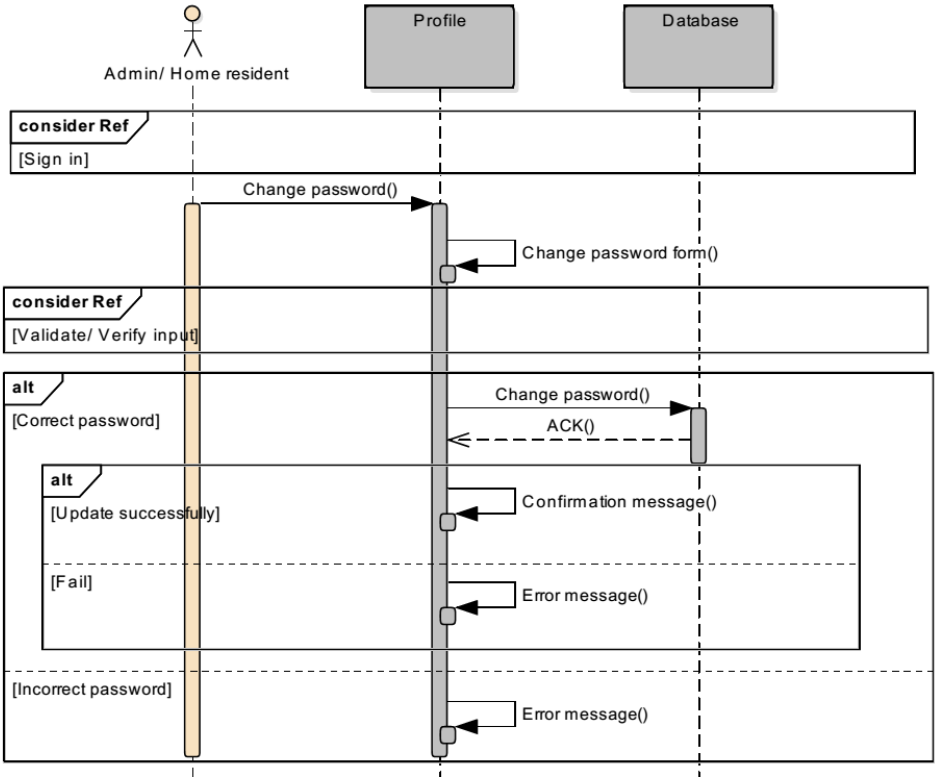


Figure 77: Change Password sequence Diagram.

5.6.2.12 View Help Tutorials

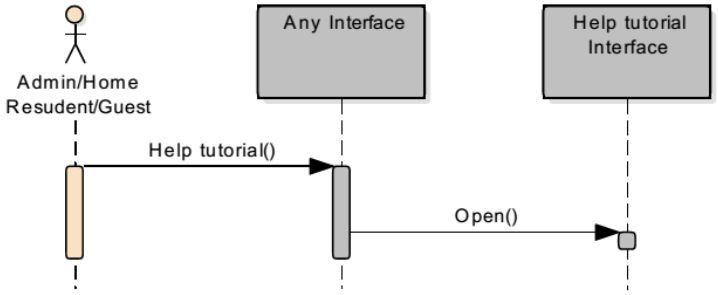


Figure 78: View Help Tutorials Sequence Diagram.

5.6.2.13 View iTrack Team/ Contact us Information

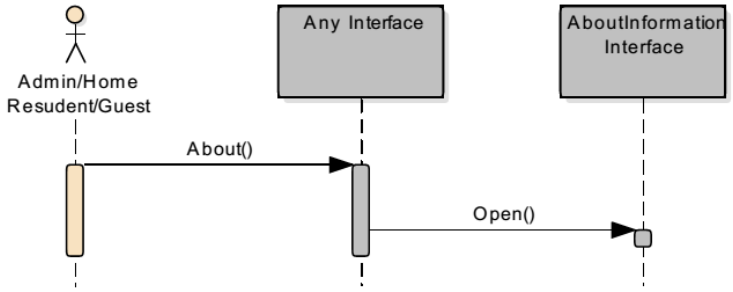


Figure 79: View iTack team/Contact Us Information Sequence Diagram.

5.6.2.14 Send Contact Message

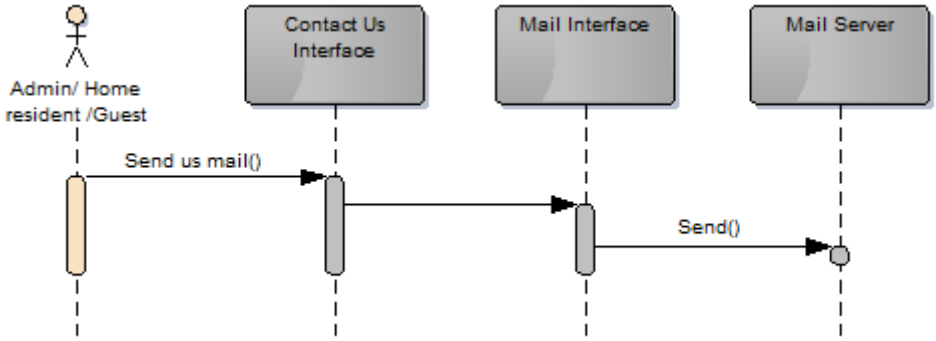


Figure 80: Send Contact Message Sequence Diagram.

5.6.2.15 View Awareness Tips

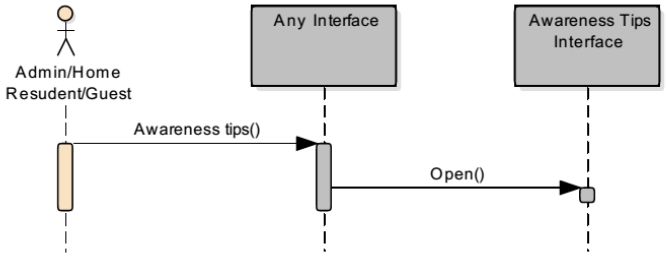


Figure 81: View Awareness Tips Sequence Diagram.

5.6.2.16 View system Features

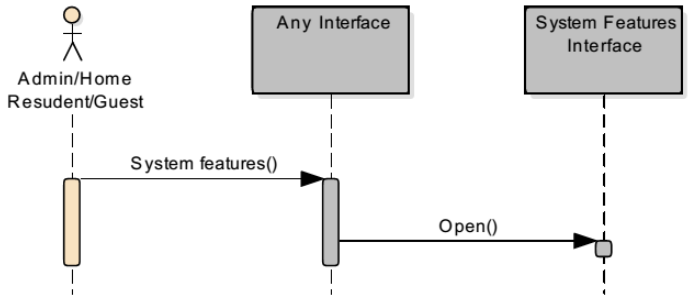


Figure 82: View System Features Sequence diagram.

5.6.2.17 View Building Features

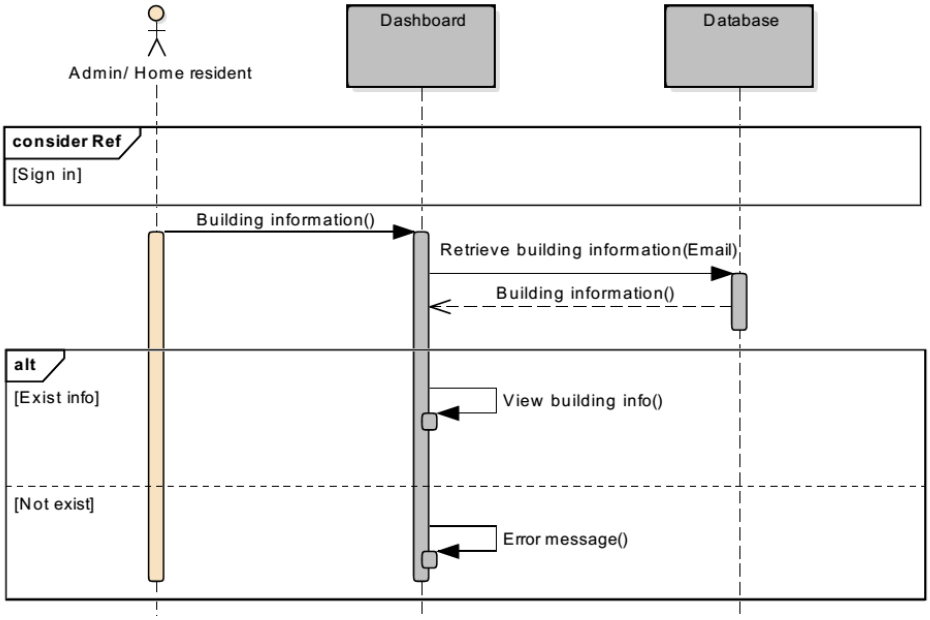
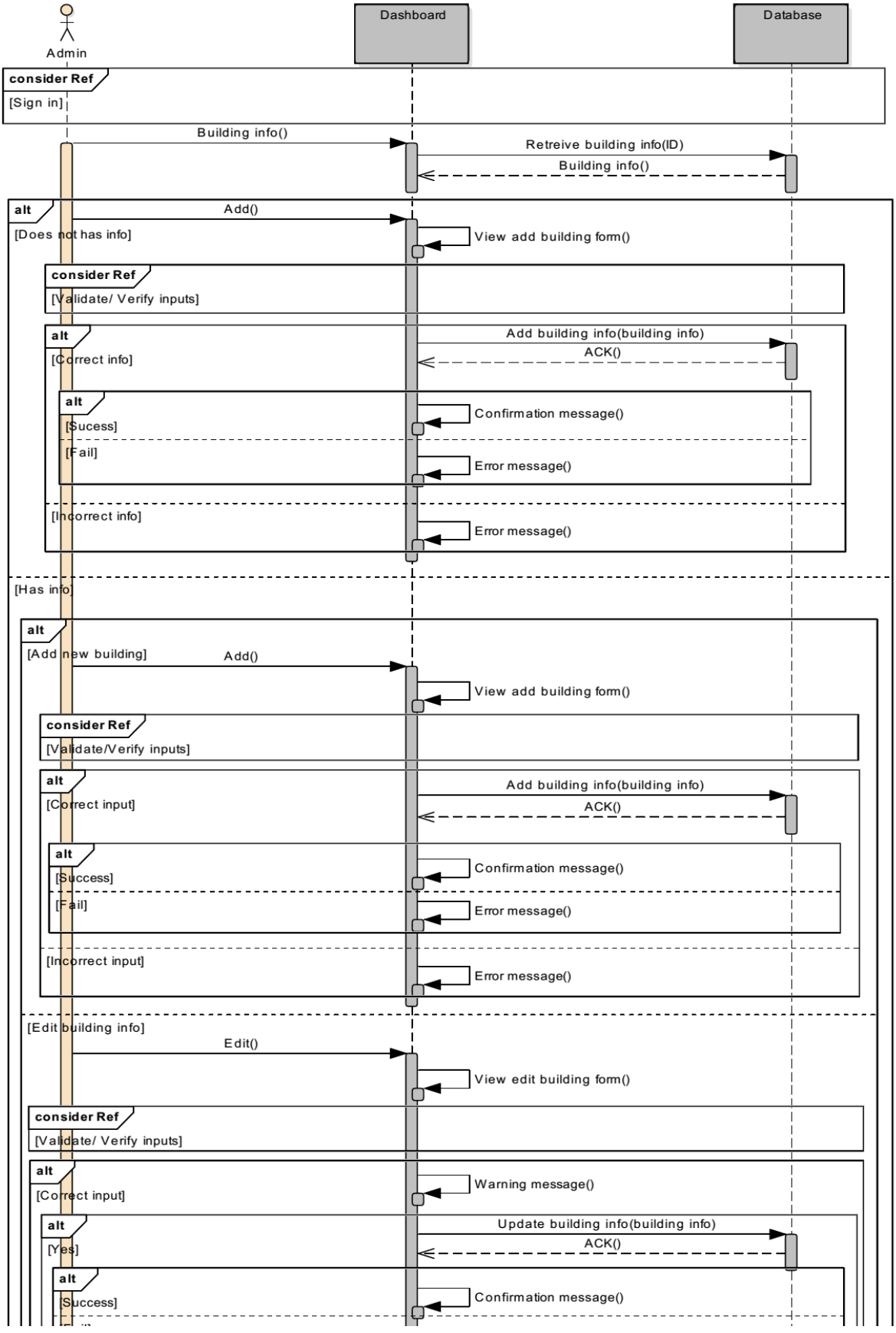


Figure 83: View Building Features Sequence Diagram.

5.6.2.18 Add/ Edit/ Delete Building Features.



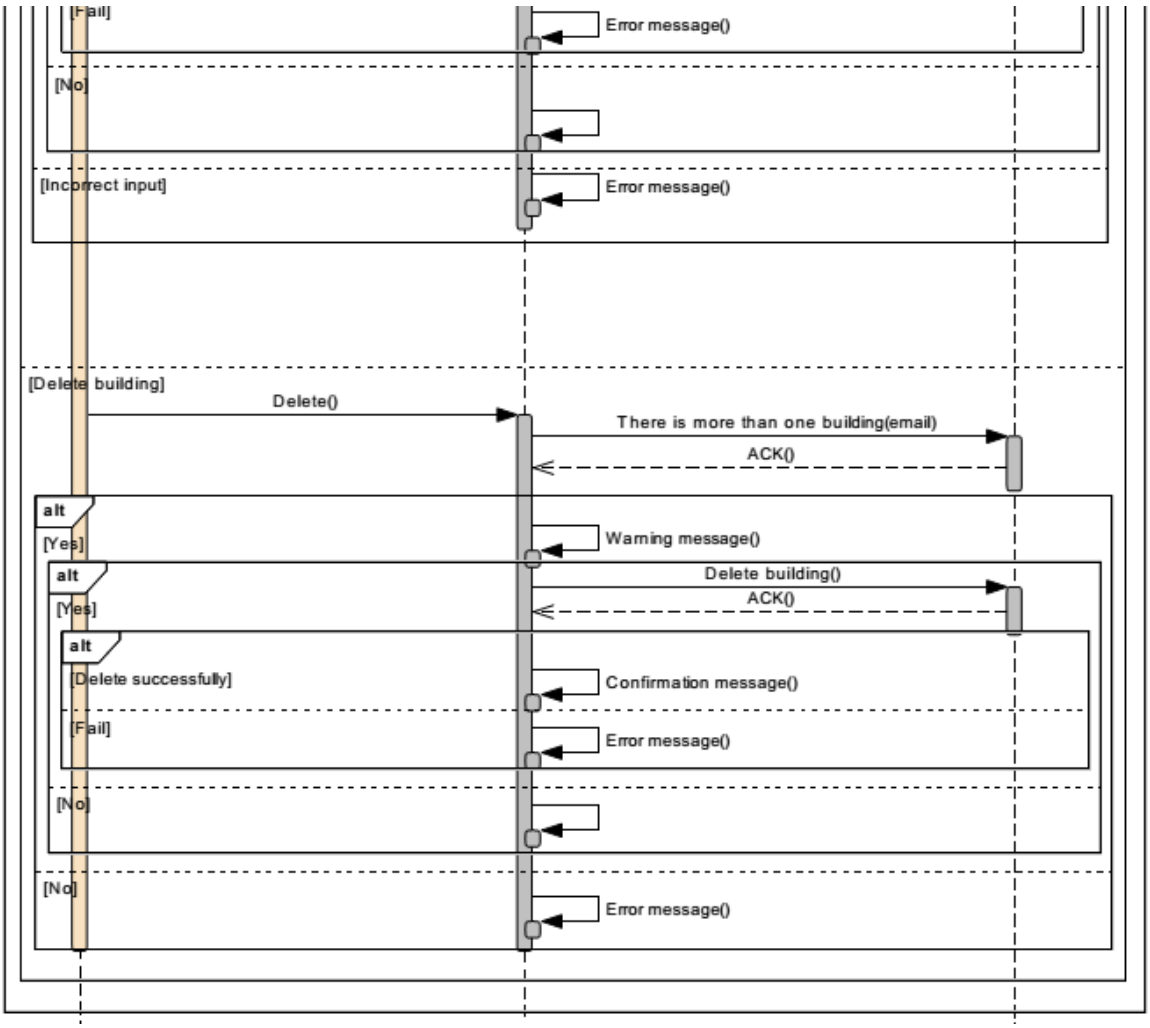


Figure 84: Add/ Edit/ Delete Building Features Sequence Diagram.

5.6.2.19 View Room Features

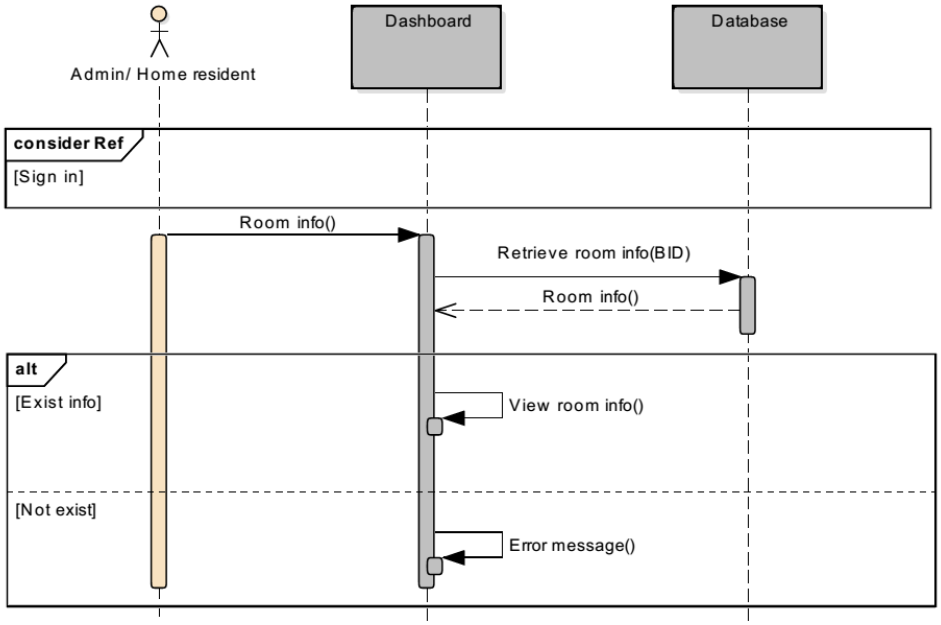
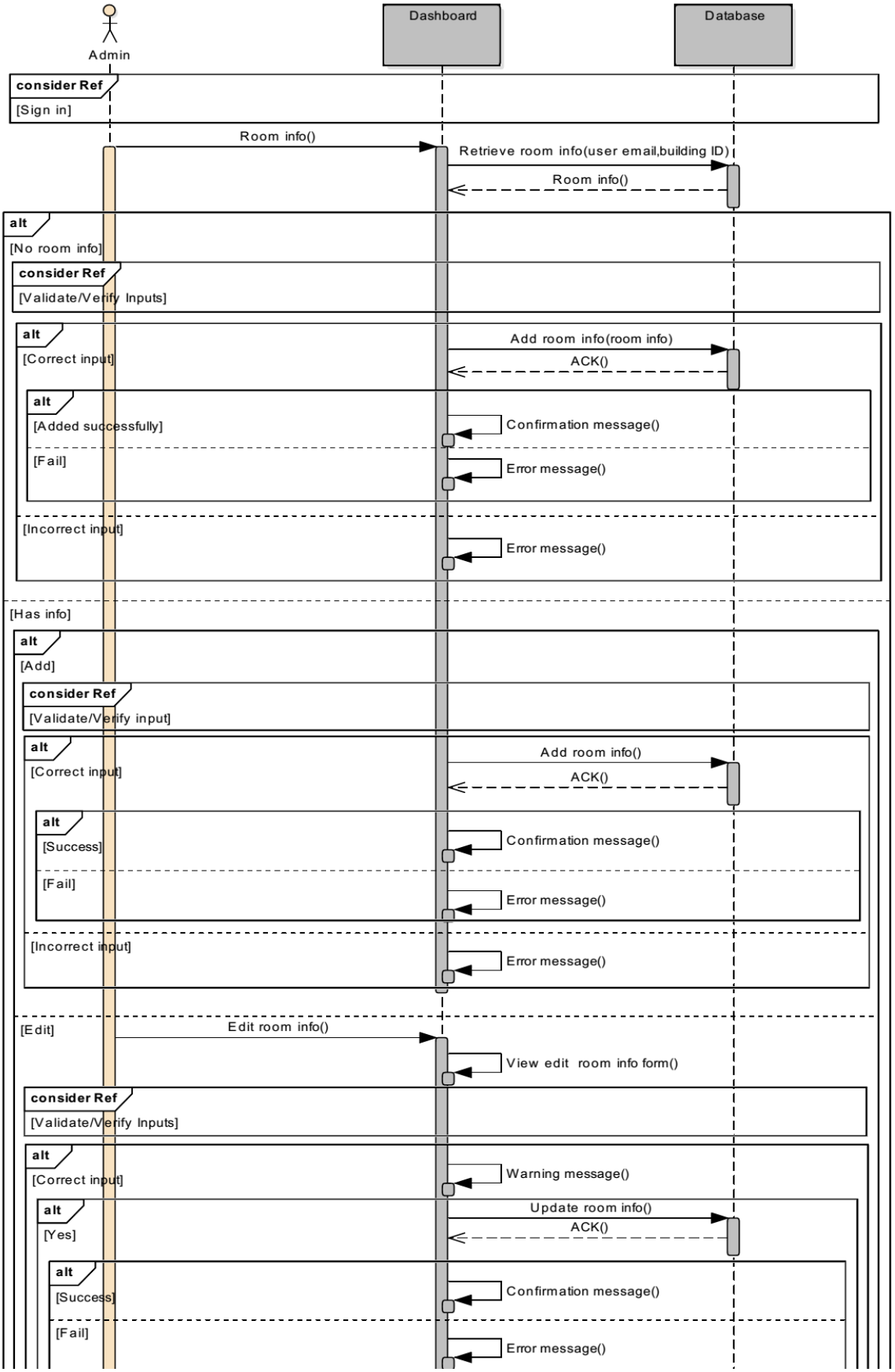


Figure 85: View Room Features Sequence Diagram.

5.6.2.20 Add/ Edit/ Delete Room Features



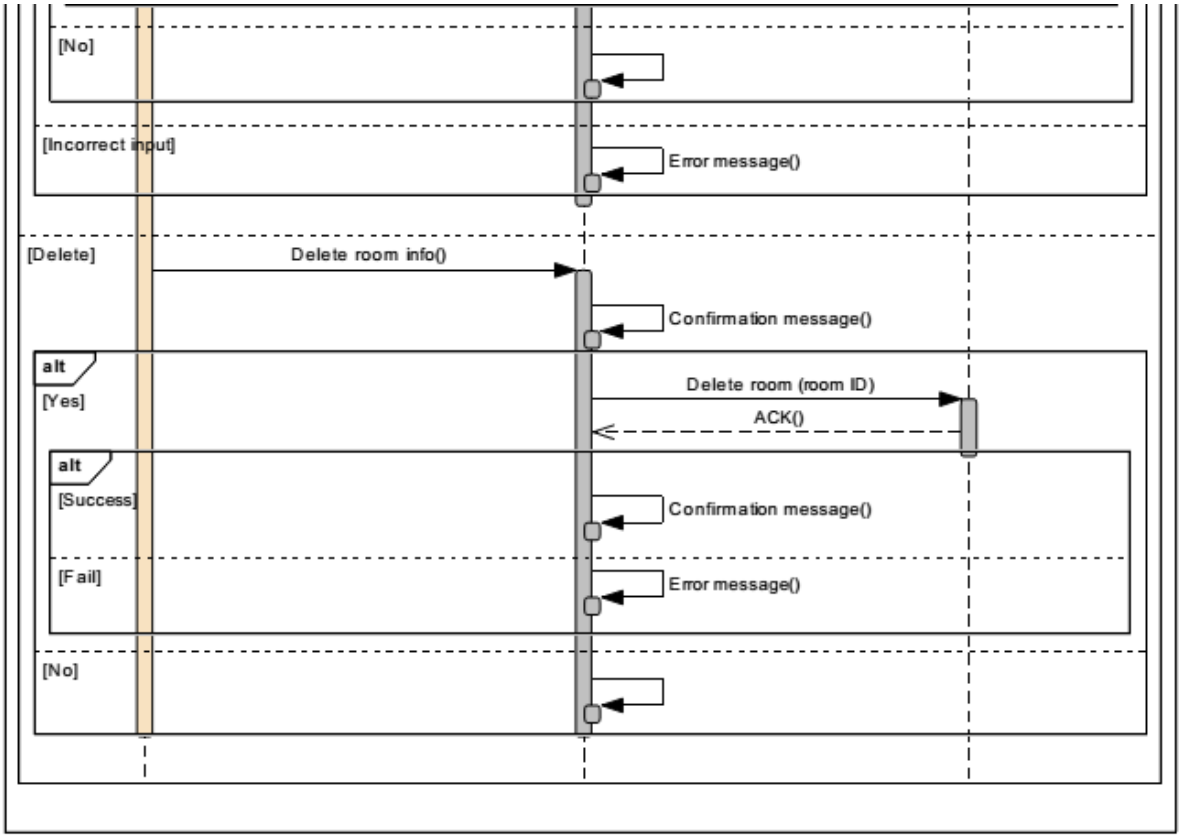


Figure 86: Add/ Edit/ Delete Room Features Sequence Diagram.

5.6.2.21 View Billing Rate

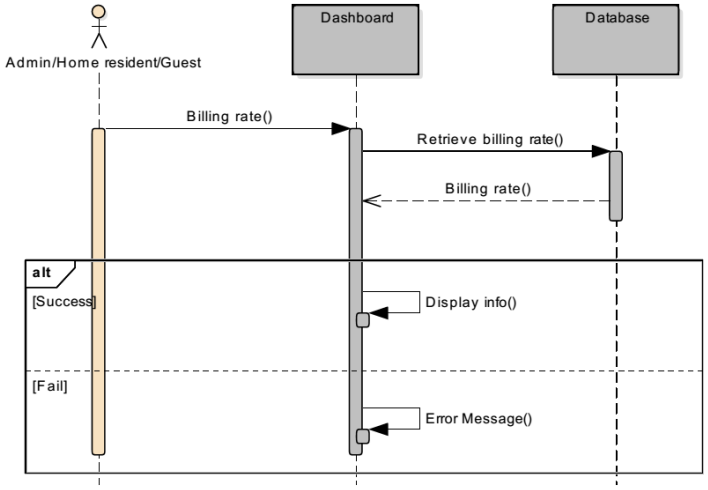


Figure 87: View Billing Rate Sequence Diagram.

5.6.2.22 View Sensor Reading

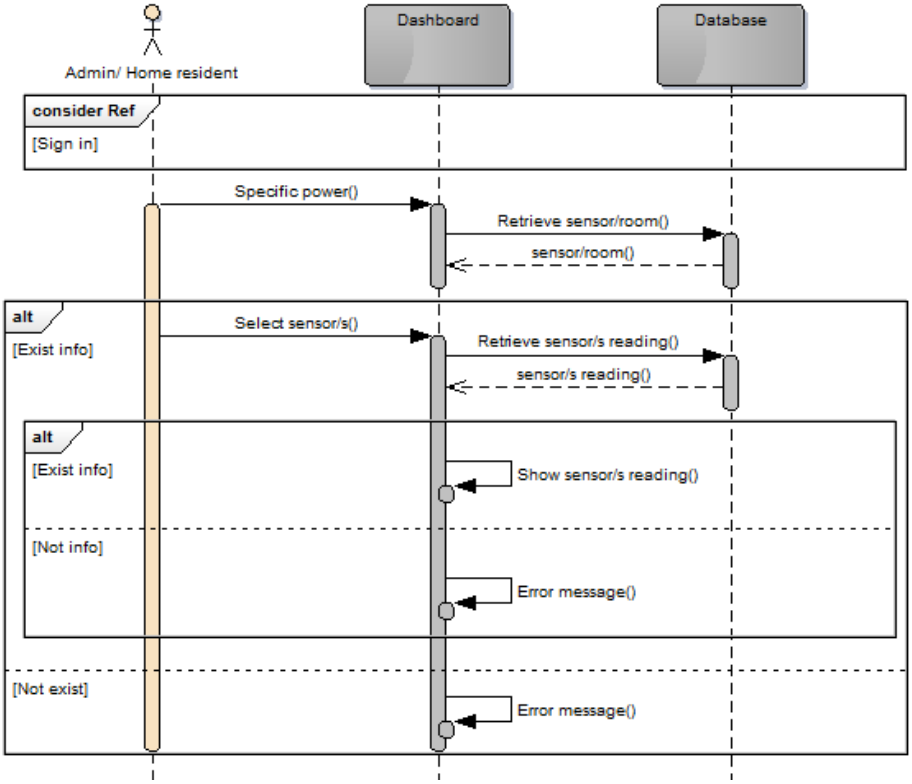


Figure 88: View Sensor Reading Sequence Diagram.

5.6.2.23 View Consumption Limit (Total)

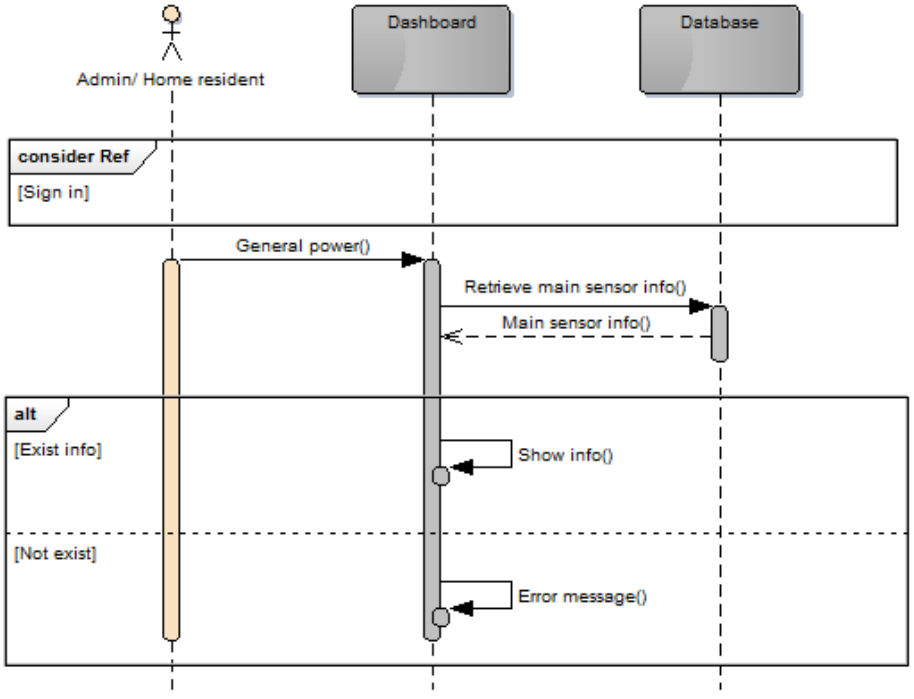


Figure 89: View Consumption Limit (Total) Sequence Diagram.

5.6.2.24 View Consumption Limit (Each)

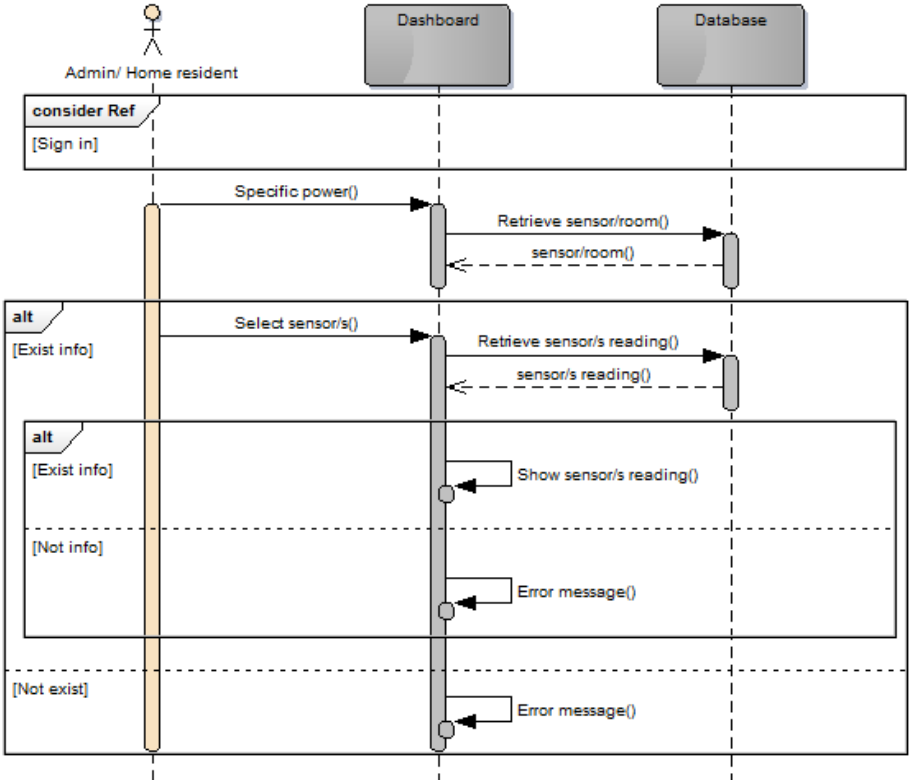


Figure 90: View Consumption Limit (Each) Sequence Diagram.

5.6.2.25 View Electricity Bill

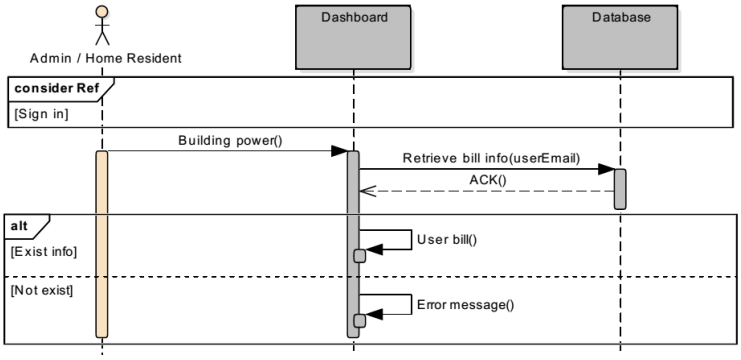


Figure 91: View Electricity Bill Sequence Diagram.

5.6.3 Interfaces Messages

The section contains the error messages and confirmation messages used in iTrack system.

5.6.3.1 Error Messages

Dashboard Interface > Building Power

Table 70: dashboard interface > building power error messages

Interface Element	Error Message
My Buildings	This field is required. Please select a building. هذا الحقل مطلوب. الرجاء اختيار مبنى لعرض المعلومات.
Time Duration	This field is required. Please select time duration. هذا الحقل مطلوب. الرجاء اختيار مدة زمنية لعرض المعلومات.

Dashboard Interface > Building Information > Edit Building Information

Table 71: dashboard interface > building information > edit building information error messages

Interface Element	Error Message
Building Type	Please select your building type. اختر نوع المبنى من فضلك.
Building Name	Please enter your building name. ادخل اسم المبنى من فضلك. The building name should not exceed 64 character. يجب ان لا يتجاوز اسم المبنى ٦٤ حرفا.

Dashboard Interface > Building Information > Add New Building

Table 72: dashboard interface > building information > add new building error messages

Interface Element	Error Message
Building Type	Please select your building type. اختر نوع المبنى من فضلك.
Building Name	Please enter your building name. ادخل اسم المبنى من فضلك. The building name should not exceed 64 character. يجب ان لا يتجاوز اسم المبنى ٦٤ حرفا.
Activation Key	Please select your activation key. ادخل مفتاح التنشيط من فضلك. Not valid activation key! مفتاح تنشيط غير صالح.

Dashboard Interface > Room Information > Edit Room Information

Table 73: dashboard interface > room information > edit room information error messages

Interface Element	Error Message
Room Name	Please enter your room name. ادخل اسم الغرفة من فضلك. Please enter no more than 64 characters. لرجاء إدخال ما لا يزيد عن ٦٤ حرفا.
Main Sensor	Room main Sensor already exists in this building. غرفة الاستشعار الرئيسية موجودة بالفعل في هذا المبنى.

Dashboard Interface > Room Information > Add New Room

Table 74: dashboard interface > room information > add new room error messages

Interface Element	Error Message
Room Name	Please enter your room name. ادخل اسم الغرفة من فضلك. Please enter no more than 64 characters. لرجاء إدخال ما لا يزيد عن ٦٤ حرفا.
Main Sensor	Room main Sensor already exists in this building. غرفة الاستشعار الرئيسية موجودة بالفعل في هذا المبنى.

Profile Interface > Sign in

Table 75: profile interface > sign in error messages

Interface Element	Error Message
Email	Please enter your email. أدخل بريدك الإلكتروني من فضلك.
Password	Please enter your password. أدخل كلمة المرور من فضلك.

Profile Interface > Forgot Password

Table 76: profile interface > forgot password error messages

Interface Element	Error Message
Email	Please enter your email. أدخل بريدك الإلكتروني من فضلك.

Profile Interface > Sign up

Table 77: profile interface > sign up error messages

Interface Element	Error Message
Full Name	Please enter your name. أدخل اسمك كاملا من فضلك. Please enter no more than 64 characters. الرجاء إدخال ما لا يزيد عن ٦٤ حرفا.
Email	Please enter your email. أدخل عنوان بريدك إلكتروني من فضلك. Please enter a valid email address. الرجاء إدخال عنوان بريد إلكتروني صالح. Please enter email no more than 256 characters. الرجاء إدخال بريد الكتروني ما لا يزيد عن ٢٥٦ حرفا.
Password	Please enter a password. أدخل كلمة المرور من فضلك. The password should be written in English. يجب ان تُكتَب كلمة المرور باللغة الإنجليزية. The password should be at least 8 character. يجب ان تتكون كلمة المرور من ٨ حروف على الأقل. The password should contain at least one uppercase alphabetic characters. يجب ان تحتوي كلمة المرور على حرف كبير واحد على الأقل. The password should contain at least one lowercase alphabetic characters. يجب ان تحتوي كلمة المرور على حرف صغير واحد على الأقل. The password should contain at least one numerical character. يجب ان تحتوي كلمة المرور على رقم صحيح واحد على الأقل. The password should contain at least one special character. يجب ان تحتوي كلمة المرور على رمز واحد على الأقل.
Re-enter Password	Please enter your password again. أدخل كلمة المرور مجددا من فضلك. Please enter the same password value again. يرجى إدخال نفس القيمة لكلمة المرور مرة أخرى.
Verification Code	Please enter the verification code. أدخل الرمز من فضلك. The entered code is wrong! Please try again. الرمز الذي أدخلته غير صحيح! حاول مرة أخرى.

Profile Interface > My Dependents > Add New Dependent

Table 78: profile interface > my dependents> add new dependent error messages

Interface Element	Error Message
Full Name	Please enter your name. أدخل اسمك كاملا من فضلك. Please enter no more than 64 characters. الرجاء إدخال ما لا يزيد عن ٦٤ حرفا.
Email	Please enter your email. أدخل عنوان بريدك إلكتروني من فضلك. Please enter a valid email address. الرجاء إدخال عنوان بريد إلكتروني صالح. Please enter email no more than 256 characters. الرجاء إدخال بريد الكتروني ما لا يزيد عن ٢٥٦ حرفا.

Profile Interface > Modify Information > Change Password

Table 79: profile interface > modify information> change password error messages

Interface Element	Error Message
Old Password	Please enter your old password. أدخل كلمة المرور السابقة من فضلك.
New Password	Please enter a password. أدخل كلمة المرور من فضلك. The password should be written in English. يجب ان تُكتَب كلمة المرور باللغة الإنجليزية. The password should be at least 8 character. يجب ان تتكون كلمة المرور من ٨ حروف على الأقل. The password should contain at least one uppercase alphabetic characters. يجب ان تحتوي كلمة المرور على حرف كبير واحد على الأقل. The password should contain at least one lowercase alphabetic characters. يجب ان تحتوي كلمة المرور على حرف صغير واحد على الأقل. The password should contain at least one numerical character. يجب ان تحتوي كلمة المرور على رقم صحيح واحد على الأقل. The password should contain at least one special character. يجب ان تحتوي كلمة المرور على رمز واحد على الأقل.
Re-enter Password	Please enter your password again. أدخل كلمة المرور مجددا من فضلك. Please enter the same password value again. يرجى إدخال نفس القيمة لكلمة المرور مرة أخرى

Profile Interface > Modify Information > Change Email

Table 80: profile interface > modify information> change email error messages

Interface Element	Error Message
New Email	This field is required. هذا الحقل مطلوب
Re-enter Email	This field is required. هذا الحقل مطلوب The email you want to change to already have an account! البريد الالكتروني الذي تريد استخدامه لديه حساب بالفعل!

Continue Registration

Table 81: profile interface > sign up error messages

Interface Element	Error Message
Full Name	Please enter your name. أدخل اسمك كاملا من فضلك. Please enter no more than 64 characters. الرجاء إدخال ما لا يزيد عن ٦٤ حرفا.
Email	Please enter your email. أدخل عنوان بريدك إلكتروني من فضلك. Please enter a valid email address. الرجاء إدخال عنوان بريد إلكتروني صالح. Please enter email no more than 256 characters. الرجاء إدخال بريد الكتروني ما لا يزيد عن ٢٥٦ حرفا.
Password	Please enter a password. أدخل كلمة المرور من فضلك. The password should be written in English. يجب ان تُكتَب كلمة المرور باللغة الإنجليزية. The password should be at least 8 character. يجب ان تتكون كلمة المرور من ٨ حروف على الأقل. The password should contain at least one uppercase alphabetic characters. يجب ان تحتوي كلمة المرور على حرف كبير واحد على الأقل. The password should contain at least one lowercase alphabetic characters. يجب ان تحتوي كلمة المرور على حرف صغير واحد على الأقل. The password should contain at least one numerical character. يجب ان تحتوي كلمة المرور على رقم صحيح واحد على الأقل. The password should contain at least one special character. يجب ان تحتوي كلمة المرور على رمز واحد على الأقل.
Re-enter Password	Please enter your password again. أدخل كلمة المرور مجددا من فضلك. Please enter the same password value again. يرجى إدخال نفس القيمة لكلمة المرور مرة أخرى

Verification Code	Please enter the verification code. أدخل الرمز من فضلك. The entered code is wrong! Please try again. الرمز الذي أدخلته غير صحيح! حاول مرة أخرى.
Full Name	Please enter your name. أدخل اسمك كاملا من فضلك. Please enter no more than 64 characters. الرجاء إدخال ما لا يزيد عن ٦٤ حرفا.
Email	Please enter your email. أدخل عنوان بريدك إلكتروني من فضلك. Please enter a valid email address. الرجاء إدخال عنوان بريد إلكتروني صالح. Please enter email no more than 256 characters. الرجاء إدخال بريد الكتروني ما لا يزيد عن ٢٥٦ حرفا.

Reset Password

Table 82: reset password error messages

Interface Element	**Error Message**
Password	Please enter a password. أدخل كلمة المرور من فضلك. The password should be written in English. يجب ان تُكتَب كلمة المرور باللغة الإنجليزية. The password should be at least 8 characters. يجب ان تتكون كلمة المرور من ٨ حروف على الأقل. The password should contain at least one uppercase alphabetic characters. يجب ان تحتوي كلمة المرور على حرف كبير واحد على الأقل. The password should contain at least one lowercase alphabetic characters. يجب ان تحتوي كلمة المرور على حرف صغير واحد على الأقل. The password should contain at least one numerical character. يجب ان تحتوي كلمة المرور على رقم صحيح واحد على الأقل. The password should contain at least one special character. يجب ان تحتوي كلمة المرور على رمز واحد على الأقل.
Re-enter Password	Please enter your password again. أدخل كلمة المرور مجددا من فضلك. Please enter the same password value again. يرجى إدخال نفس القيمة لكلمة المرور مرة أخرى.

5.6.3.2 Confirmation Messages

Dashboard Interface > Building Information > Edit Building Information

Table 83: dashboard interface > building information > edit building information confirmation messages

Operation Condition	Confirmation Message
Before editing building information	Are you sure that you want to edit your building's information? هل انت متأكد من رغبتك بتحديث معلومات المبنى الخاص بك؟
Building information edited	Your building information is updated successfully! المعلومات حدثت بنجاح.
Building information is not edited	Could not update information! Please try again later. لا يمكن تحديث المعلومات في هذا الوقت! يرجى المحاولة مرة أخرى في وقت لاحق.

Dashboard Interface > Building Information > Add New Building

Table 84: dashboard interface > building information > add new building confirmation messages

Operation Condition	Confirmation Message
Building added	Your building information is added successfully! تم اضافة معلومات المبنى الخاص بك بنجاح.
Building is not added	Could not add information! Please try again later. لا يمكن اضافة معلومات في هذا الوقت! يرجى المحاولة مرة أخرى في وقت لاحق.

Dashboard Interface > Building Information > Delete Building

Table 85: dashboard interface > building information > delete building confirmation messages

Operation Condition	Confirmation Message
Before deleting a building	Deleting this building will cause deleting the associated rooms and their consumption information. Are you sure you want to delete this building? حذف هذه المبنى سوف يتسبب بحذف الغرف التابعة له شاملا معلومات الاستهلاك. هل انت متأكد من رغبتك بحذف هذه الغرفة؟
Building deleted	Your building is deleted successfully! المعلومات حذفت بنجاح.
Building is not deleted	Could not Delete building! Please try again later. لا يمكن حذف معلومات في هذا الوقت! يرجى المحاولة مرة أخرى في وقت لاحق.

Dashboard Interface > Room Information > Edit Room Information

Table 86: dashboard interface > room information > edit room information confirmation messages

Operation Condition	Confirmation Message
Room information edited	Your information is updated successfully! المعلومات حدثت بنجاح.
Room information is not edited	Could not update information! Please try again later. لا يمكن تحديث معلومات في هذا الوقت! يرجى المحاولة مرة أخرى في وقت لاحق.

Dashboard Interface > Room Information > Add New Room

Table 87: dashboard interface > room information > add new room confirmation messages

Operation Condition	Confirmation Message
Room added	Your information is added successfully! المعلومات اضيفت بنجاح.
Room is not added	Could not add information! Please try again later. لا يمكن اضافة معلومات في هذا الوقت! يرجى المحاولة مرة أخرى في وقت لاحق.

Dashboard Interface > Room Information > Delete Room

Table 88: dashboard interface > room information > delete room confirmation messages

Operation Condition	Confirmation Message
Before deleting a room	Deleting this room will cause deleting the associated consumption information. Are you sure you want to delete this room? حذف هذه الغرفة سوف يتسبب بحذف معلومات الاستهلاك التابعة لها. هل انت متأكد من رغبتك بحذف هذه الغرفة؟
Room deleted	Your room is deleted successfully! المعلومات حذفت بنجاح.
Room is not deleted	Could not delete room! Please try again later. لا يمكن حذف معلومات في هذا الوقت! يرجى المحاولة مرة أخرى في وقت لاحق.

Profile Interface > Sign in

Table 89: profile interface > sign in confirmation messages

Operation Condition	Confirmation Message
Failed	The username or password you entered is not correct. عفوا اسم المستخدم او كلمة المرور الذي قمت بإدخاله غير صحيح.

Profile Interface > Forgot Password

Table 90: profile interface > forgot password confirmation messages

Operation Condition	Confirmation Message
User email does not have account	There is no account with the email you entered in iTrack ! لا يوجد حساب مع البريد الإلكتروني الذي أدخلته في iTrack.
The password reset email sent	Check your email (User Email) for changing your password! تحقق من بريدك الالكتروني (بريد المستخدم) لتغيير كلمة مرورك.
The password reset email is not sent	Could not help you at this time! Please try again later. لا يمكن مساعدتك في هذا الوقت! يرجى المحاولة مرة أخرى في وقت لاحق.

Profile Interface > Sign up

Table 91: profile interface > sign up confirmation messages

Operation Condition	Confirmation Message
Email already registered for an account	The email you want to create an account with already have an account! Cannot create account with this email. البريد الإلكتروني الذي تريد به إنشاء حساب جديد مستخدم بالفعل! لا يمكن إنشاء حساب مع هذا البريد الإلكتروني.
Account created	An account has been created for you. Check your email (User Email) for account activation! Until you activate your account you can Sign in and use iTrack with limited privilege. تم انشاء الحساب تحقق من بريدك الالكتروني لتفعيل حسابك وحتى تقوم بذلك يمكنك تسجيل دخولك ل iTrack ولكن بامتيازات محدودة
Account not created	Could not create account for you at this time! Please try again later. لا يمكن انشاء حساب لك في هذا الوقت! يرجى المحاولة مرة أخرى في وقت لاحق.

Profile Interface > My Profile

Table 92: profile interface > my profile confirmation messages

Operation Condition	Confirmation Message
Inactive account	Your account is not active! Check your email for activation. حسابك غير فعال تحقق من بريدك الالكتروني لتفعيل الحساب.

Profile Interface > My Dependents > Add New Dependent

Table 93: profile interface > my dependents> add new dependent confirmation messages

Operation Condition	Confirmation Message
Email already registered for an account	The email you want to create an account with already have an account! Cannot create account with this email. البريد الإلكتروني الذي تريد به إنشاء حساب جديد مستخدم بالفعل! لا يمكن إنشاء حساب مع هذا البريد الإلكتروني.
New dependent added	An account has been created for your dependent. Ask him/her to check his/her email (User Email) to continue the registration! تم إنشاء حساب لعميلك. اساله / اسالها للتحقق من بريده الإلكتروني ومواصلة التسجيل.
New dependent is not added	Could not create dependent account at this time! Please try again later. لا يمكن انشاء حساب لعملائك في هذا الوقت! يرجى المحاولة مرة أخرى في وقت لاحق

Profile Interface > My Dependents > Delete Dependent

Table 94: profile interface > my dependents> delete dependent confirmation messages

Operation Condition	Confirmation Message
Dependent deleted	Your dependent is deleted successfully! المعلومات حذفت بنجاح.
Dependent is not deleted	Could not delete dependent! Please try again later. لا يمكن حذف معلومات في هذا الوقت! يرجى المحاولة مرة أخرى في وقت لاحق.

Profile Interface > Modify Information > Edit General Information

Table 95: profile interface > modify information> edit general information confirmation messages

Operation Condition	Confirmation Message
General information edited	Your information is updated successfully! تم تحديث معلوماتك بنجاح.
General information is not edited	Could not update information! Please try again later. لا يمكن تحديث المعلومات في هذا الوقت! يرجى المحاولة مرة أخرى في وقت لاحق.

Profile Interface > Modify Information > Change Password

Table 96: profile interface > modify information> change password confirmation messages

Operation Condition	Confirmation Message
Password changed	Your Password has been updated successfully! كلمة المرور حدثت بنجاح.
Password is not changed	Could not change password! Please try again later. لا يمكن تغيير كلمة مرورك في هذا الوقت! يرجى المحاولة مرة أخرى في وقت لاحق.

Profile Interface > Modify Information > Change Email

Table 97: profile interface > modify information> change email confirmation messages

Operation Condition	Confirmation Message
Email changed	Check your email (New Email) for email change to take effect! Until you verify your new email, you can sign in with your current email. تحقق من بريدك الالكتروني (البريد الإلكتروني الجديد) لتفعيل التغيير بالبريد الإلكتروني! وحتى تتحقق من البريد الإلكتروني الجديد الخاص بك يمكنك الدخول بالبريد الإلكتروني الخاص بك الحالي.
Email is not changed	Could not change email! Please try again later. لا يمكن تغيير بريدك الالكتروني في هذا الوقت! يرجى المحاولة مرة أخرى في وقت لاحق.

Continue Registration

Table 98: profile interface > sign up confirmation messages

Operation Condition	Confirmation Message
Account created	Your account has been created successfully! لقد تم انشاء حسابك بنجاح.
Account not created	Could not create account for you at this time! Please try again later. لا يمكن انشاء حساب لك في هذا الوقت! يرجى المحاولة مرة أخرى في وقت لاحق.

Reset Password

Table 99: reset password confirmation messages

Operation Condition	Confirmation Message
Password changed	Your Password has been changed successfully! لقد تم تغيير رقمك السري بنجاح.
Password is not changed	Could not change password! Please try again later. لا تغيير رقمك السري في هذا الوقت! يرجى المحاولة مرة أخرى في وقت لاحق.

Verify Email

Table 100: verify email confirmation messages

Operation Condition	Confirmation Message
Email verified	Your email is verified and your account is active now! لقد تم التحقق من بريدك الالكتروني و حسابك الان نشط.
Email is not verified	Could not verify your email at this time! Please try again later. لا يمكن التحقق من بريدك الالكتروني في هذا الوقت! يرجى المحاولة مرة أخرى في وقت لاحق.

Change Email

Table 101: change email confirmation messages

Operation Condition	Confirmation Message
Email changed	Your email is changed! لقد تم تغيير بريدك الالكتروني و حسابك الان نشط.
Email is not changed	Could not change your email at this time! Please try again later. لا يمكن التحقق من بريدك الالكتروني في هذا الوقت! يرجى المحاولة مرة أخرى في وقت لاحق.

5.7 Summary

Section 5.1 Design Mapping and System Overview

- The purpose of this chapter is to guide the developer through the implementation phase.
- The developers of the iTrack system are the main audience of this system.

Section 5.2 Design Considerations

- The iTrack system will be a web base system.
- MySQL will be the used software to develop the iTrack database.
- PHP, HTML, CSS, JavaScript and jQuery are the website development programs that will be used to develop iTrack.
- The iTrack website will be developed using OOP methodology and MVC architecture.
- MatLab will be used as simulation tool.

Section 5.3 System Architecture

- The system architecture will be client server with n-tier architecture.
- The hardware architecture contains EmonTx, EmonBase and regular home router.
- The software architecture consists of three files: view, model and controller files.

Section 5.4 Database Design

- This section discusses the design of the database in detail.
- iTrack database consists of eight entities and eight binary relationships.

Section 5.5 User Interface Design

- This section discusses the interfaces design in detail.
- The iTrack interfaces will be implemented using ready template from the Internet.
- There are 12 interfaces in iTrack system.
- The designing of iTrack interfaces will follow the eight golden rules.
- This section mentioned the element of the interfaces and the objective of each element.

Section 5.5 Detailed Design

- This section introduced the structure of the model and controller files.
- The sequence diagrams of each use case are stated in this section.
- All the error messages and confirmation messages that are used in iTrack system to give the user proper feedback are listed in this section.

Chapter 6 System Test Plan

This System Test Plan (STP) document describes the testing phases and scenario of a wireless energy consumption monitoring system, the iTrack. First, an introductory section clarifies the purpose; scope and objectives of system test plan of iTrack system. Followed by test items. Subsequently, features to be tested, and features not to be tested are stated. After that, the testing approach and testing process are described in detail, followed by the Pass/ Fail Criteria, Environmental requirements and summary.

Outline

6.1 Purpose, Scope and objectives

6.1.1 Purpose

The purpose of this System Test Plan (STP) document is to define the testing strategies and tools to be used in the iTrack system testing.

The main intended audience for this STP is the software developer team that will test the iTrack system. Also, this document might be of interest to developers, interested to learn about wireless energy consumption monitoring systems. Although the document is fairly technical, our potential customers that will install and use the system in their household can benefit from it to check all the functionalities of the system.

6.1.2 Scope

The scope of the testing chapter is to describe how the functionality of iTrack system will be tested. The system's test will be conducted using various system approaches that include: construction testing, system testing, senior based testing and stress testing.

6.1.3 Objectives

The main objectives of the test plan document are as follow:

- Define the testing strategies to be employed, the scope of testing, reference materials used in the document, definitions & acronyms, and the tools used to complete the testing.
- Identify the project related information needed to complete the testing, functionalities to be tested.
- Define the approaches that will be deployed in the testing procedure.
- Specify the main criteria and the process of testing.
- Describe the environmental requirements in which testing will be conducted.

6.2 Test Items

The iTrack items fall into two categories: iTrack software component or job control procedure.

iTrack software components are: model, view, and controller. iTrack will be tested as one unit when testing these components. The test will cover:

- Checking the correctness of data flow between these three items.
- Checking the correctness of data presented to the user in the view.
- Checking the correctness of data fetch from database by the software logic

iTrack job control processes that work as independent items; Connecting utility with iTrack, Connecting hardware with database, sending alarm messages. These processed will be tested for:

- Checking the correctness of data flows between the utility, hardware and iTrack.
- Checking that the alarm message is send in right situation.

6.3 Features to Be Tested

All iTrack software components functional and non-functional features specified as SRS will be tested. The detailed method for testing will follow in this document.

6.4 Features Not to Be Tested

This section introduces the features not to be included in the testing process and highlights the reasons behind that.

The following non-functional features of the system are not going to be tested:

- The system storage space should hold the sensor's reading for a year. To test this feature the system should put in use for a year. Since there will not be long time to test the system this feature will not be tested. However, the required space given a sensor topology will be estimated and the house-owner will be informed.
- Original developers or any other developers could carry the system maintenance. Since there will not be a new version of the system this feature will not be tested.

6.5 Approach

This section introduces the different testing approaches to that will be preformed to test iTrack system.

6.5.1 Construction Testing

All the functionalities of iTrack system will be tested by:

- Testing the statements that construct the code one by one to make sure that its syntax and semantic are correct.
- Testing the integration of these statements (functions) to make sure that they work fine together.
- Testing the integration of these functions (Classes) to make sure that the classes work as expected.
- Testing the integration of these classes to make sure that these classes can work together, transfer the data between them and transfer the data from the classes and interfaces.

6.5.2 Integration Testing

After testing all the system functionalities, the iTrack team will also test the integration between the hardware and the software. The testing will cover checking the correctness of the data coming from the hardware to iTrack database. Since the hardware is very simple, the iTrack system will be tested with data coming from simulation for large building more information mentioned in section 6.6 Testing Process.

6.5.3 Security Testing

The developers will test the security of the system by entering the system using unusual paths. Enter the verify email, continue registration, change email and reset password interface using wrong verification code or wrong email. Check that an error message display. Insure that:

- The error messages are not revealing any sensitive information.
- The password is encrypted.
- The session duration and session termination after timeout or logout.
- Password field is not having autocomplete enabled.

6.5.4 Performance Testing

- Check page load on slow connections.
- Check response time for any action under light, normal, moderate and heavy load conditions.
- Check database query execution time.
- Check the system energy consumption.

6.6 Testing Process

6.6.1 Testing Tasks

All the following software functional features are going to be tested:

6.6.1.1 Specify the Language Task

Table 102: 'Specify the Language' Test

Requirement	The system should allow the users to specify the system language.
Test	• Choose a specific language. Check that the system language is changed to the chosen language.

6.6.1.2 Sign Up Task

Table 103: 'Sign up' Test

Requirement	The system should allow the users to create an account.
Test	• Enter a valid personal information (name, picture, phone number, and birth date), email and password. Check that the system sends a verification email to the email that entered in the form. • Verify the sent email. Check that the system creates the account in the system and shows the user related information. • Enter an invalid ID, password or leave the fields empty. Check that the system shows error message and does not send a verification email nor create account.

6.6.1.3 Sign In/Out Task

Table 104: Log In/Out ' Test

Requirement	The system should allow the users to log in/out from the system.
Test	• Enter a valid email and password. Check that the system enters to the system and shows the user related information. • Enter an invalid email, password or leave the fields empty. Check that the system shows error message and does not enters to the system. • Press Sign out link, check that the profile goes back to its original status (Sign in/ Sign Up).

6.6.1.4 Forget Password Task

Table 105: ' Forget Password ' Test

Requirement	The system should allow the users to reset his/her password.
Test	• Click on forget password link and enter your email. Check that the system sends an email to you that have a link to reset password page. • Click on forget password link and enter an invalid email or leave the field empty. Check that the system shows error messages and does not sends an email to you.

6.6.1.5 View/Edit Profile Information Task

Table 106: ' View/ Edit Profile Information ' Test

Requirement	The system should allow the users to view/edit profile information.
Test	• Click on my profile tab. Check that the system shows the user related information. • Click on edit icon. Check that the system shows the corresponding information to edit. • Enter valid information for editing. Check that the system updates the information successfully. • Enter invalid information for editing. Check that the system shows error message and does not update the information.

6.6.1.6 View Dependent Information Task

Table 107: 'View Dependent Information' Test

Requirement	The system should allow the admin to view his/her dependent.
Test	• Click on my dependent tab. Check that the system shows the correct dependent related to the admin.

6.6.1.7 View Connection Information Task

Table 108: 'View Connection Information' Test

Requirement	The system should allow the home resident to view his/her connection.
Test	• Click on my connection tab. Check that the system shows the correct connection related to the home resident.

6.6.1.8 Add/ Delete Dependent Task

Table 109: 'Add/ Delete Dependent' Test

Requirement	The system should allow the admin to add/delete dependent.
Test	• Enter a valid name, email and phone number. Check that the system adds the dependent. • Enter an invalid name, email and phone number. Check that the system shows error message and does not add the dependent. • Click on trash icon. Check that the system deletes the corresponding dependent.

6.6.1.9 Change Email Task

Table 110:'Change Email' Test

Requirement	The system should allow the users to change email.
Test	• Click on the modify information tab and enter a valid new email twice. Check that the system sends email verification. • Verify the email. Click on the link provided in the email, check that the system updates the email successfully. • Enter an invalid email. Check that the system shows error message and does not send a verification email.

6.6.1.10 Change Password Task

Table 111: 'Change Password' Test

Requirement	The system should allow the users to change password.
Test	• Click on the modify information tab and enter the old password and valid new password twice. Check that the system updates the password successfully. • Enter invalid password. Check that the system shows error message and does not update the password.

6.6.1.11 View Help Tutorials Task

Table 112: 'View Help Tutorials' Test

Requirement	The system should allow the user to view help tutorial.
Test	• Choose the help tutorial tab. Check that the system displays several tutorial videos.

6.6.1.12 View Contact Information Task

Table 113: 'View Contact Information' Test

Requirement	The system should allow the user to view contact information.
Test	• Choose the contact us tab. Check that the system displays a several ways for communication such as, email or social media.

6.6.1.13 Send Contact Message Task

Table 114: 'Send Contact Message' Test

Requirement	The system should allow the user to send contact message.
Test	• Choose contact us tab and click on send us email button. Check that the system opens a mail server to send message and check that the system receives the message.

6.6.1.14 View Awareness Tips Task

Table 115: 'View Awareness Tips' Test

Requirement	The system should allow the user to view awareness tips.
Test	• Choose awareness tips tab. Check that the system displays awareness tips.

6.6.1.15 View System Features Task

Table 116: 'View System Features ' Test

Requirement	The system should allow the user to view system features.
Test	• Choose system features tab. Check that the system displays the system features.

6.6.1.16 View Building/Room Features Task

Table 117: ' View Building's Features ' Test.

Requirement	The system should allow the users to view building/room features.
Test	• Choose a building information tab. Check that the system shows the related building/room information.

6.6.1.17 Add/Edit/ Delete Building/Room Features Task

Table 118: 'Add/Edit/ Delete Building/Room Features' Test

Requirement	The system should allow the users to add/edit/delete building/room features.
Test	• From building information tab, choose plus icon to add building/room. Add valid building information (building name, type, activation key)/ room information (room name, description, specify if it has the main sensor or not and the limit). Check that the system adds the building/ room information. • From building information tab, choose edit icons to edit building/room. Check that the system shows the correct corresponding information. Add valid building information (building name, type)/ room information (room name, description, specify if it has the main sensor or not and the limit). Check that the system updates the building/ room information. • Enter an invalid building information (building name, type, activation key)/ room information (room name, description, specify if it has the main sensor or not and the limit) or leave these fields empty. Check that the system shows error massage and does not add/update the building/room information. • Click the trash icon to delete building/ room information. Check that the system deletes the corresponding building/room information.

6.6.1.18 View Billing Rate Task

Table 119: 'View Billing Rate' Test

Requirement	The system should allow the users to view billing rate.
Test	• Choose electricity bill tab and choose a building type. Check that the system displays the information of the chosen building type.

6.6.1.19 View Sensor's Reading Task

Table 120: ' View Sensor's Reading ' Test

Requirement	The system should allow the users to view sensors reading.
Test	• Choose building power tab and choose your building name. Check that the system shows a correct consumption rate chart of the main sensor. • Choose building power tab and choose sensor/s and period. Check that the system shows a correct consumption rate chart that reflects to the choices.

6.6.1.20 View Consumption Limit Task

Table 121: ' View Consumption Limit ' Test.

Requirement	The system should allow the users to view consumption limit.
Test	• Choose building power tab and choose your building name. Check that the system shows a correct limit of the main sensor. • Choose a building power tab and general power. Check that the system shows a correct limit pointer that reflects to the choices.

6.6.1.21 View Electricity Bill Task

Table 122:'View Electricity Bill ' Test

Requirement	The system should allow the user to view bill's calculations.
Test	• Choose building power tab. Check that the system shows the correct calculations that reflect the sensors and building specifications. • Perform incorrect specifications of building or sensor/s. Check that the system shows incorrect calculations.

6.6.1.22 Receive Alarm Message Task

Table 123: ' Receive Alarm Message ' Test.

Requirement	The system should send an alarm message when the consumed limit approximately reaching the 75% of the specified limit.
Test	• The consumption rate approaches to the consumption limit. Check that the system sends an alert message. • The consumption rate does not approach to the consumption limit. Check that the system does not send an alarm message.

6.6.2 Simulation

Simulation is the imitation of the operation of a real-world process, probable real life condition, system or to forecast future effects of assumed circumstances or factors over time.

Since we had test the system for a small size prototype topology, the purpose of the simulation is to test the system with incremented degree of complexity in terms of size.

There are three main types of electrical domestic circuits ring circuit, radial circuit and lighting circuit. Ring and radial circuits provide sockets and fused connection units for plugs and appliances. Lighting circuit used for overhead lighting. It is basically multi-point radial circuits. We construct a model that covers only the lighting system in the home.

Case study:

By using Matlab and Simulink software, we simulate a real-size Saudi home which contains four bedrooms (master, maid, child 1 and child 2), two living rooms (male and female), kitchen and office. It's basically a simple AC circuit with resistance, switches, current and voltage sensors, see *Figure* ***92***. The sensors will measure the current (A) and voltage (V) then calculate the power (W). After that, we calculate the energy consumption (KWH) using formula $\text{Energy kwh} = \text{power} * 10 * 2.78 * 0.00000010 * 100$ and round the result by multiplying with 1E+24.

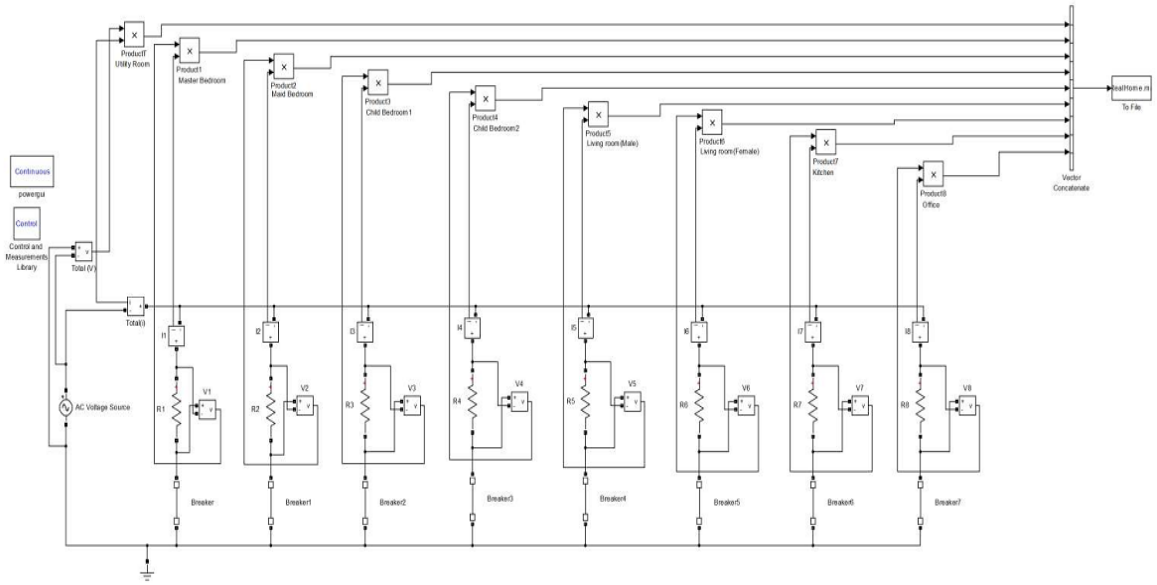


Figure 92: home circuit model

AC voltage source = 220 v

Master room, living room (male) and kitchen = 578 ohms

All other rooms = 1156 ohms

X-axis represents time

Y-axis represents consumption energy

There are four scenarios. First, we ran the circuit with all lights in all rooms is ON for one minute. Second, we turned OFF all the lights except the light that in the master room for one minute. Third, we turned ON all the lights in all bedrooms (master, maid, child 1 and child 2) for two minutes. Finally, we turned OFF the lights in bedrooms and turned ON the lights in living rooms for two minutes. Then, the extracted data went to the server and displayed in the iTrack system. See the result in *Figure* ***93***.

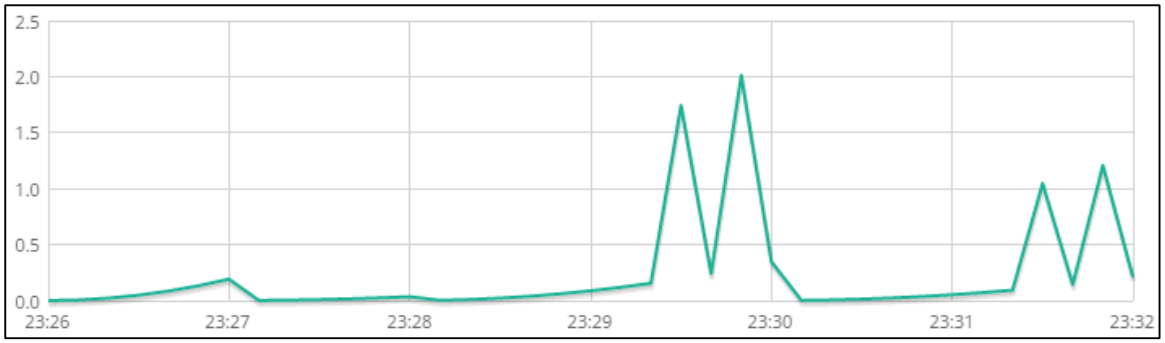


Figure 93: Energy consumption result

*Figure **93*** shows that the maximum value of the Energy consumption is in the period from 02:29:20 to 02:30:20, which is in the third scenario when all lights of the bedrooms are ON for two minutes.

6.7 Pass/ Fail Criteria

If each functionality of iTrack system passes all the previous testing mentioned in section 6.5 Approach and section 6.6 Testing Process, it will be considered as success functionality. However, if the functionality fails in one approach of the testing a modification of the system will take place in order to reach the success.

6.8 Environmental requirements

In order for these tests to be conducted, the hardware should be plugged to the electricity and it should send the data to its database. In addition, the software should be uploaded to an online server that supports sending email and Cron job.

6.9 Summary

Section 6.1 Purpose, Scope and objectives

- The main purpose of STP is to organize the testing process.
- The scope of testing covers all iTrack functionality.

Section 6.2 Test Items

- iTrack software components and job control procedure are the two categories of iTrack items.
- The MVC of iTrack will be tested as one unit.
- iTrack has three job control processes.

Section 6.3 Features to Be Tested

- All the functional and non-functional features of iTrack will be tested.

Section 6.4 Features Not to Be Tested

- System storage space and system maintenance are the functionality that will not be tested.

Section 6.5 Approach

- The construction testing will be bottom up testing, which will start with testing each single statement up to testing the integration between the system classes.
- The integration testing will test if the hardware and software can work together.
- Many unusual scenarios will be conducted to insure the security of the system.

Section 6.6 Testing Process

- Testing tasks sub-section contains the entire tasks that will be tested besides to how to test these tasks.
- In order to test the system with more complex scenarios, a simulation tool was used.

Section 6.7 Pass/ Fail Criteria

- If the system's fail, further modification will take place.

Section 6.8 Environmental Requirements

Plug in the hardware to the electricity and uploading the software to a server are the environmental requirements of iTrack system.

Chapter 7 User Manual

This manual has been prepared as one of the deliverables of iTrack senior project. It contains an explanation about how to use iTrack system. It is designed to be used by the end user of the iTrack system.

Outline

7.1 Introduction

7.1.1 Scope and Purpose

iTrack is wireless energy consumption monitoring system. It contains two parts: software part and hardware part. The software part is a website that provides energy consumption data for any size of building. The hardware is an open source monitoring system provided by openenergymonitor.com that contains EmonTx (wireless sensor nodes) and Raspberry Pi (base-station) components to provide a Real-time sensor measurements data to the users in order to make them more aware of their power consumption habits.

7.1.2 Process Overview

This document will help you to understand the iTrack so you can use it in the right way. Please read this document carefully before using the system in your building. The sequence of using the system:

- Guide Tour of iTrack.
- Using iTrack system.
- Specify the language (عربي/English).

NOTE: Before using iTrack website you need to place the emontx near your meter cabinet, Plug in the CT sensor and the AC-AC Voltage into the emonTx, Clip the sensor around either the live or neutral wire of the circuit you wish to measure. (Don't clip around both as the magnetic fields will cancel) then setup the Raspberry Pi by using ready-to-go image method. For more detail you can visit http://openenergymonitor.org/emon/.

7.2 Guide Tour of ITrack

You can visit iTrack website from www.itracksystem.com and view the general pages from the top menu.

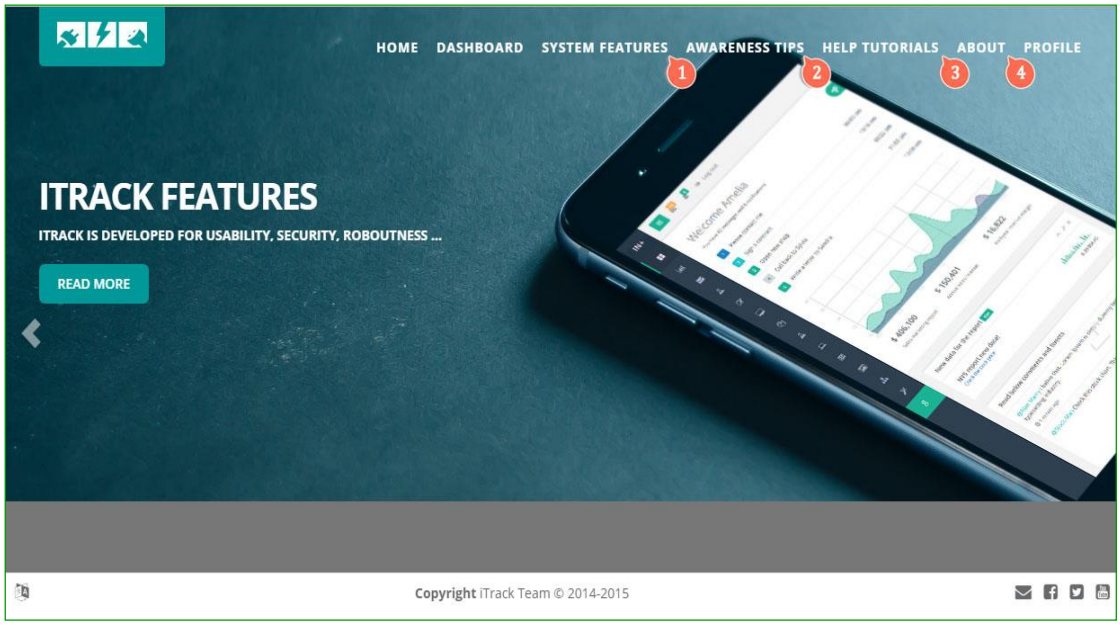


Figure 94: Home interface

1. Select system features to read about iTrack features.

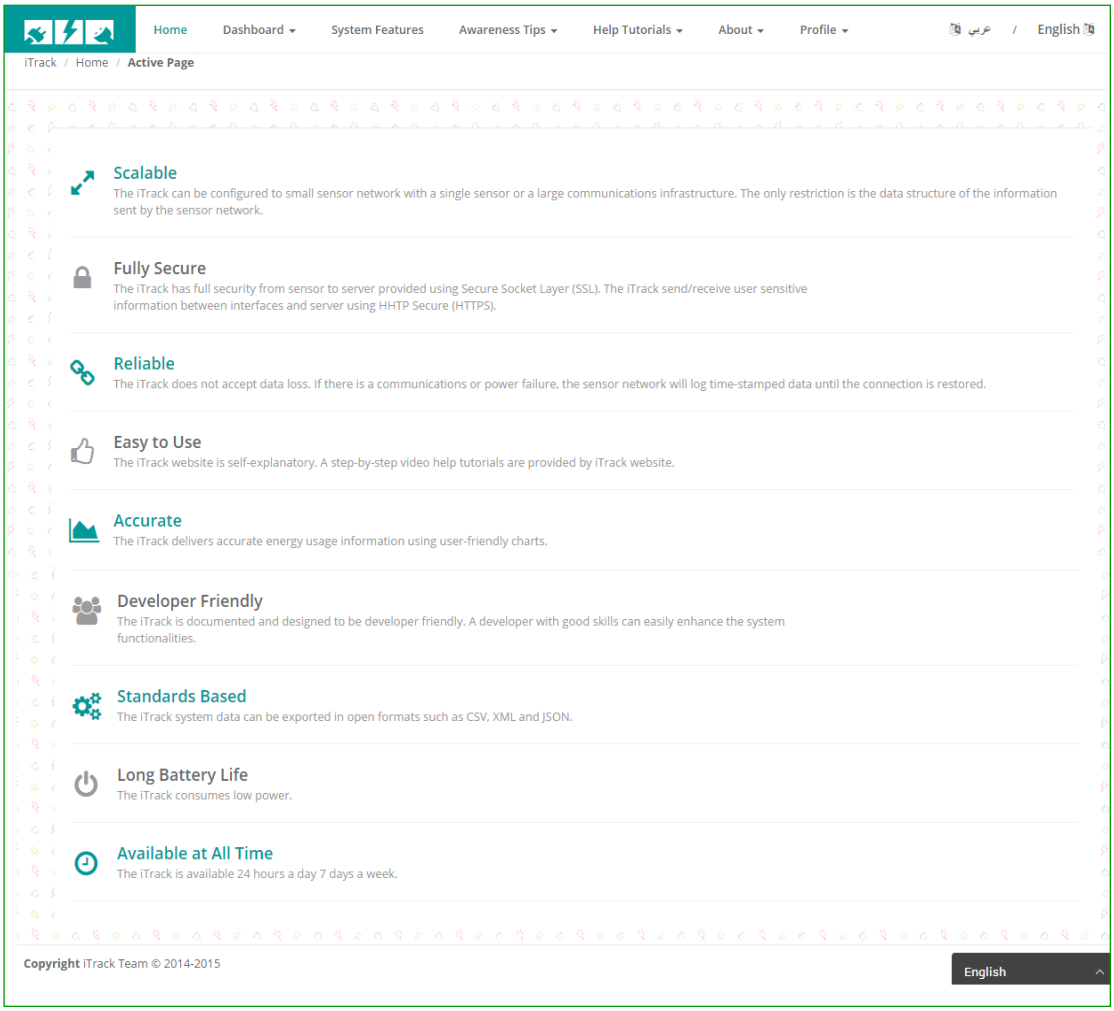


Figure 95: System features interface

2. Select awareness tips help you to improve energy efficiency. There are three tips categories (General, Safety and Saving Energy).

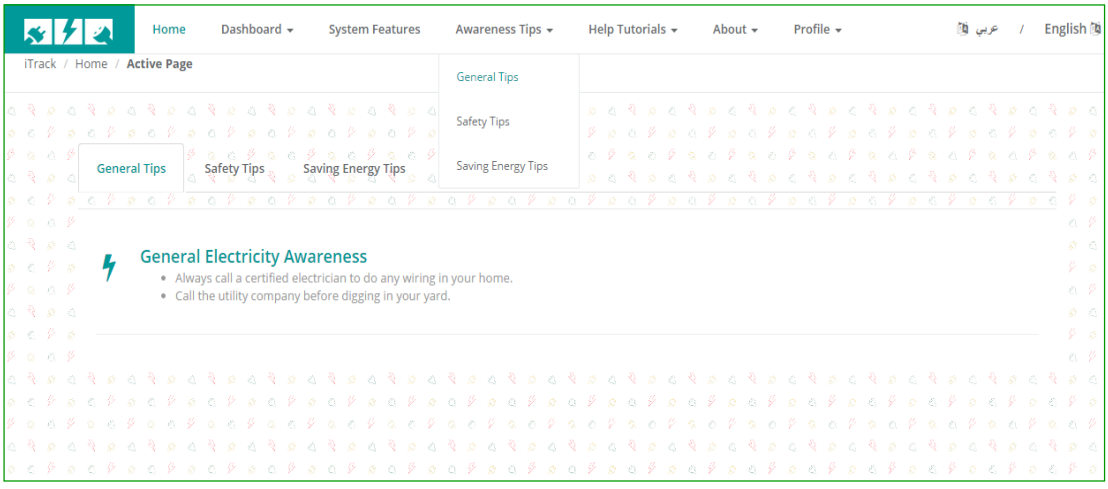


Figure 96: Awareness Tips interface

3. Select help tutorial to display videos that guide you in (Guide Tour of iTrack, How to Create Account, How to Set Power House Properties Information and How to Use iTrack to Monitor the Power Consumption).

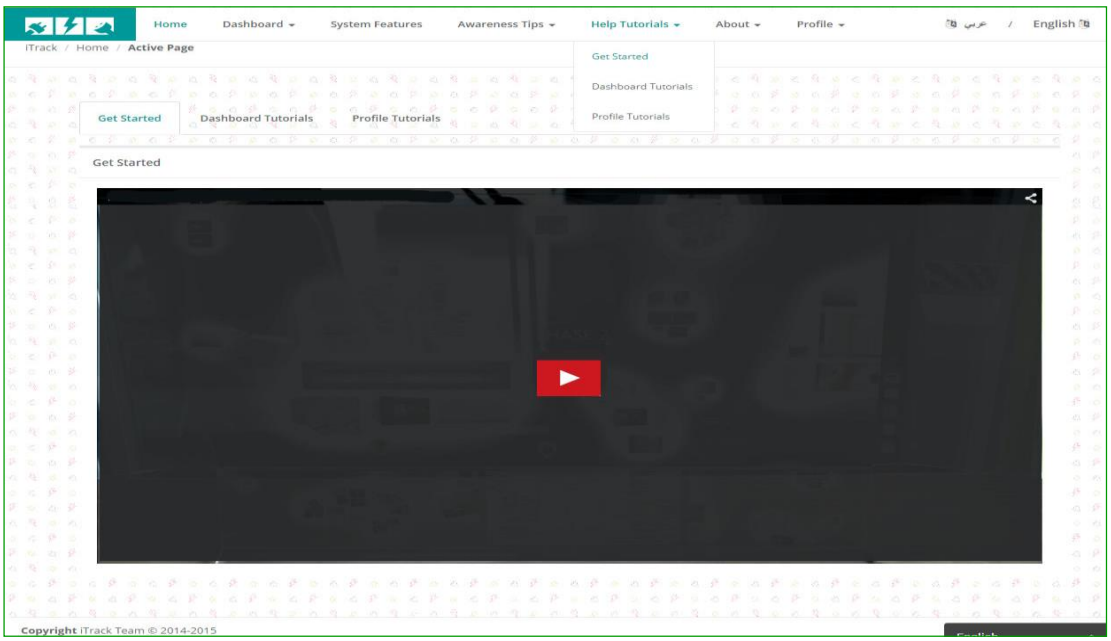


Figure 97:Help Tutorial interface

4. Select about to display:

4.1 iTrack team member.

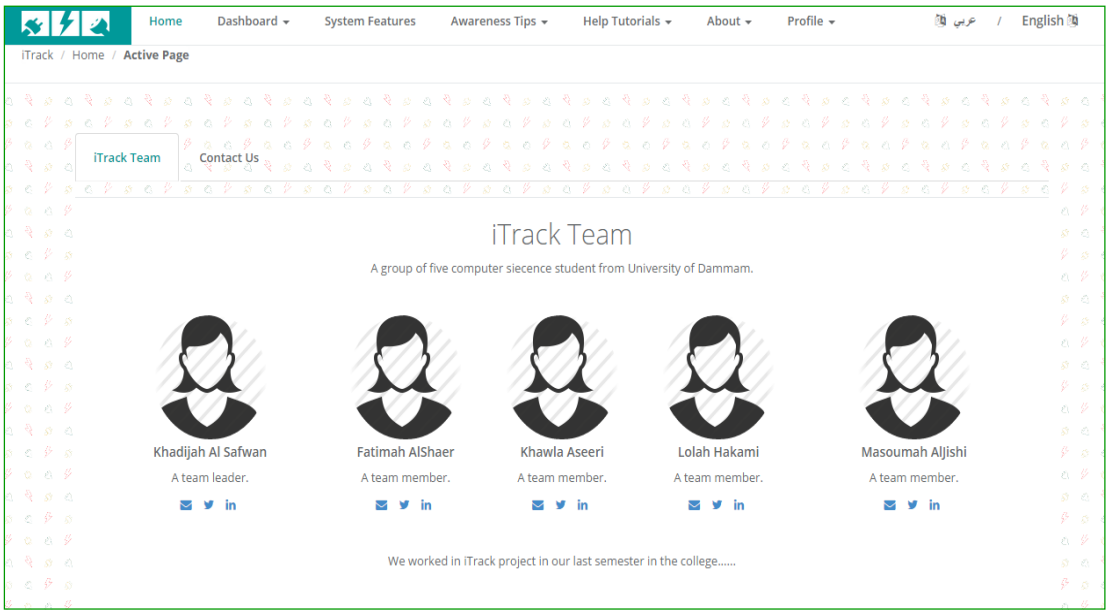


Figure 98: ITrack member interface

4.2 Contact us by sending an email.

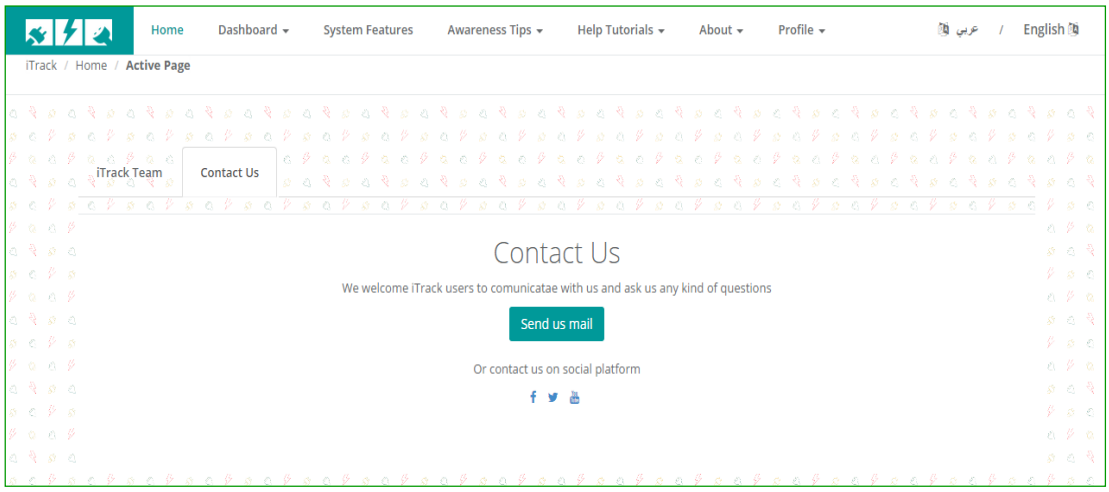


Figure 99: Contact us interface

7.3 Using iTrack

7.3.1 How to Create Account

You can manage your profile by:

1. Sign up to create new account.

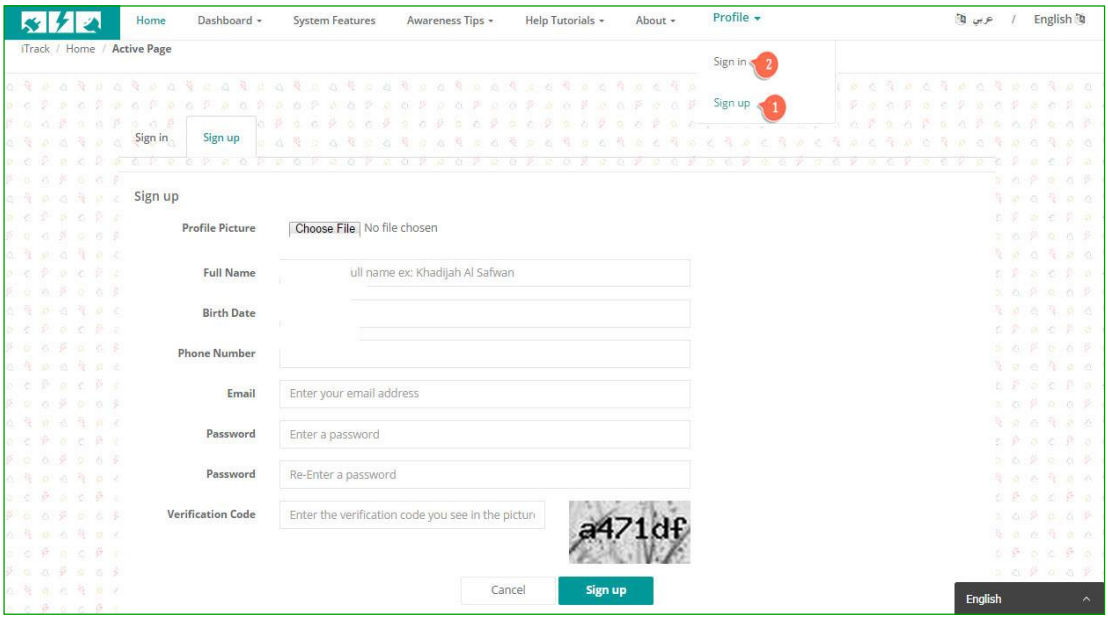


Figure 100: Sign up interface

2. Sign in if you had an account.

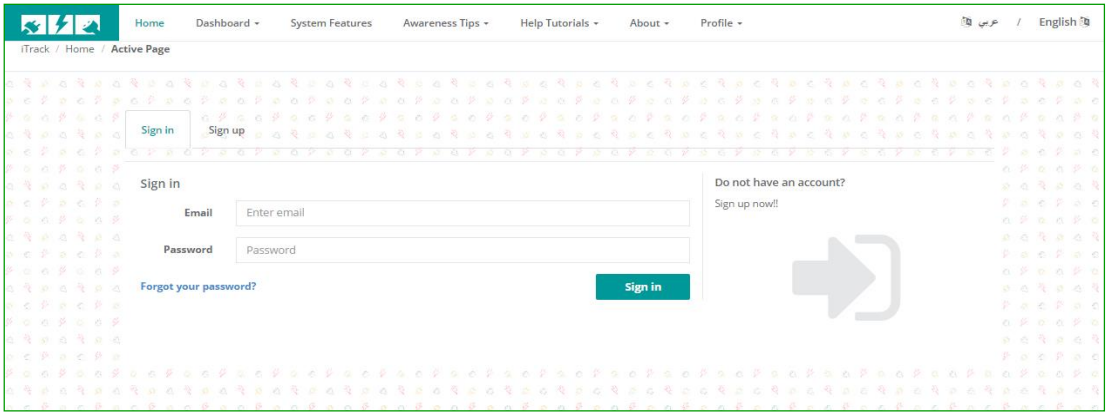


Figure 101: Sign in interface.

NOTE: you need to visit the link that has been sent to your email to activate your account and to have a full privileges for using iTrack website.

By sign in the profile drop down list will be changed.

1. Select my profile to see your information.

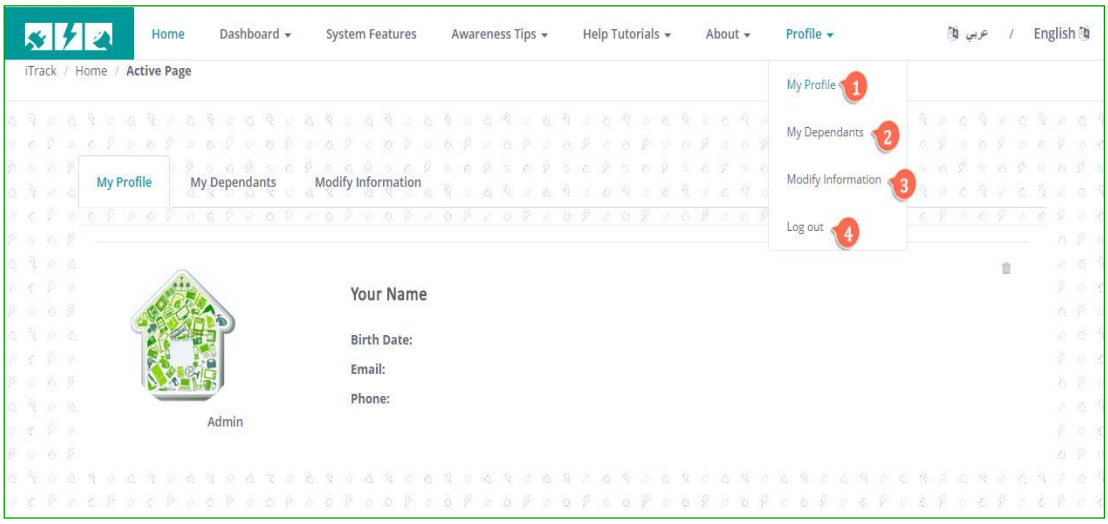


Figure 102: My profile interface.

2. Select my dependents to display your dependent and add new dependent.

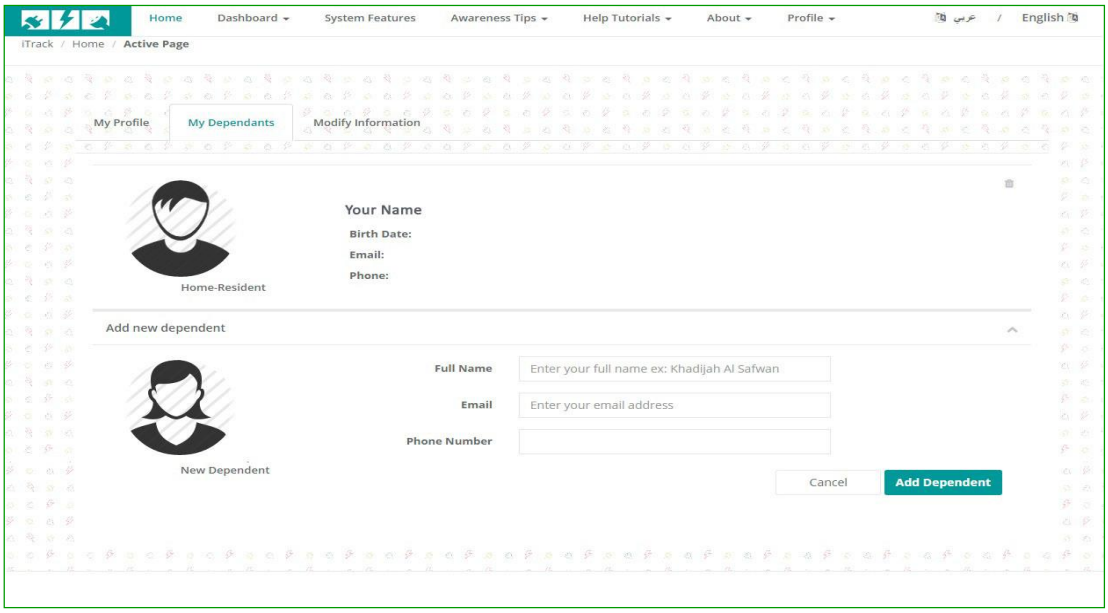


Figure 103: My dependent interface.

NOTE: your dependent need to visit the link that has been sent to his/her email to activate his/her account and to be able to use iTrack website.

2.1 After the dependent clicks the link, the continue regestraion form will appear.

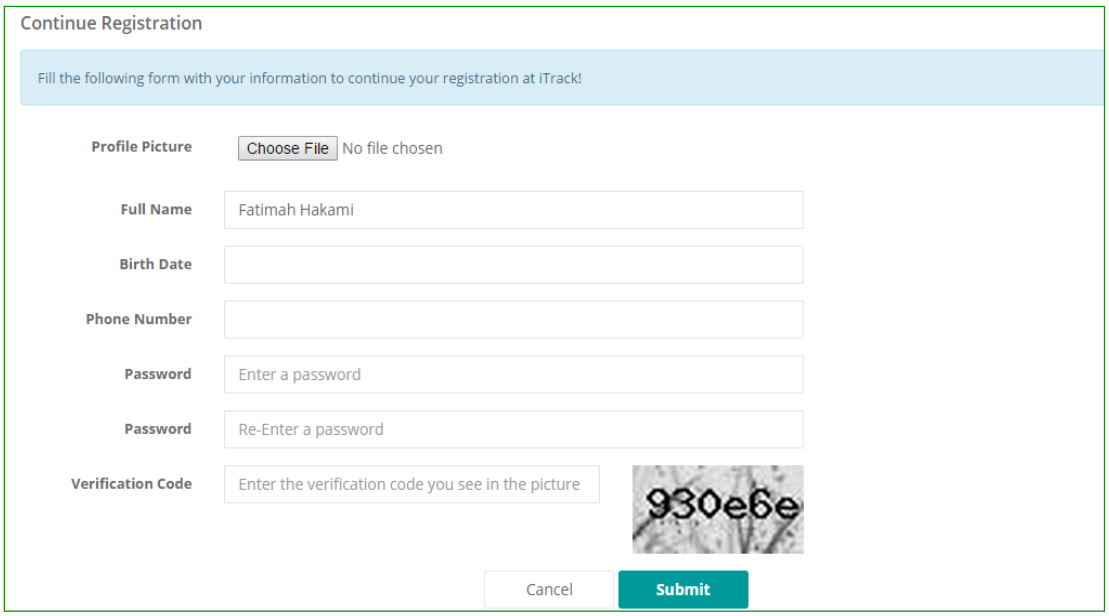


Figure 104: Continue registration interface.

2.2 Click (submit) button then new dependent information will be created and the information in my dependent tab will be updated.

3. Select modify information to change your general information, change password or change email.

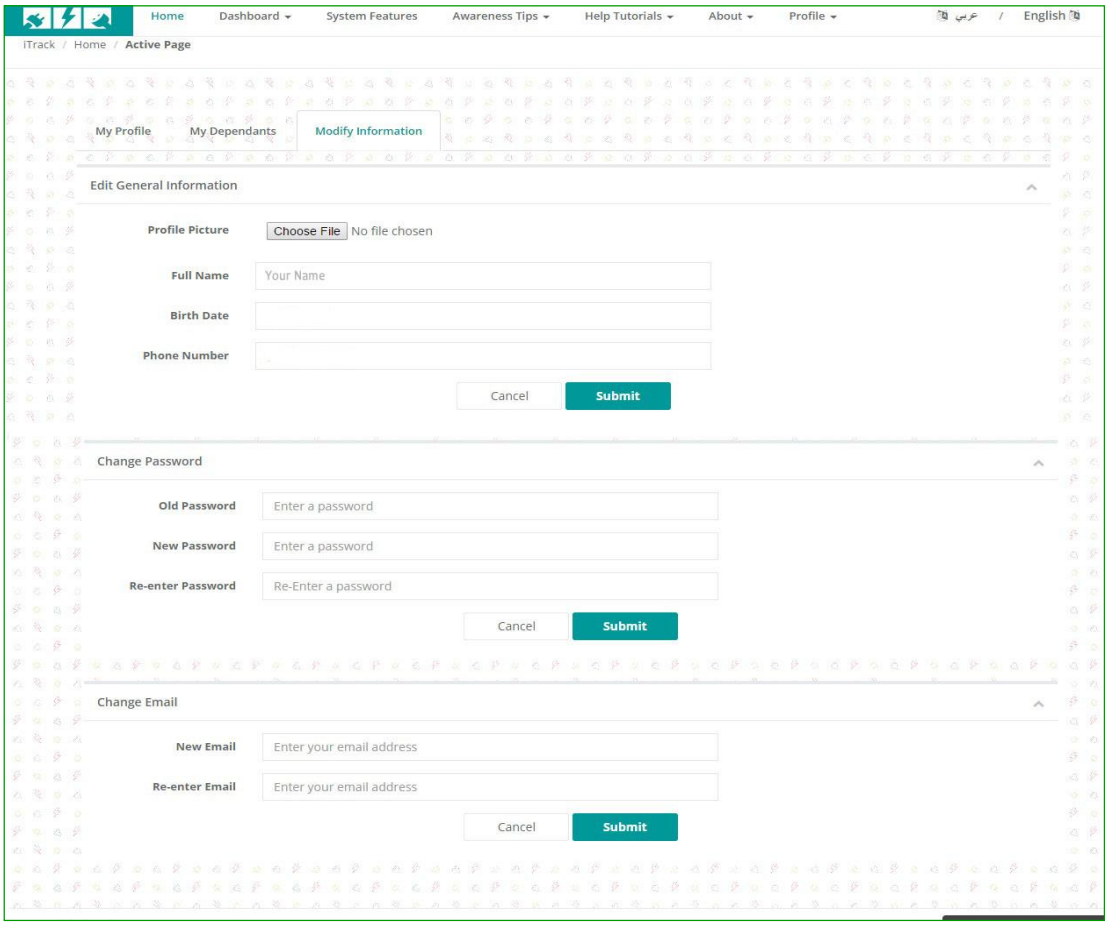


Figure 105: Modify Information interface.

4. Select log out to exit from iTrack website.

7.3.2 How to Set Power House Properties Information

You can set your house power by:

1. Select the building information from dashboard drop down list from top menu.

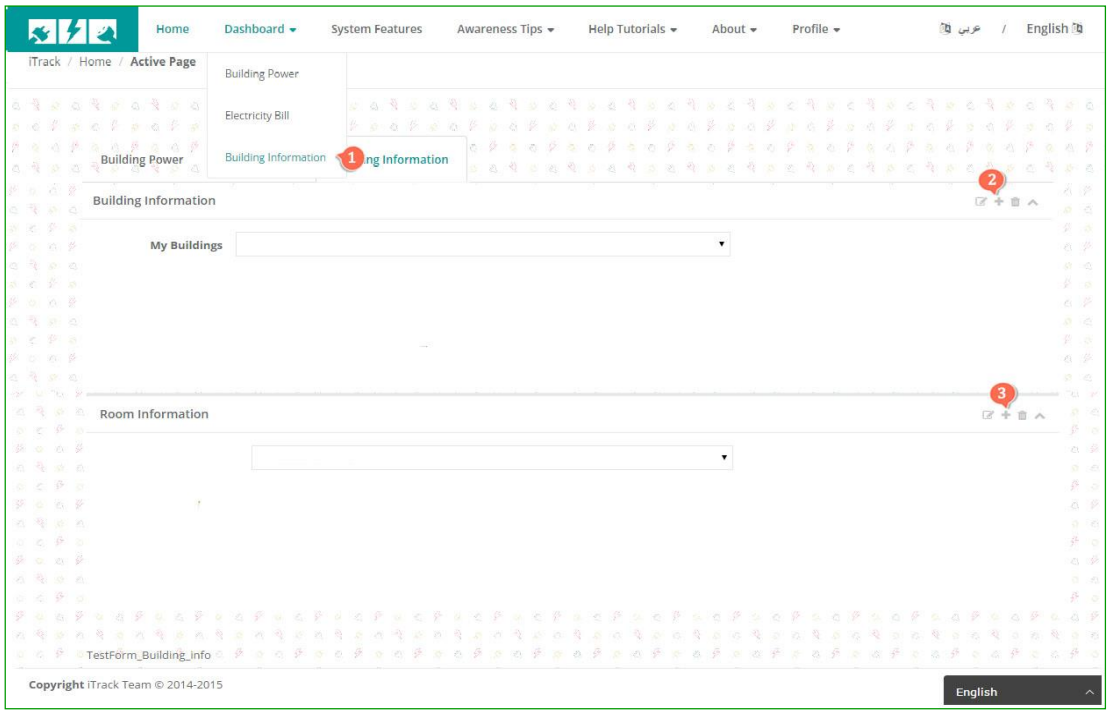


Figure 106Building information interface

2. Click (+) icon in building information box to add your building. Add new building box will appear.

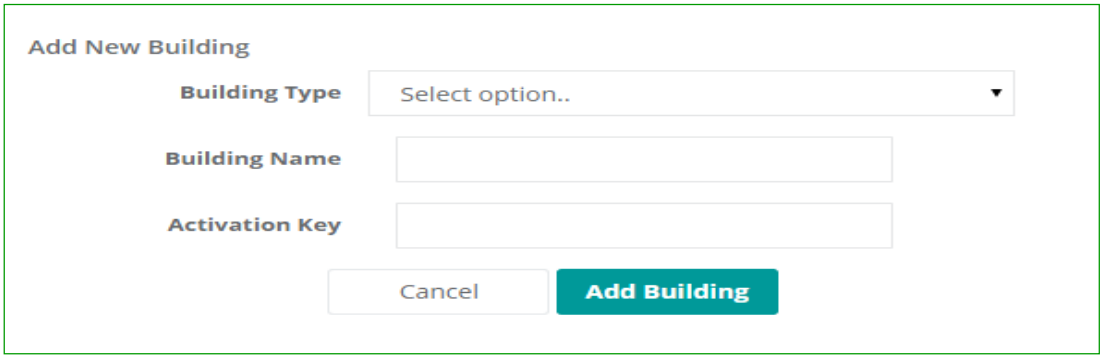


Figure 107: Add new building interface.

NOTE: you need to have the valid activation key provided from iTrack team member.The contact us page can helpe you to get it.

3. After you add building information, click (+) icon in Room information box to add your Room, Add New Room box will appear.

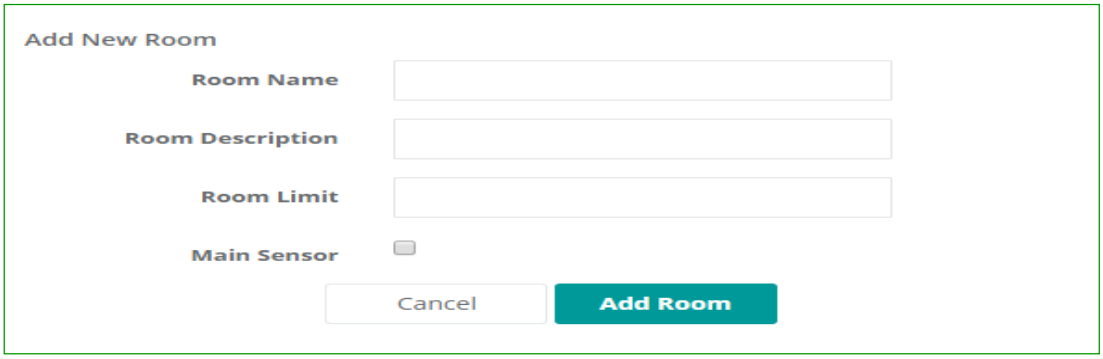


Figure 108: Add new room interface.

NOTE: you should specify one of your rooms as main sensor. If you don't have one the website will display alert message.

By adding building and room information you can select them from drop down list to display, edit or delete:

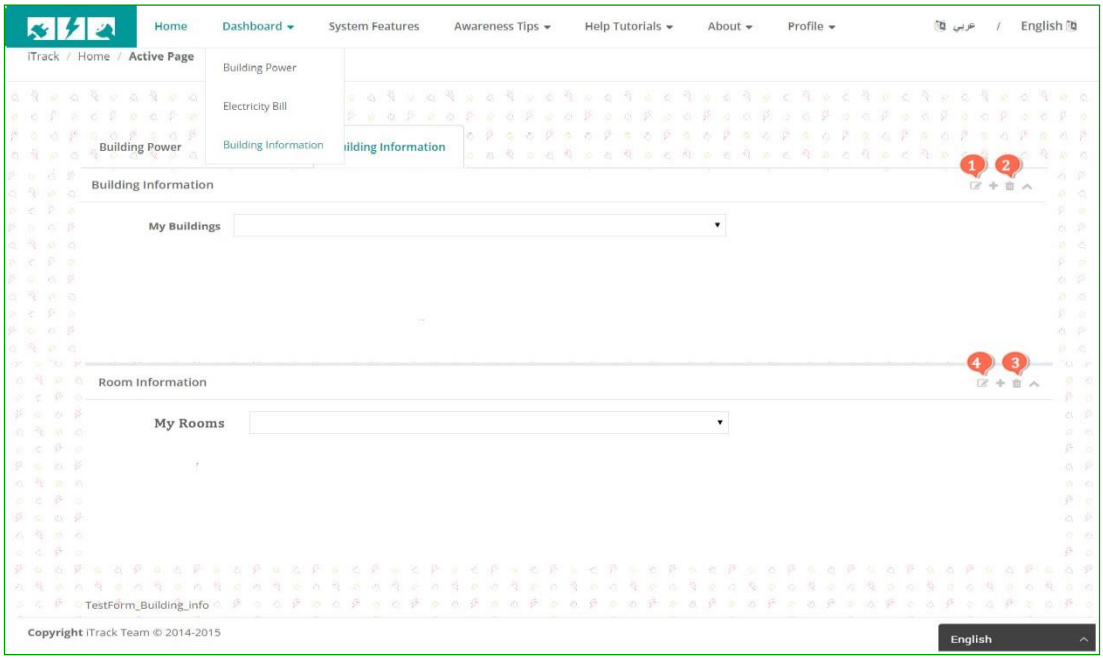


Figure 109: Display, edit or delete building interface.

1. Select the building from my buildings drop down list then click (edit) icon in building information box to edit your building .The edit building Information box will appear.

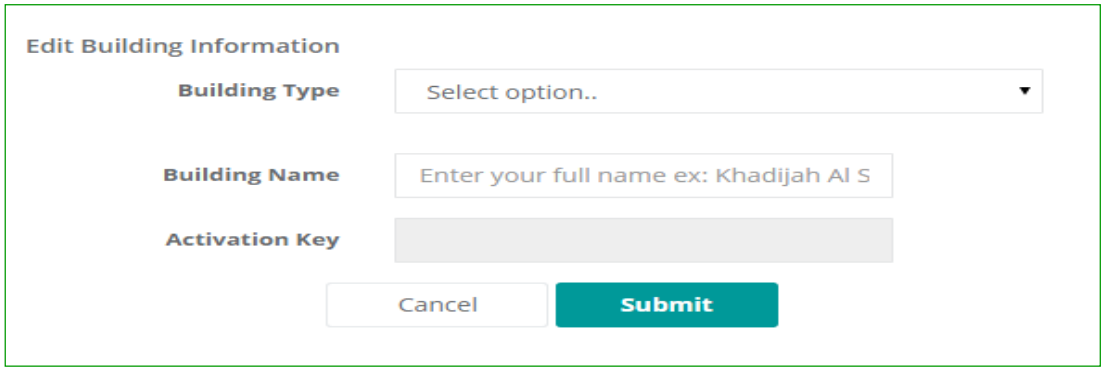


Figure 110: Edit building information interface.

2. Select the building from my buildings drop down list then click (delete) icon in building information box to delete your building .The confirm message will appear.

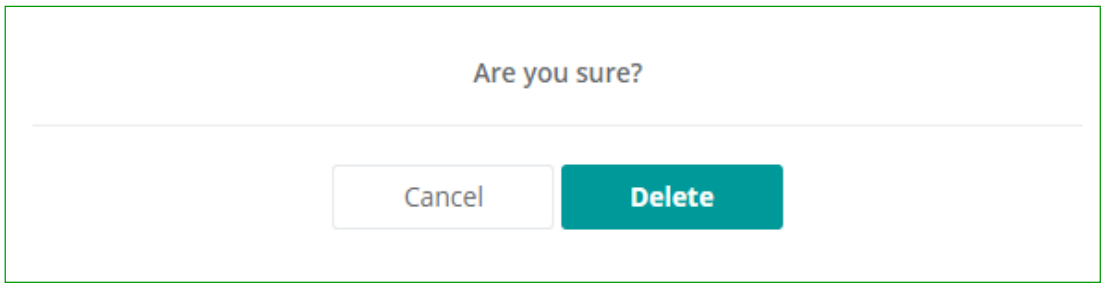


Figure 111: Delete building information confirmation message.

3. Select the Room from my rooms drop down list then click (delete) icon in Room information box to delete your room .The confirm message will appear.

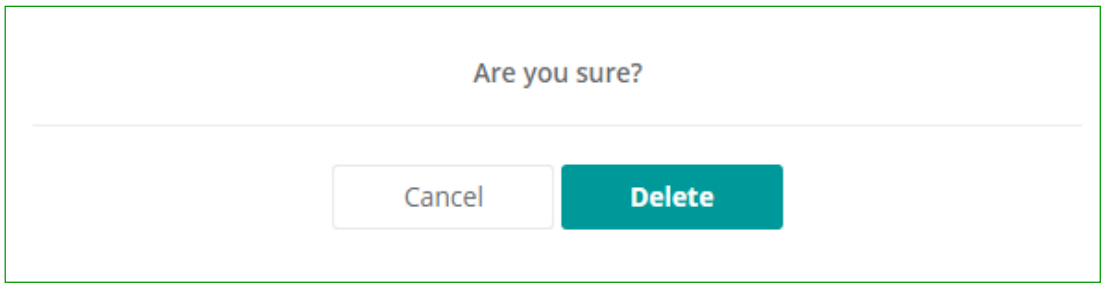


Figure 112: Delete room information confirmation message.

4. Select the Room from My Rooms drop down list then click (edit) icon in Room information box to edit your rooms .The edit room information box will appear.

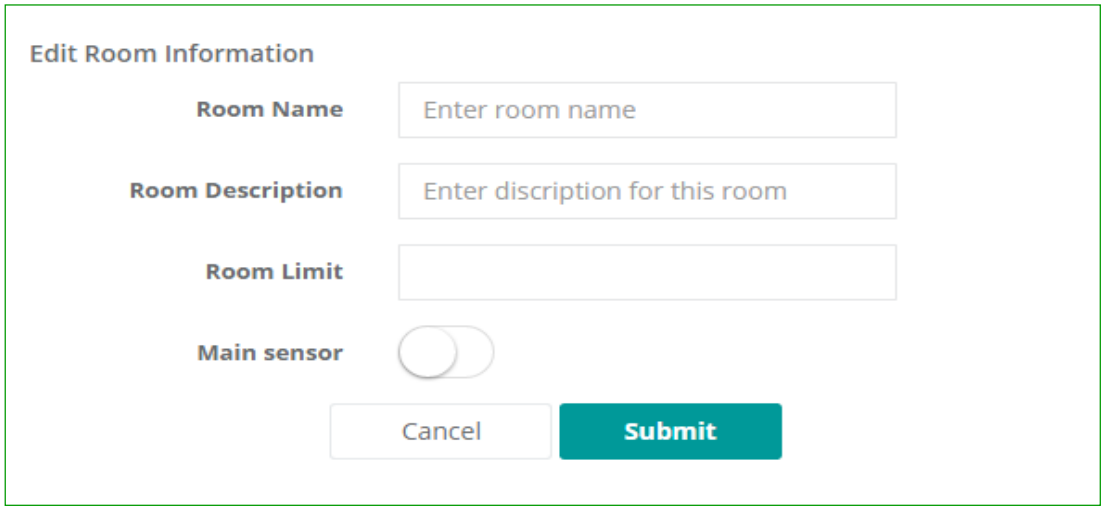


Figure 113: Edit room information interface.

7.3.3 How to Use iTrack to Monitor the Power Consumption

After you add building and room information from building information tab, you can monitor your building power consumption and compare between specific sensors power consumption by:

1. Select the building power from dashboard drop down list from top menu.

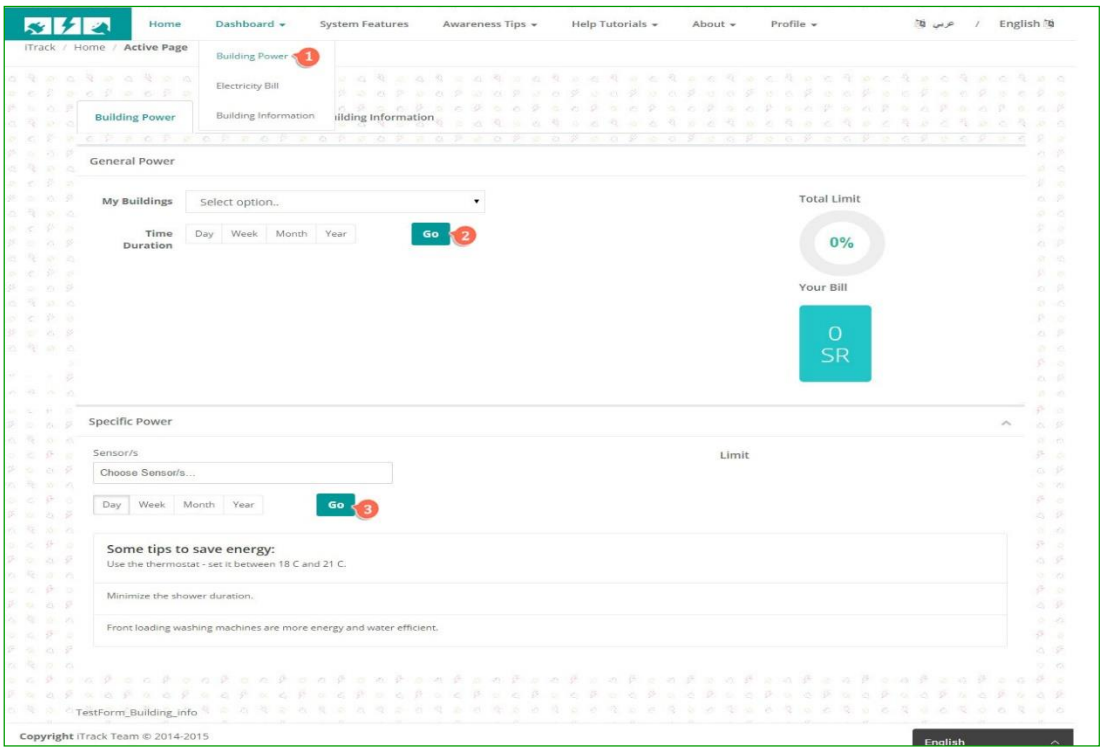


Figure 114: Building power interface.

2. Select the building from my Building drop down list then click (Go) button. The building power consumption chart, limit and the bill will appear.
3. Select the rooms/sensors from sensors drop down list then click (Go) button. The specific power consumption charts, limits will appear. You can select up to six sensors.

NOTE: you must select the building and sensor from drop down list befor you click go button .If you don't select the website will display error message and information will not be displayed.

4. Select electricity bill tab to see electricity bill for selected building type from the drop down list.

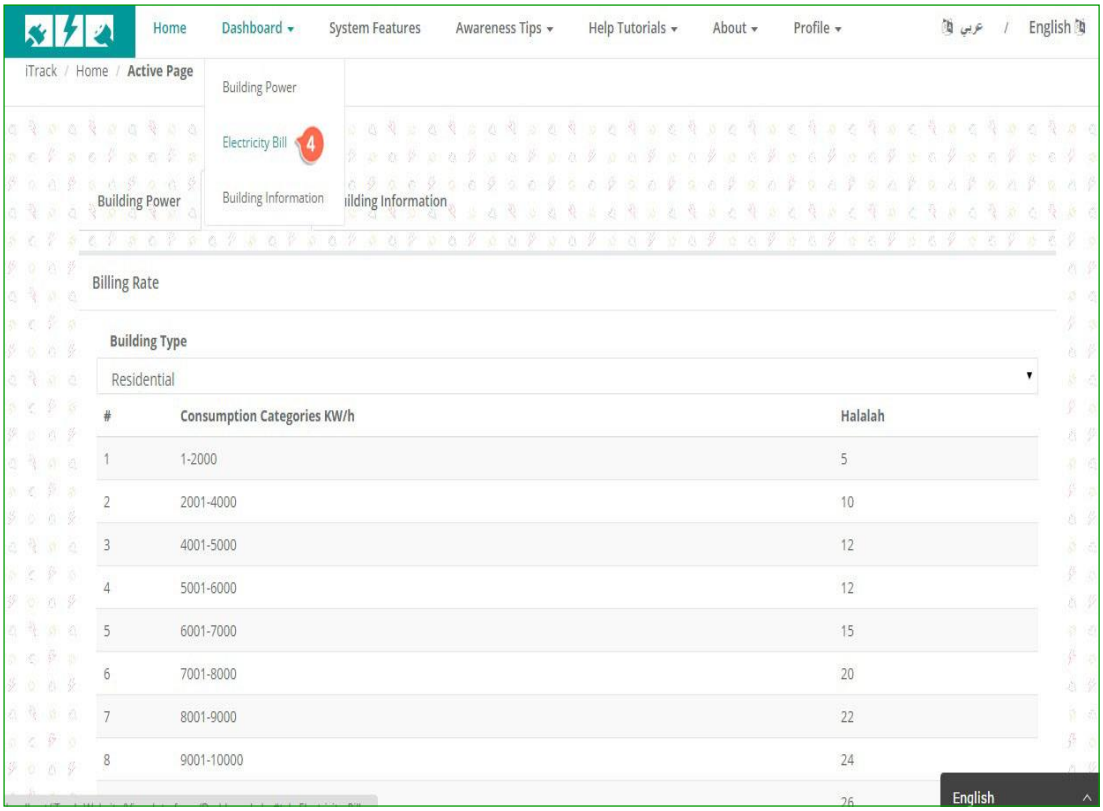


Figure 115: Electricity bill interface.

7.4 Specify the language (عربي/English)

iTrack system is available in two language (عربي/English), you can select one of them from the top menu. The English is the default one.

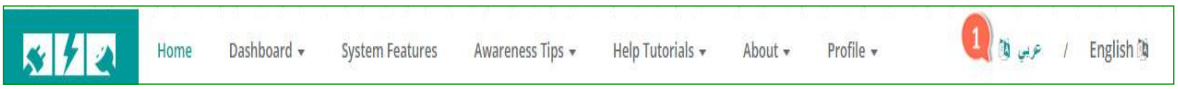


Figure 116: Specify language.

Chapter 8 Conclusion and Recommendations

This conclusion and recommendation is the last part of iTrack system documentation. It encloses the conclusion about the project and the recommended actions for iTrack project continuation.

Outline

8.1 Conclusion

To conclude, iTrack is home energy consumption monitoring system that communicates usage data to the customers in order to make them more aware of their power consumption habits. We can proudly say that iTrack has successfully met the stated requirements. iTrack development let us apply all the areas of computer science studied throughout our bachelor program. It also touches in the interface of computer science, computer engineering and electrical engineering. iTrack as a senior project is considered to be a complete project where our skills and knowledge has been expanded.

8.2 Recommendations

For the purpose of expanding the scope of iTrack and reaching its vision, we recommend the continuation of iTrack system development. We donate our project resources, software and hardware, to the college of computer science and information technology for project continuation. In the following two sections, some recommend improvement and development of iTrack software and hardware is presented.

8.2.1 iTrack Software:

For continuation of development and improvement of iTrack software we recommend:

- Integration of iTrack with the Saudi Electrical Company database for billing rates, electricity customer numbers, bills information,...
- Enhancement of iTrack features by implementing new useful functionalities. For example: adding visual blue print of the house instead of inserting the building informations using forms, calculate the bill for each room instead of the whole building, ..etc
- Improvement of iTrack by adding error detection techniques of abnormal situations in the home electrical cuircit.
- Improve system by adding learning techniques to predict the future electrical consumption.

8.2.2 iTrack Hardware:

For development of iTrack hardware we recommend:

- Development or construction of a hardware device that can be sold and installed easly in buildings to read electrical consumption information.
- Invistigation of the hardware network performance and topology.

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