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SMART HOME DEVELOPMENT PROJECT

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1. Problem Definition

Smart home technology, also known as home automation, provides homeowners security, comfort, convenience and energy efficiency by allowing them to control smart devices, often by a smart home app on their smartphone or other networked device. Smart home systems and devices often operate together, sharing consumer usage data among themselves and automating actions based on the homeowners' preferences. This is what we are also trying to achieve. Build a smart house in which devices can be connected to each other, making life easier. Although we want to build a smart house from the ground up, the components built into the system are mostly already implemented; we just improve them and try to come up with new technologies or functionalities.

1.1. Project Scope

We are trying to build a smart house that has the following features:

- Mood Lighting
- Intelligent Audio Connectivity
- Thermostat
- Repeater Kit
- Streaming Media
- Motion Alarm Sensor
- Noise Alarm Sensor

Each of these functionalities is incorporated in the house project we are proposing and they have many ramifications. For example, the Noise Alarm Sensor is used for keeping the house secure and away from predators, but this same noise sensor is used for other different features such as voice recognition and control. This way, the user is one click away from turning any device on, and from making his house, a home. We will further discuss each of these functions and key approaches (with every challenge they face) in continuation in this paper.

2. Current approaches to Smart Homes

Smart Homes and IoT, in general, have known in the last decade the biggest expansion in the technology field. Every system developed has been inclined towards automation and, therefore, helping people in their day to day tasks. Having this in mind, our desired functionalities have been already been implemented by other systems, however as any technology, smart homes can be evolved because they still have some problems that we try to overcome in our own proposed project.

2.1. Mood

2.1.1. Mood Lighting

The first functionality we are addressing is mood lighting. Smart lighting is a common entry point for home automation, but what is the point of upgrading to mood lighting in the first place? Controlling the lighting, either remotely in-app, using voice commands or using noise

sensors, puts convenience at uppermost. Therefore, we propose a system that can satisfy the needs of clients' either if they want the light in their house to stay at a certain level depending the time of the day and the sun or they just want light to turn on when they pass by.

Advantages:

- Conserve energy
- Convenience: when you walk into a room, light automatically comes on / when there is more light outside, the light inside will be less bright, but as the sun sets, light inside will be brighter

Drawbacks:

- High initial costs
- Lack of control
- Unwanted brightness level of light

Here are some major spaces in your home that could benefit from mood lighting:

- Bathroom
- Bedroom
- Dining Room
- Kitchen
- Living Room
- Outdoors

2.1.1.1. Mood Lighting in the Bathroom

Setting up lamps in the bathroom is problematic, so the obvious analog solution to mood lighting when you are soaking in the tub is a scented candle.

Smart bulbs allow you to sidestep the lamp and control the main light bulb in-app on your smartphone. It is a great way to adjust the brightness levels and switch up the coloring depending on whether you are firing up for your day or unwinding after hard hours at the office.

2.1.1.2. Mood Lighting in the Bedroom

Chances are you have a smart speaker or smart display in the bedroom. This is the obvious starting point for mood lighting in the boudoir.

2.1.1.3. Mood Lighting in the Dining Room

Lamps on dressers and tables work well in the dining room.

Strip lights used lightly around mirrors, clocks, and other features can also work well in some cases.

You can also take advantage of the main light for mood lighting, as long as it's dimmable. This can be applied throughout the house allowing you to control personalized brightness levels with a swipe, a voice command or sensors.

2.1.1.4. Mood Lighting in the Kitchen

Under-cabinet lighting is an effective way to mix things up in the kitchen.

Down lighting works well, too. Get yourself some LED downlights so you can save energy and costs at the same time as injecting some personality into your kitchen lighting.

2.1.1.5. Mood Lighting in the Living Room

Using LED strips along with robust voice-activated smart lighting lets you stay in complete control of the atmosphere in your living room, without needing to get up off the couch.

Simple dimmers give you brightness levels on tap while you can switch up the colors of your lights in-app or using your digital butler of choice.

2.1.1.6. Mood Lighting Outdoors

Get creative outside, too.

You can use outdoor smart plugs to automate and control old landscape lighting.

Whether you have an intimate dinner party or a boisterous BBQ planned, make sure you have the lighting on lock.

2.1.2. Intelligent audio connectivity

Bluetooth speakers – which enable you to play music directly from your smartphone or tablet – are also a common sight in Smart Homes. Just like with lighting, you can also link up multiple speakers to form an intelligent multi-room audio system that delivers a premium audio experience throughout your home. You can select songs, adjust the volume and fine-tune your sound via an app; the system can even be controlled by voice if you have a compatible Smart Home system installed.

Advantages:

- Listen to music anywhere in the house (perfect for the bathroom)
- Link multiple speakers for a better experience
- Control music from your phone, you don't need to reach the speakers anymore in order to adjust the sound level, for example

Drawbacks:

- Compatibility: your phone and/or tablet may not be compatible with the audio integrated system
- Installing such a system can be difficult

2.2. Energy Efficiency

With smart technology, homeowners can take control over their energy usage with a variety of energy-saving appliances. For your convenience, these machines can be controlled remotely, so you never have to worry about forgetting to turn them off.

Often, people run their dishwashers and laundry machines at the same time as multiple households across an electrical grid, which creates peak demands for energy. With automation, you can ensure that these appliances operate during off-peak hours.

2.2.1. Thermostat

Since heating and cooling comprise about half of the typical electric bill, those looking to save an energy buck often look to smart tech: In fact, the first piece of every home is typically a new smart thermostat. What makes these tiny pieces of tech so intelligent? Smart thermostats, like other smart devices, allow you to remotely control your home's temperature via mobile or internet-connected device. This unique capability makes operation more convenient, offering greater control of heating and cooling, and thus, energy savings.

They offer remote operation from anywhere via smartphone, mobile device, or voice-operated home automation systems like Google Home and Alexa, and tons of added bells and whistles, including energy-usage reports to help you identify additional opportunities for savings.

With a programmable thermostat, you can set the temperature to different levels at predetermined times throughout the week. For example, during the winter, you can set the inside temperature to a lower level when you are at work and the house is unoccupied.

Advantages:

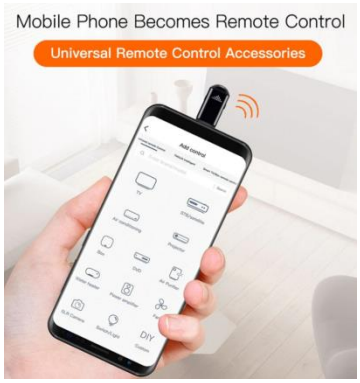
- Multiple settings
- It lets you be energy-conscious without a lot of effort; set it and forget it
- Informs you about maintenance needs: A smart thermostat will alert you when it's time to change the filter in your air conditioner and furnace

Drawbacks:

- If you work from home, or there is always someone there, then programming the thermostat is not that much needed
- Not all heating and cooling units are compatible with a smart thermostat; that can be a problem if you plan to change the equipment often
- The software and touchscreen display panel can be tricky to learn

2.3. Entertainment

2.3.1. Repeater Kit



With a plethora of home theatre components and brands on the market, it has become increasingly difficult to place the products out of sight, yet within reach. An infrared repeater kit solves the problem and has become a smart home essential, allowing you to use an existing IR remote control to operate multiple audio-visual components located behind closed doors or walls in an entertainment cabinet or equipment closet.

Long gone are the days of messy remote control drawers. Today you can dim the lights, kick on the A/C, set the security, and turn on your favourite movie all from the same remote.

Forgot to turn on the dishwasher? No need to get up! Set the cycle to run straight from the phone you are using to control the entertainment and mood lighting. These products are great and can be programmed by just about anyone.

Advantages:

- Control every device using the same wireless connected remote (phone)
- Cannot lose equipment's remotes anymore

Drawbacks:

- Out of signal range equipment
- If you lose the phone, you lose control to every equipment component

2.3.2. Streaming Media

Entertainment right now is overflowing with technology. With the rise of streaming media and internet-connected media, you are able to upgrade your viewing and listening experience in your home completely.

Use Alexa, Google Home, or other smart speakers to control what content you are delivered throughout your day. You can consolidate all of your music services and change the tune for every room.

With smart TV and projectors, you can have access to all your favorite media straight from your home cinema. If you wish, you can control all of these systems through one remote, which is also connected to your home's appliances.

Advantages:

- Handle your Social Account on Bigger Screen
- Upgrade your viewing and listening experience

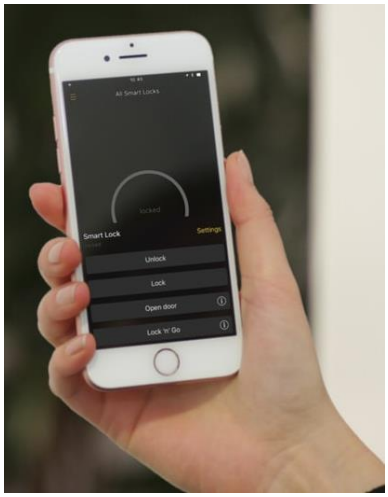
Drawbacks:

- The risk of never being offline and the threat of cyber theft increases: theft of data and loss of privacy is very common

2.4. Security

2.4.1. Motion Door and Window Sensor

Every time the door or windows is opened, you'll receive an alert telling you what's happened. You can also use the smartphone app to quickly check all the doors and windows fitted with a Window or Door Sensor are closed before you leave home.



It's a simple system that works well, and definitely one of the best sensors that we've come across.

Advantages:

- It does not need any wires which make it easy if you need to reposition your motion sensors into another area of your house or office
- Automatically dialling 911 when it detects unwanted entry

Drawbacks:

- The sensor will be started by any movement, such as a pet, and not always by a threat
- Each component of your motion alarm sensor must be within radio range of each or else the sensors will not be able to trigger an alarm
- Since wireless motion sensor alarms can cover only certain areas of your house it is best to install them in rooms where your valuable properties are kept

2.4.2. Noise Sensor

Your Ring Alarm detects an issue. You'll receive notifications when the noise detector is triggered. You can check the smartphone app to verify whether it's simply a family member coming home or something more serious.

Advantages:

- They are easily affordable
- Perfect for home safety
- It is easy to manipulate sound in real time. Hence earlier recording is not needed

Drawbacks:

- Often it picks up near by radio signals and hence interference cancellation microphones are needed
- The wireless microphones have limited coverage range
- Operation time of wireless microphone is limited due to battery life

3. Stakeholders and their needs

The stakeholders can be a varied group of people. Because everyone is different, we have conducted a research in which we discovered the people that could be most interested in our project.

The first fact that could differentiate our stakeholders is age. Younger people are generally more interested in technology and they are more eager to try new things and in general more eager with technology. Our smart home is mostly done to simplify the life of everyone and young people are all about simplification of their life. Therefore, our main stakeholder in the age group are the younger people.

The older people could also be an interest, but here the level of education and revenue can highly influence their need of purchasing a smart home. Moreover, richer and smarter people would buy want a smart home more than the same people in their age group.

Another factor that can determine our success on the market is whether we intend to make it available for independent users or collaborate with certain institutions or companies that wish to include it in certain bigger projects.

After thorough consideration, we have decided to make it available for both independent and project based users, but to make a clear distinction between the characteristics of the two groups and thus adapt the marketing plan in accordance with the differences.

In addition, a big stakeholder can be investors that could want the technology we are using and reusing the technology in other house projects.

These being said, we have divided the stakeholders into the following categories:

1. users (buyers)

1.1. independent users (ranging from 20 - 50 years)
1.2. group users which, in turn, will be divided into:
1.3. designers and developers
1.4. insurance companies
1.5. housing corporations
1.6. service providers
1.7. caregiving institutions
1.8. the government

2. owners (our team)
3. creditors
4. suppliers

4. System requirements

4.1. Software

As for the software used in the implementation it should be updated with the latest hardware in order to perform in the best way possible. The location is a decisive variable in the requirements for operations as it determines most of the materials used and how to use it. The age of users of the smart home is another variable that is very important as the usability and simplicity of the software will be determined according to the understanding of the users.

Many types for the equipment used are spread throughout the market. We cannot say there is a perfect type because each person has his own need and has his own perfect view for his dream home but there is a certain criteria and certain limit that must be taken in consideration to achieve a good level for the equipment. In all smart homes, the equipment must be electronic so the chosen type must be efficient and not expensive. In the field of software, our equipment will be connected with the Internet all the time to update the software of the components. The software is easy, simple and can be used by each person and with different ages. Talking about the facilities our smart home will provide a lot of features.

First feature is the smart control access that will let the user control every single part in his home like lights, temperature etc.

Second, the light system that contains smart motion sensors that sense the heat of the human being body to light the rooms.

Similarly, as we said above this chapter categorizes requirements for creating applications in smart homes. The list of requirements provides guidance for tool developers from an industry perspective. A composition tool should either fulfil these requirements inherently or provide means to solution developers (e.g., installers, homeowners) to cover relevant aspects with little effort. The requirements are clustered in seven categories, each of which consists of three to five requirements.

4.1.1. Simplicity

Simplicity describes the complexity of application development. It involves the interaction between the system and the application developer.

- *Learning*: Targeting usually untrained home end users the composition tool must be easy to learn and simple to use.
- *Building/Changing:* Experienced or trained users should be able to quickly develop or modify even complex applications.
- *Levels of abstraction*: Providing multiple layers of abstraction allows to hide implementation details to end users and to expose them to more advanced developers.

4.1.2. Modelling

This category deals with requirements that affect the way the smart home applications can be modelled.

- *Eventing:*

Applications in smart homes are highly event-driven. This is due to domain characteristics as well as resource and energy constraints of devices. Thus it should be possible to model fine-grained event management (e.g., subscribe, unsubscribe) and event delivery. It should further be possible to model event management, to deal with both synchronous and asynchronous events, and to handle events with defined and undefined order.

- *Expressiveness*:

Smart home applications combine information from multiple domains (e.g., health care, security). To make creation of such applications efficient, application developers should be limited in their capabilities to some extent. However, the challenge is to still provide the expressiveness that is needed to develop powerful domain-specific and cross-domain applications.

- *Statefulness*:

Modelling states of the complete environment and transitions between states is closely related to state-based devices in the home domain. This results in different behaviour of a function with respect to a system's state (e.g., when logged in or not logged in).

4.1.3. Time

The ability to impose timing constraints on the system is crucial for two reasons. First, smart home applications affect the real world. Second, applications interact with resource-constrained devices which exhibit limited availability and varying delays. This distinction between real world data timing and communication timing may significantly impact fulfilling the requirements in complex scenarios. For example, the age of a sensor reading may include the real world time of the measurement as well as the time of transporting the data from the source to the sink.

- *Hard real-time*:

  A system which supports hard real- time guarantees that a certain action is performed within a given time frame. Smart home developers can specify this time frame in application development. In near term we expect no use case that requires actual hard real-time.

- *Soft real-time*:

  In contrast to hard real-time, missing a time frame in a soft real-time system is not considered as an error but a quality problem. Over time, if soft real-time deadlines are missed more often, system acceptance suffers.

- *Age*:

  In systems with energy-constrained devices caching mechanisms are used to reduce energy consumption. Providing means to the developer to speicify a minimum or

maximum age of sensor readings is required (e.g., a heating device which uses room temperature measurements).

- *Synchrony*:

  Performing actions synchronously (e.g., using a checkpoint-based approach) or intentionally asynchronously allows the developer to specify that events start or end at the same time (e.g., lights are switched on at the same time or avoiding all devices to be switched on at the same time to prevent from peaks in the power supply system). This requirement mostly addresses quality (acceptance) of the system.

- *Periods*:

  For periodical actions application developers must be able to specify both the period of events and a maximum jitter each event may have.

4.1.4. Mobility

Mobility includes both mobile devices and changes in the system (e.g., devices and services leave or join the system).

- *Discovery*:

  Discovery enables detection and integration of devices statically during design time or dynamically during runtime. In case of a repository, devices are located based on a match between their capabilities and the user's preferences.

- *Device Disappearance*:

  The opposite of discovery denotes the capability of a system to detect when devices or services leave the network and to react accordingly.

- *Location Awareness*:

  Some applications require location-aware devices and services. Thus application developers should be able to :

  a) find out the location of specific devices and

  b) find devices with respect to a given location in order to use services of these particular devices.

4.1.5. Technical

This section describes technical requirements to a composition solution.

- *Interaction with Heterogeneous Services*:

  Interconnecting heterogeneous services and devices (e.g., DPWS, REST, non-IP based) is necessary to develop smart home applications. Services might both reside on devices in the home or in the Internet (e.g., higher valued services like include weather forecast in heating control).

- *Extensibility*:

  Using new functionalities which are not foreseen at design time requires extensible tools and methods for application development. As an example, device discovery might be included later on but not in the first revision of the solution.

- *Data Manipulation:*

  Interacting with devices and services from different vendors requires mapping data representations and data formats and allows dealing with concepts that are modeled differently in different domains. This requires transforming an instance of a model into another model or transforming instances of two different models into a higher level model.

- *Traceability*:

  Tracing actions (e.g., start of a process, invoking an event) is often required either for statistics or liability issues.

4.1.6. Security, Safety and Privacy

- *Process Safety:*

  Unsafe applications negatively affect devices or the environment in a way that is not foreseen by the developer and must be predicted to ensure process safety.

- *Confidentiality*:

  Information of the system should not be visible to anyone except for a defined group of people.

- Authentication and Authorization:

  Enabling confidentiality requires fine-grained authentication and authorization mechanisms to access processes, devices and services.

4.1.7. Miscellaneous

This category contains all requirements that do not match the other categories.

- *Process Integrity*:

  Concurrent smart home applications should not contradict with each other (e.g., reduce and increase heating setting). Such contradictions can be detected during design or run time. During design time, the application developer can react accordingly. Capturing contradictions during run time requires the application developer to specify a specific decision in advance (e.g., prioritize one application, throw an error, or make a compromise).

- *Transaction*:

  Executing a group of actions with transactional behavior maintains integrity of the application. However, in contrast to IT systems, rolling back actions within transactions is sometimes not possible. The actions may affect the physical world, which sometimes does not foresee being reverted (e.g., a sprinkler system).

- *Resource management*:

Often cooperation with resource-constrained devices relies on a trade-off between functionality and resource constraints. It should be possible to specify how the application reacts to changing resources (e.g., cache sensor values in case battery level decreases).

- *Streaming*:

  Video, audio and data streaming is required in multiple domains such as in security (e.g., transmitting a video stream of a surveillance camera) and in health care (e.g., remote patient monitoring).

- *Concurrency & Scalability*:

  The system must be able to execute two or more concurrent processes at the same time. The need for more processing power should not grow exponentially with the number of users, devices or processes. This is often reached by a well-defined distribution.

  This section presents a logical separation of requirements, each of which can be fulfilled individually. Application scenarios always consist of a complex set of these requirements and categories. In these sets, individual requirements are often mutually dependent. For example, periodically measuring sensor readings may require synchronously measuring data with a maximum age and real- time access to an actuator activity based on the readings.

4.2. Hardware

To build a smart home, the hardware components can be subdivided into:

4.2.1. Control Hub:

Also known as a Gateway, the centralized control hub is a device that is connected to your network router. It is the brain of an IoT automation system. All sensors (hundreds of them) are embedded in smart appliances that talk to the Gateway. It means that you will need to install a lot of sensors in your home so that they can send and receive operating commands **(**data**)** through the Gateway.

4.2.2. Sensors:

You might be surprised to learn that there could be thousands of IoT sensors present in smart appliances or installed throughout your house according to customized requirements. The following types of sensors are common for most home automation applications:

- Light sensors
- Temperature sensors
- Noise sensors
- Motion sensors
- Smoke and fire sensors
- Water sensors

When a sensory switch is connected to a centralized control hub in your house, the control application (software) can execute the commands itself and operate on devices based on pre-set instructions.

Wireless Connectivity & Cloud Network

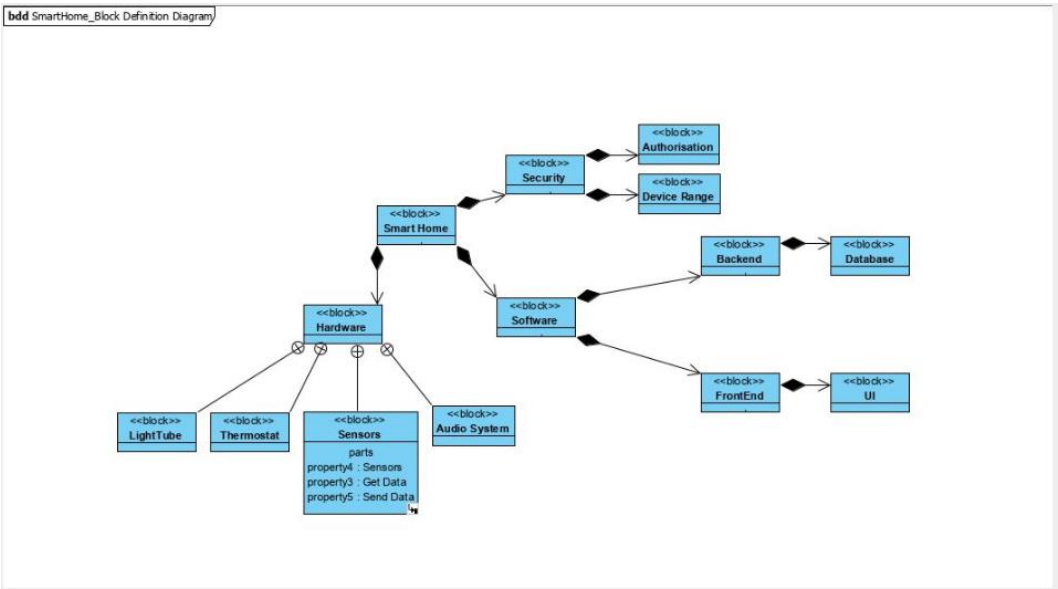
It's how all the devices (sensors, gateways) communicate with each other and store the reference data on the cloud. The signals between controllers and smart sensors are wirelessly exchanged via a communication protocol installed in your home. The cloud network gives you the flexibility to access the data from anywhere and then send the operational commands to the hub from any remote location whenever necessary.

5. Planned Approach

As a starting point for Smart Home project, we started with WBS Project Management that shows the project deliverables and work that needs to be completed in a project, which actually guides the project team on what needs to be done in an organized manner. After this we created the Gantt Chart which schedule the tasks, being easy to understand, clear and has visual representation of time frames. At the end we made the Risk Management Plan to identify potential problems before they occur so that risk-handling activities may be planned and invoked as needed across the life of the product or project to mitigate adverse impacts on achieving objectives. All the diagrams can be found in the annexes.

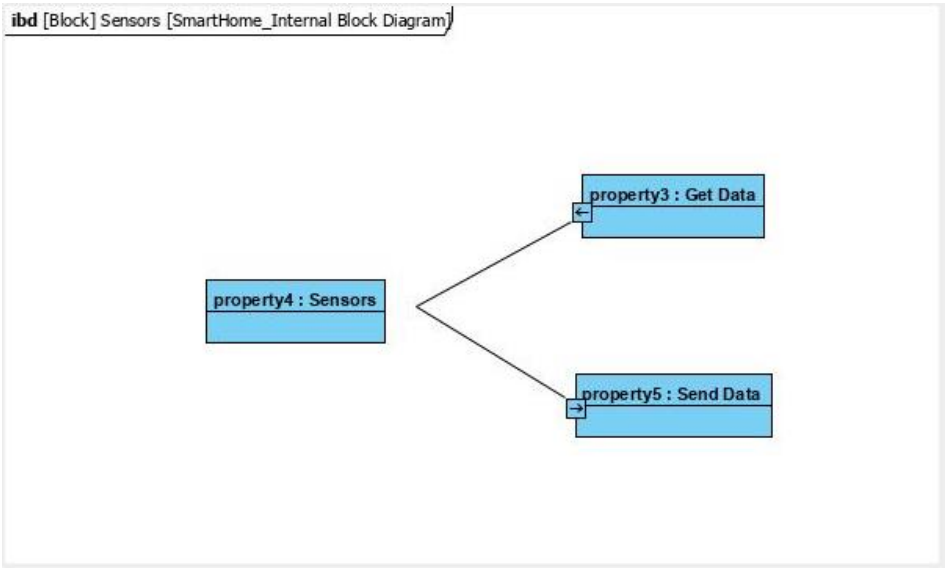
5.1. Block Diagram

The Smart Home diagram contains three main blocks: Hardware, Software and Security. The Hardware block is described by four parts: LightTube, Thermostat, Sensors and Audio System. The Software block contains a FrontEnd part – the Client-Side of the application – where the customer can interact with the system, and a BackEnd part – the Server-Side of the application – connected to a database is order to receive and store data from sensors, and to keep the history of the system states. The last block, but not the least important, is the Security one, where the user can use the application only with authorization (login) and within a range.



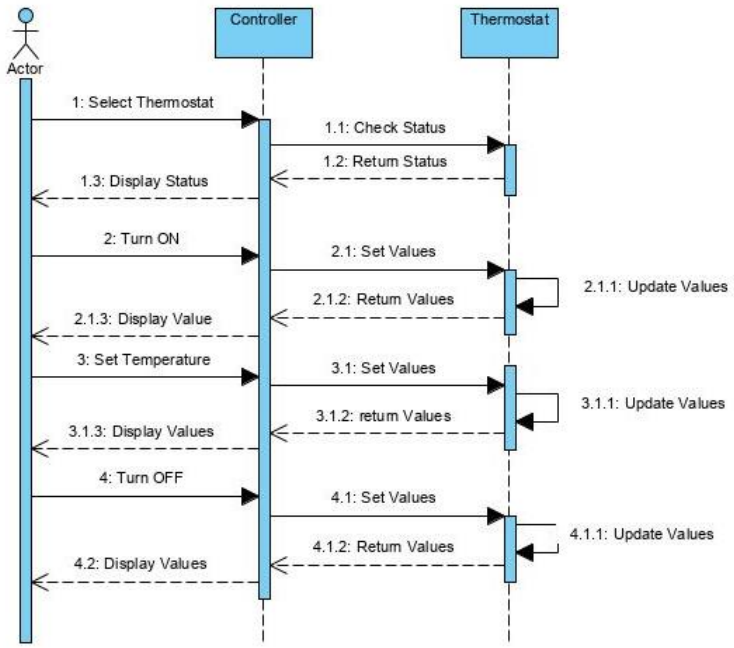
5.2. Internal Block Diagram

Our application is based on the connection between the hardware part and the software part. In this case, we have the Internal Block Diagram for the Sensor block. The Sensor block has two main properties: to get data from external sources and send it to the backend.



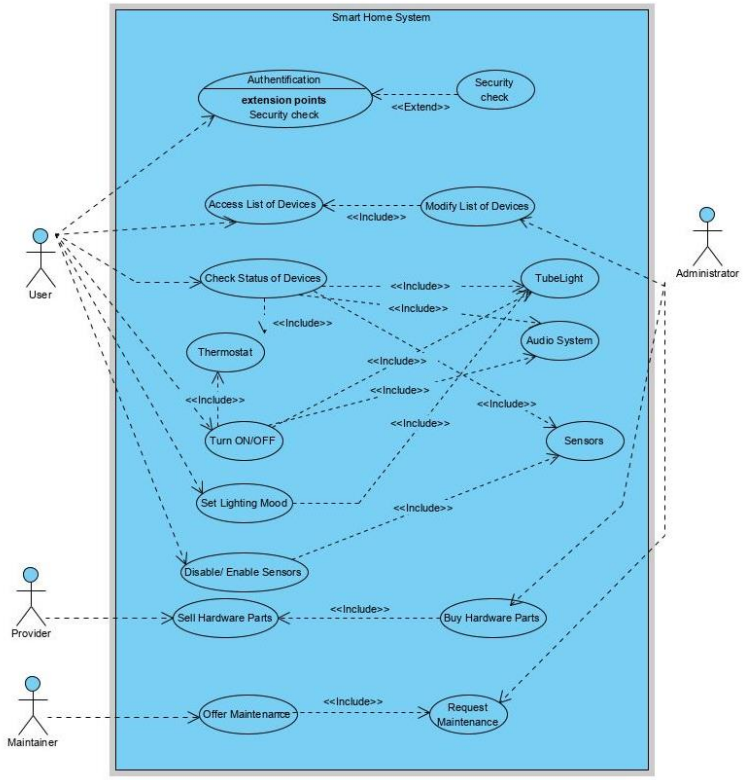
5.3. Sequence Diagram

One facility of our system is controlling the thermostat. You can choose from displaying the current status of the thermostat, turning ON/OFF and changing the temperature. In this way, you will be able to control your thermostat remotely, but within the range we agree with the customer.

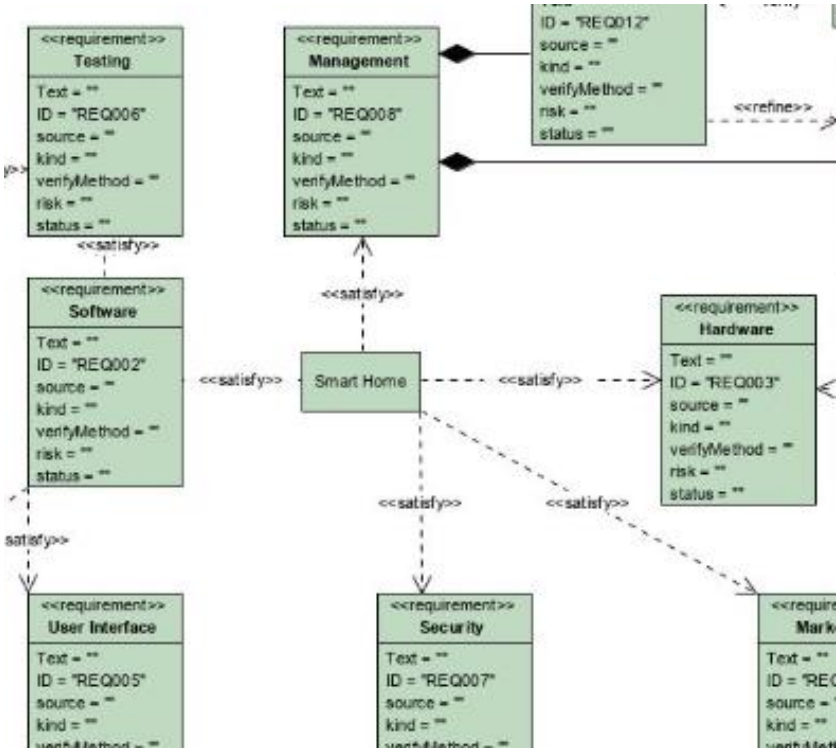


5.4. Use Case Diagram

The Smart Home system has four types of actors: user, administrator, provider and maintainer. The user must authenticate in order to use the application. From the application, the user can manage the system, access the list of devices and check their status. Some functionalities of the system are the following: turn ON/OFF the thermostat, tubelight or the audiosystem, set lighting mood and enable/disable the sensors. The administrator can manage the list of devices, and also use the functionalities. The role of the provider is to sell hardware parts, when the administrator wants to buy hardware parts. The maintainer should offer maintenance everytime an administrator requests maintenance.



5.5. Requirements Diagram



As we can see from the name of the system, Smart Home, we will implement an intelligent solution for homes and that means we need to get accurate data, to manage it and keep the performance of our Smart Home system at a high level. In order to have all of these at a time, we must use the latest technologies and equipment. Also, we need to make sure that our system is secure, so our customer won't face any problems. Our application should have an optimal implementation, so we can provide updates and maintenance. The whole diagram is attached in the annexes.

5.6. WBS & Gantt Chart

The first thing we did when we decided to implement a Smart Home System was to make a project management plan, in order to have a well-defined idea for our project. We used the Project Control concept to set milestones in order to control the project process better.

The purpose of research component in our project was to help us accomplish our goal: to create an intelligent, innovative solution for homes, based on what people need and want. As we said earlier, we must use the latest technologies and equipment for our solution, so we had to find the ones that fit our project. The Research Report (Milestone 1) will contain data from the research phase, like surveys responses, competition analysis and technical research.

In the next phase we established the requirements of our projects and divided them into basic and advanced, by the order of implementation. This means that even if we set the basic requirements along with the research phase, we should wait for the research report to be done in order to set the advanced requirements.

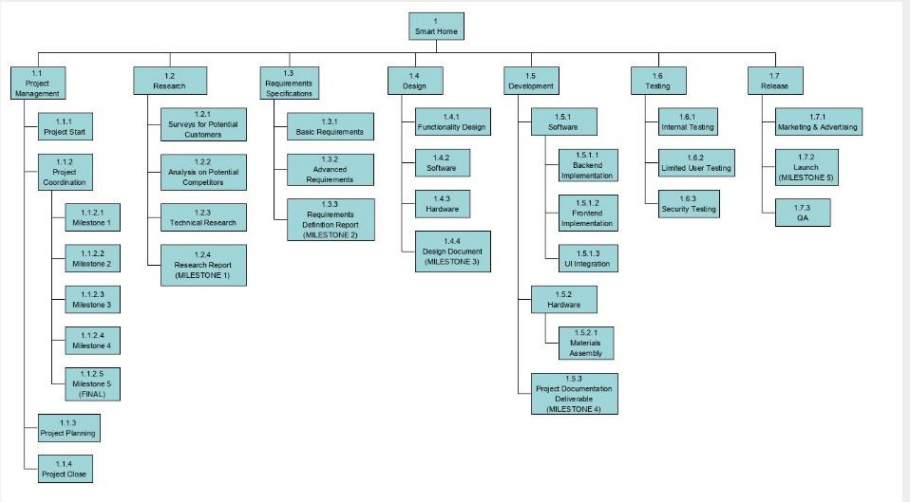
The design component is an important step, and we divided it into three small phases: functionality, software and hardware. It is important for a smart system to have a practical design, in order to receive the most accurate data, and the application should be user-friendly so the customer would use it easily.

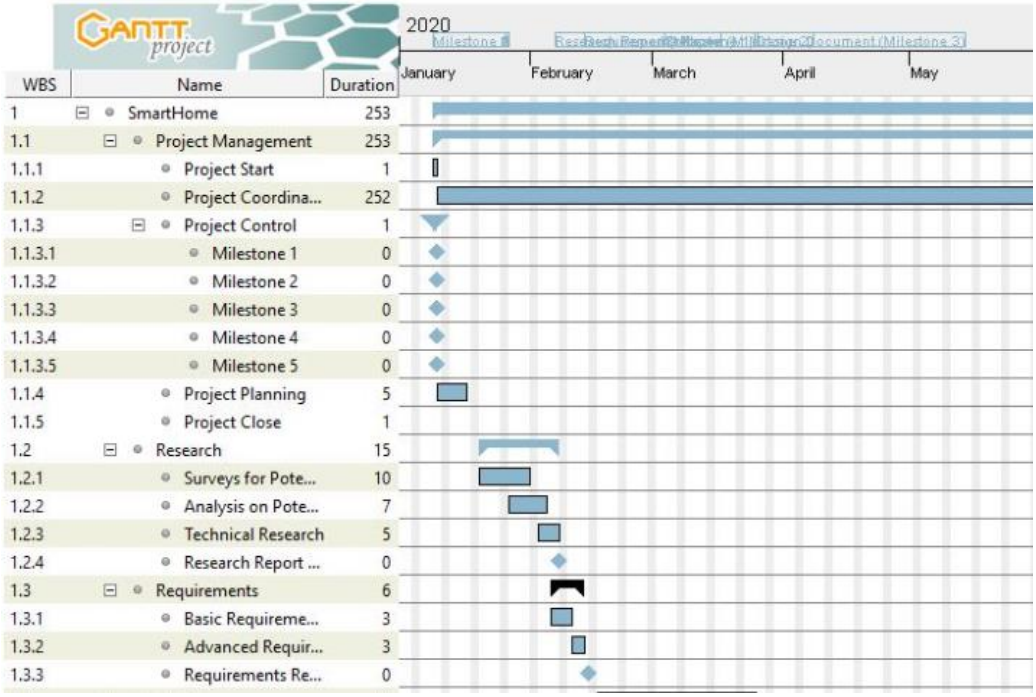
For the development phase, we have two different sides: software and hardware. The software implementation consists in three phases: backend, frontend and UI integration. The hardware implementation is composed by equipment assembly. At the end of this phase, we will get the Project Documentation Deliverable, so the Milestone 4.

Our developers and potential customers will test the application, because it is important to have a perfectly functional application and to resolve the bugs in time.

The last step before the release is to prepare the market for our application using marketing & advertising. Once the product is released, we will continue to check its performance, considering the customers' opinions.

You can find the complete diagram & chart in annexes.





6. Challenges and issues

In order to create a system, which needs to become smarter, self-organized, sustainable, resource efficient, robust and safe, in order to meet stakeholder demands, we are facing a number of issues.

In our system, there are many challenges and issues as there are many parts involved in the project.

The main issue that could happen is going over our budget as there are many hardware parts involved and if they are not the right quality they could break and with that time and money, resources can be lost.

Another challenge is the human errors and bad planning that might happen. Having a late demo out can create a bad marketing and image for the product as people might want to see how this works and could make an early buy of the project. In this way, a late planning in a late stage can be very damaging and this should be taken in consideration right from the begging of the planning of the project.

A big challenge for both the software side, but also the hardware side, is the further maintability of the project. A code bad written or an electronic system that could be hard to reach in order to make maintenance of the project could be very harmful for the further advancement of the entire system. Realistically the entire plan of the project might not be ready at the time of the release, or many aspects could be improved, especially from the software side of it, so creating parts that could easily evolve and be maintain if anything fails is an important aspect and a big challenge when planning or during the creation of the system.

A challenge that could cause problems is security. Security in a smart home is very important as private data and anomalies could happen to an unsecured system. Nowadays,

cyber-attacks threaten all the devices we own, especially in our home. Recently, a baby securing camera has been caught been hacked and the hacker was talking with a young child that was in danger at that moment. For a smart home, where you can set the temperature through an application is important that no one can access the data and set the temperature to an endangering level for the person that is living in that house.

The risks are enumerated in the Risk Management Plan Annex and the Fishbone diagram.

7. Quality Assurance

The two metrics that I have chosen to measure the quality of the final project are:

1. Defect removal effectiveness
2. Fix backlog and backlog management index

1. *This is a product quality metric.*

The metric can express how quickly the defects were found and solved during the entire development process. This metric is important because it can measure the effectiveness of the team as the system as a whole.

The formula used is DRE = $\frac{\text{Defect removed during development}}{\text{Defects latent in the product}} \times 100\%$

It is called early defect removal when used for the front-end and phase effectiveness for specific phases. The higher the value of the metric, the more effective the development process and the fewer the defects passed to the next phase or to the field.

Using a logging platform that shows all the defects that have been found for each phase (in software development are the so-called sprints) and the formula can be directly used on the defects found.

They evaluate how effective the defect removal of the product is.

A quality model for this can be McCall quality method.

2. *This metric represents a Maintenance Quality Metric.*

This is similar to the other metric, but instead of measuring the entire project development period, it measures only a month of defects that came and were solved.

The formula is BMI = $\frac{\text{Number of problems closed during the month}}{\text{Number of problems arrived during the}} \times 100\%$

It represents the number of problems, in all areas that the system covers, under the problems solved. The percent expresses how effective was the maintenance of the system.

In order to collect data you need an application or an excel in which you can log all the problems that appeared during one month and check the ones that have been solved.

The quality attributes that it evaluates is the Maintenance Quality Metric and it represents how good the maintenance during a month is.

8. Conclusions

Smart homes started as a futuristic idea and have become a need that anyone wants. In a world where pollution is our main concern, it's normal to turn at technology to help us live in a cleaner way. A thermostat in a house it's not just a commodity but can also save a lot of energy by learning from us. Advantages include energy efficiency, customization and ease of use while disadvantages include cost and internet reliance. Keeping in mind that technology is rapidly changing, it is important to recognize how technology is changing how we function within our households.

To work as a team can get difficult as everyone is different and with different opinions and work ethics. It was important to think through the planning of the project and discover our strengths and difficulties as a team.

Our product was thought so it will give an user, or better said a house owner, the possibility to not lift a finger while controlling everything in the house. It is a unique experience as it not only gives you the normal data, but you can change the data by enhancing your house. The thought was to first deliver and then improve. We are ready to take all the feedback from our users and create an improved application.

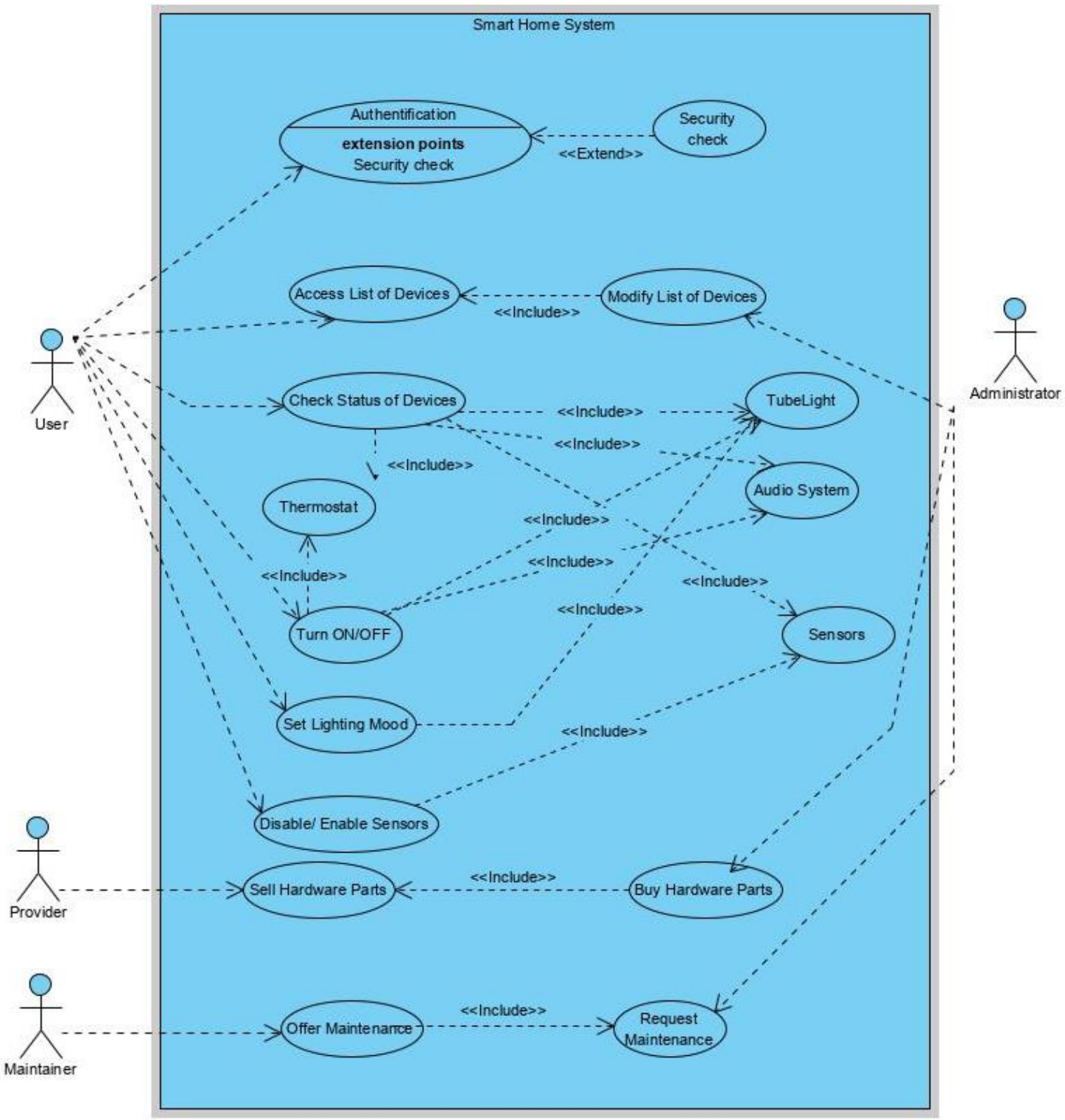
As a conclusion, we can say that this project was a real challenge for us. We had the opportunity to think of a solution and also, we had to prepare the process behind that solution. I think we did a really good job, because we worked like a real team. This project taught us the importance of planning and communication, in order to identify and prevent the issues that may appear, but also to provide a good solution if something bad happens. We used everything we learned in the Systems Engineering class and we can say that it was a good practice for our future.

9. References

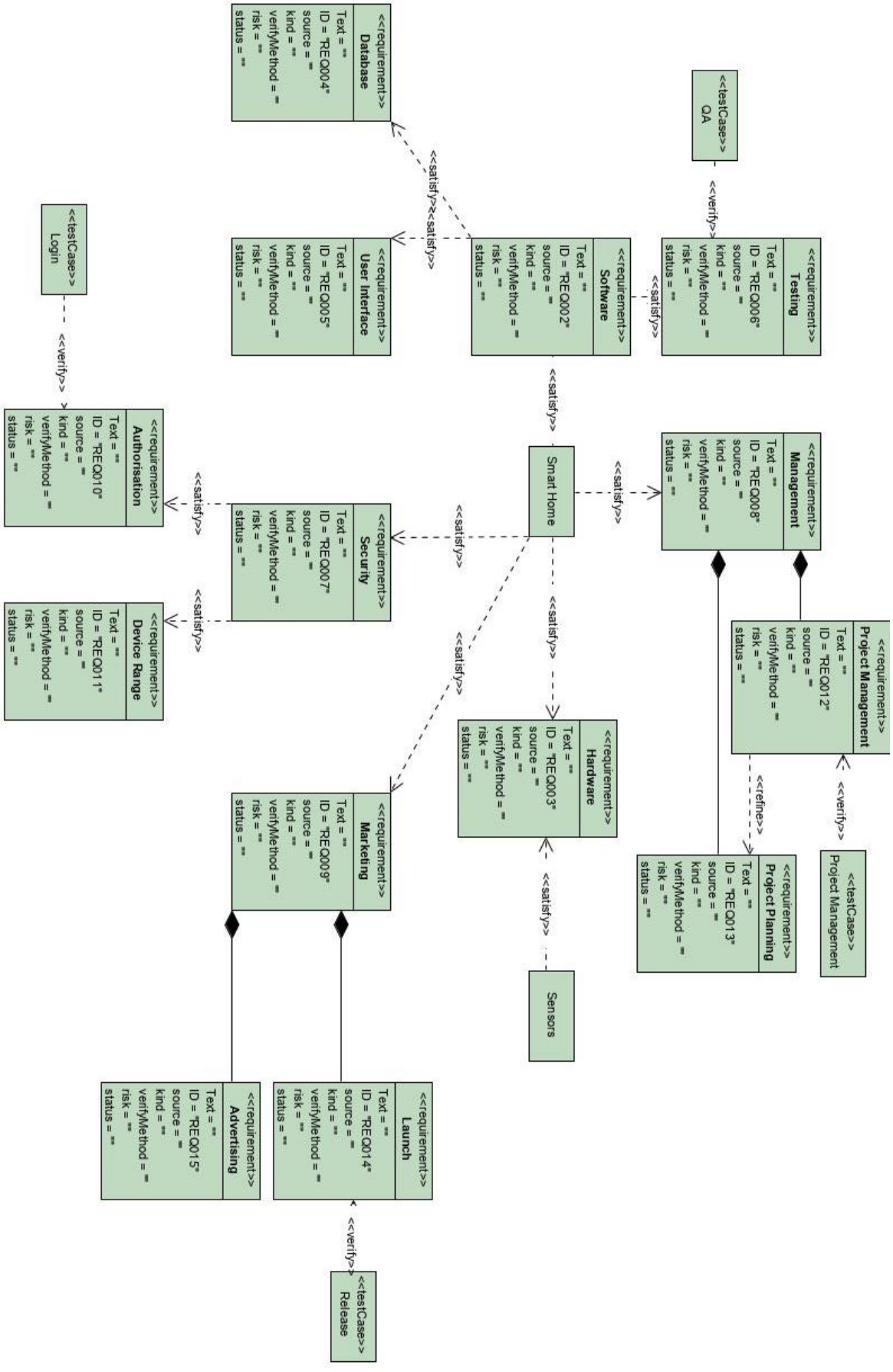
1) Byron Loker (March 21, 2017), 5 key elements of smart home functionality, from *https://www.dwell.com/article/5-key-elements-of-smart-home-functionality-9a9df3b4*
2) Robert Jones (December 4, 2019), Best smart sensors 2019: secure and protect your home, from *https://www.t3.com/features/best-smart-sensors*
3) Janette Baumann (September 19, 2019), Smart Homes: Intelligent living with smart house technology, from *https://g-pulse.com/smart-house-technology*
4) Staff Reporter (November 22, 2019), 5 Amazing Features of Every Smart Home, from *https://www.natureworldnews.com/articles/42687/20191122/5-amazing-features-of-every-smart-home.htm*
5) Ryan Jackson (August 2019), How To Get Mood Lighting In Your Home, from *https://blog.smarthome.com/smart-lighting/how-to-get-mood-lighting-in-your-home/*
6) Abdullah Mohhamed El-Sayed, Omar Raed El-Sayed, Abdulrahim Hesham, Mohamed Abdulah El-Tahan, Omar Hesham (May 2013), Smart Home System Analysis from *https://www.academia.edu/4375055/Smart_Home_System_Analysis*
7) Christian Beckel, Heinz Serfas Robert Bosch, Elmar Zeeb, Guido Moritz, Frank Golatowski, Dirk Timmermann (2011). Requirements for Smart Home Applications and Realization with WS4D-PipesBox from https://www.vs.inf.ethz.ch/publ/papers/beckel-2011-pipesbox.pdf
8) Richa Vaish, (August 13, 2019), Internet of Things: Automate Everything In Your Home from *https://dzone.com/articles/internet-of-things-based-smart-home-automation*
9) Neil Vigdor, (Dec 15, 2019), Somebody's Watching: Hackers Breach Ring Home Security Cameras from New York Times *https://www.nytimes.com/2019/12/15/us/Hacked-ring-home-security-cameras.html*

10. Annexes

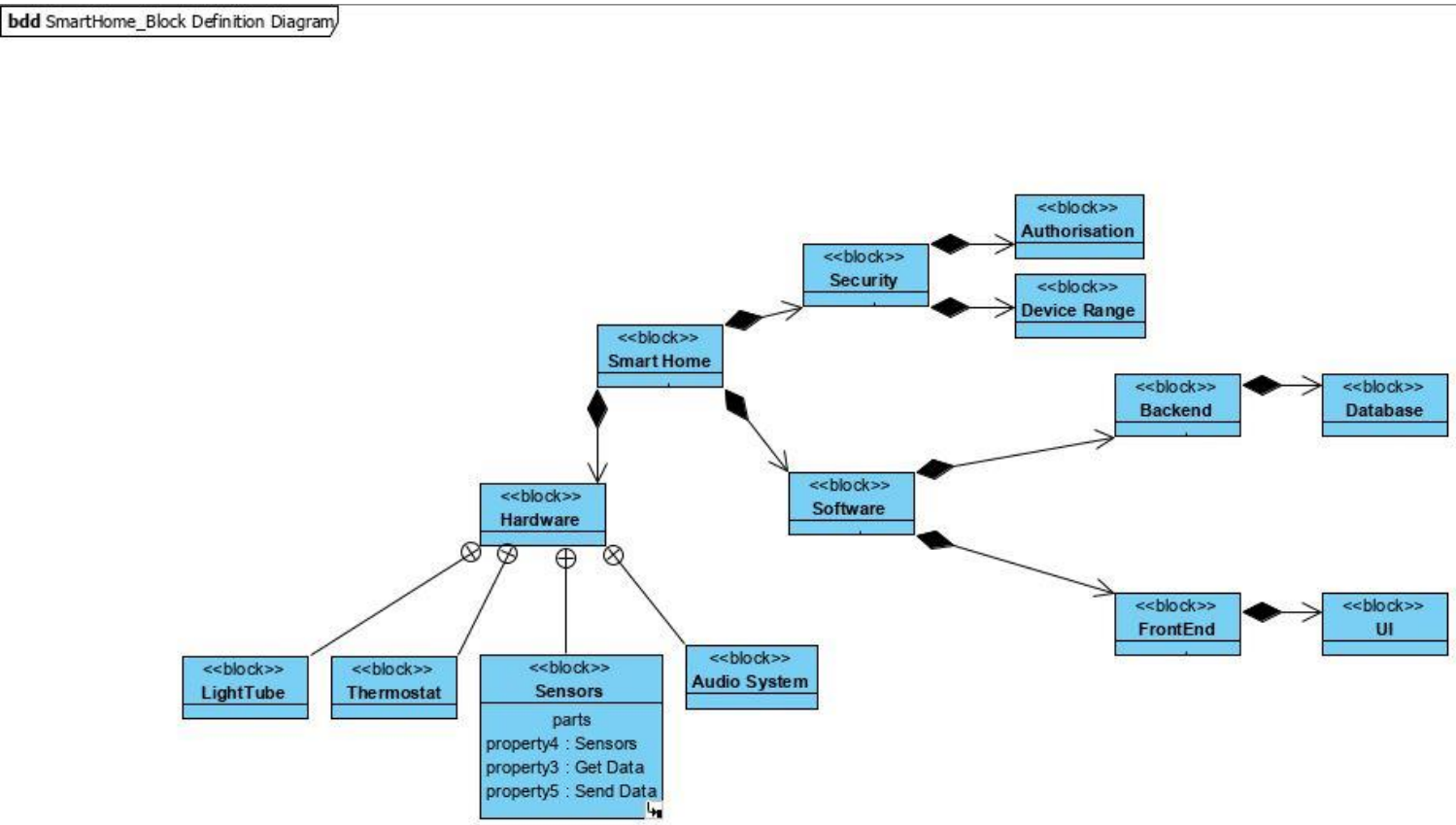
Use Case Diagram



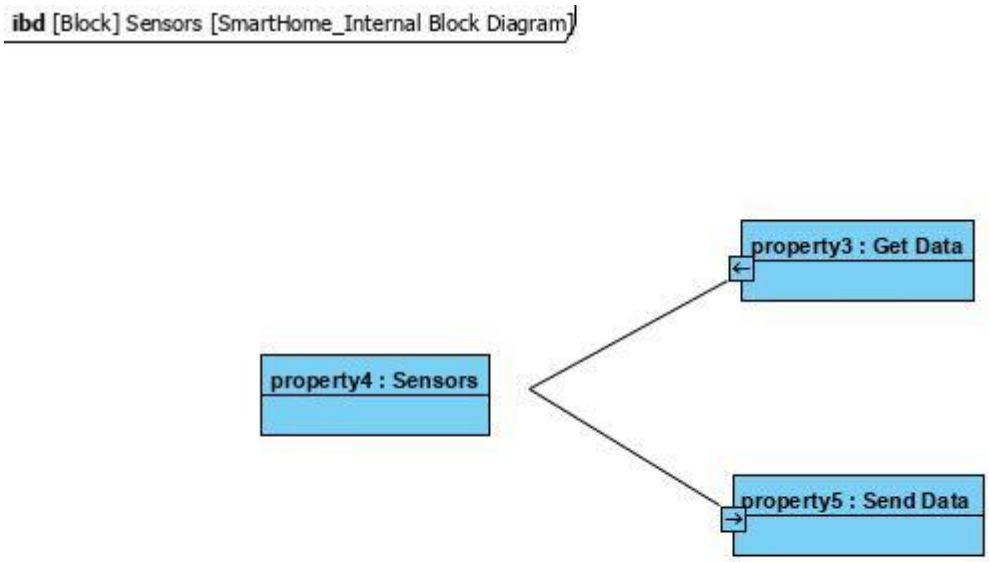
Requirements Diagram



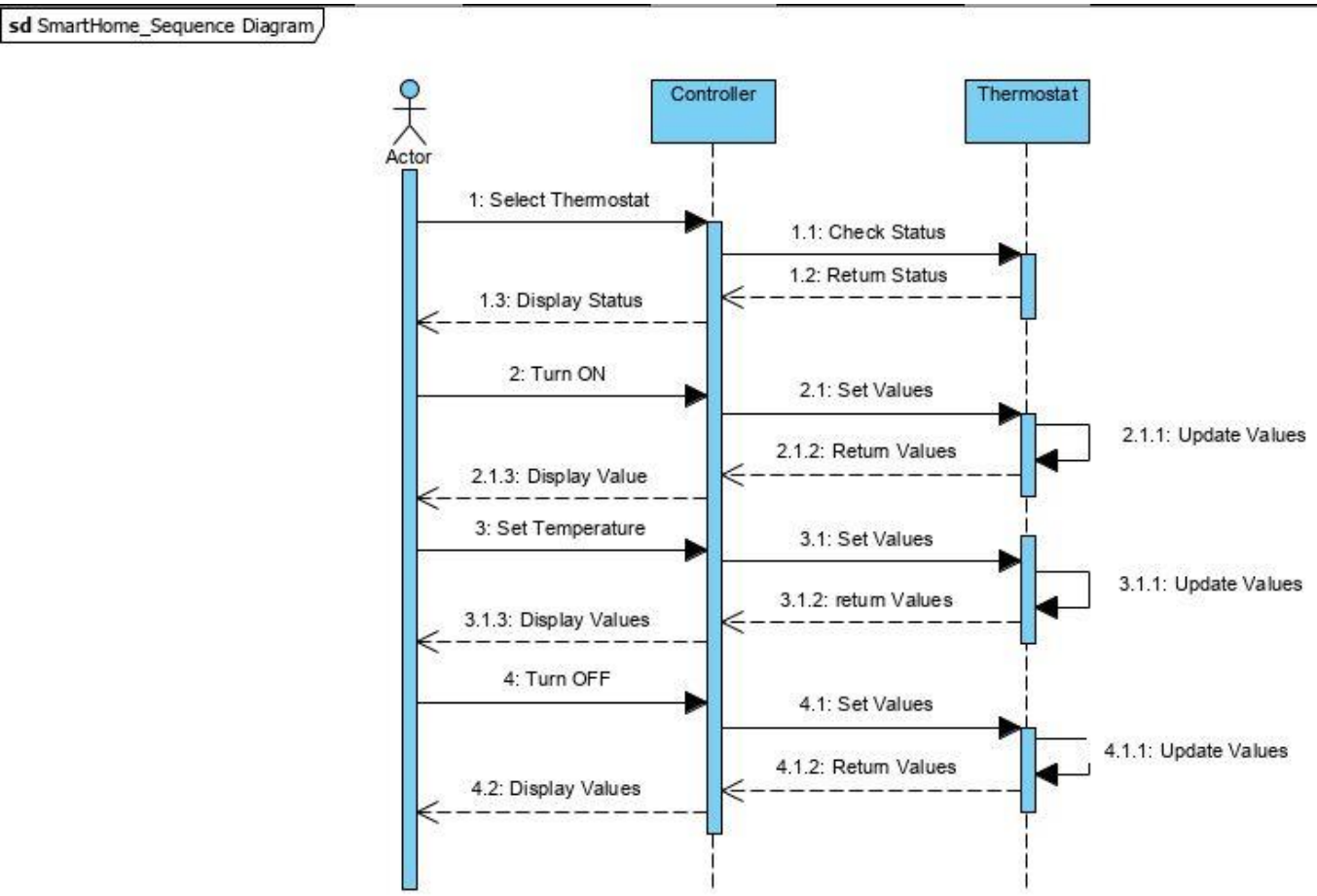
Block Diagram



Internal Block Diagram

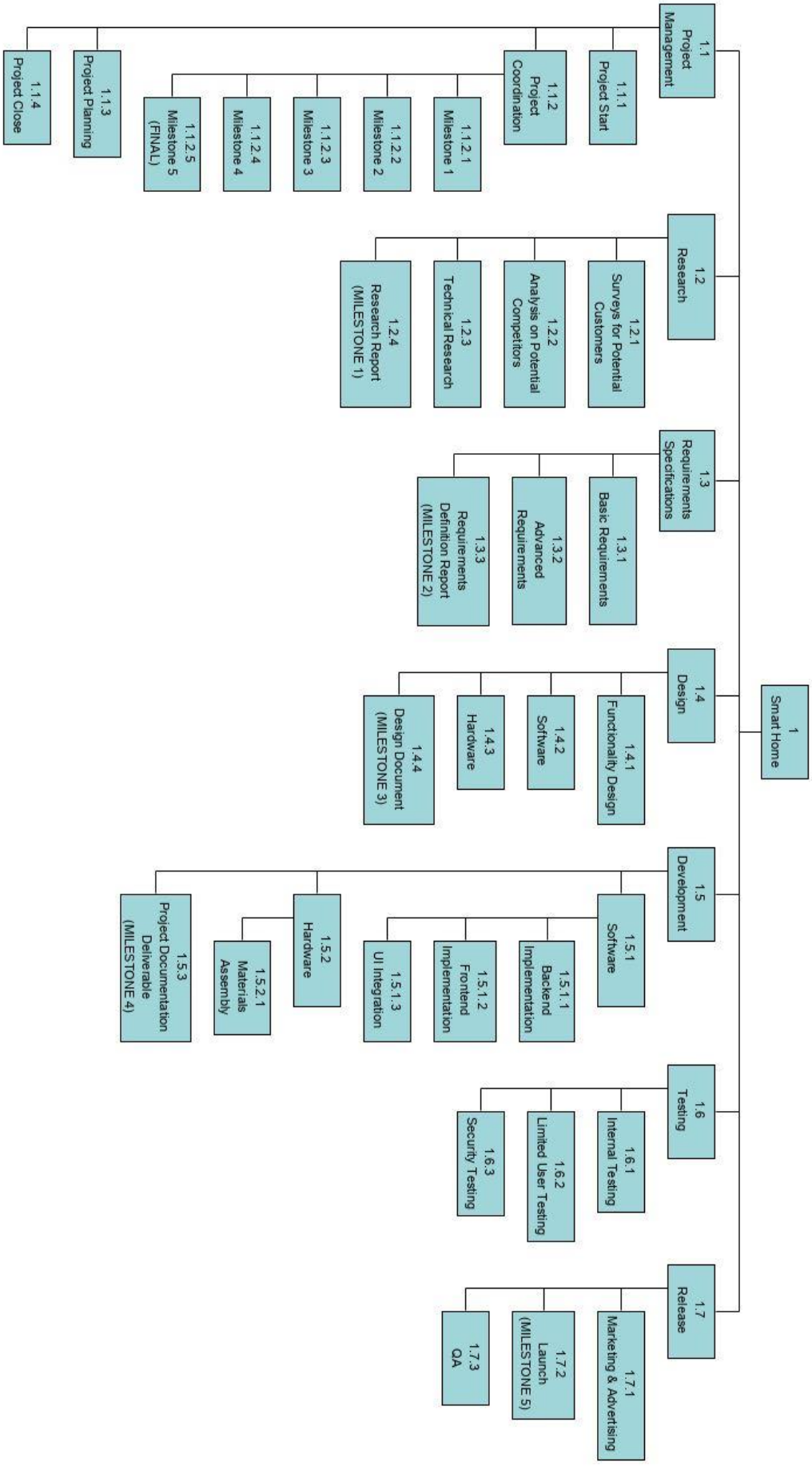


Sequence Diagram

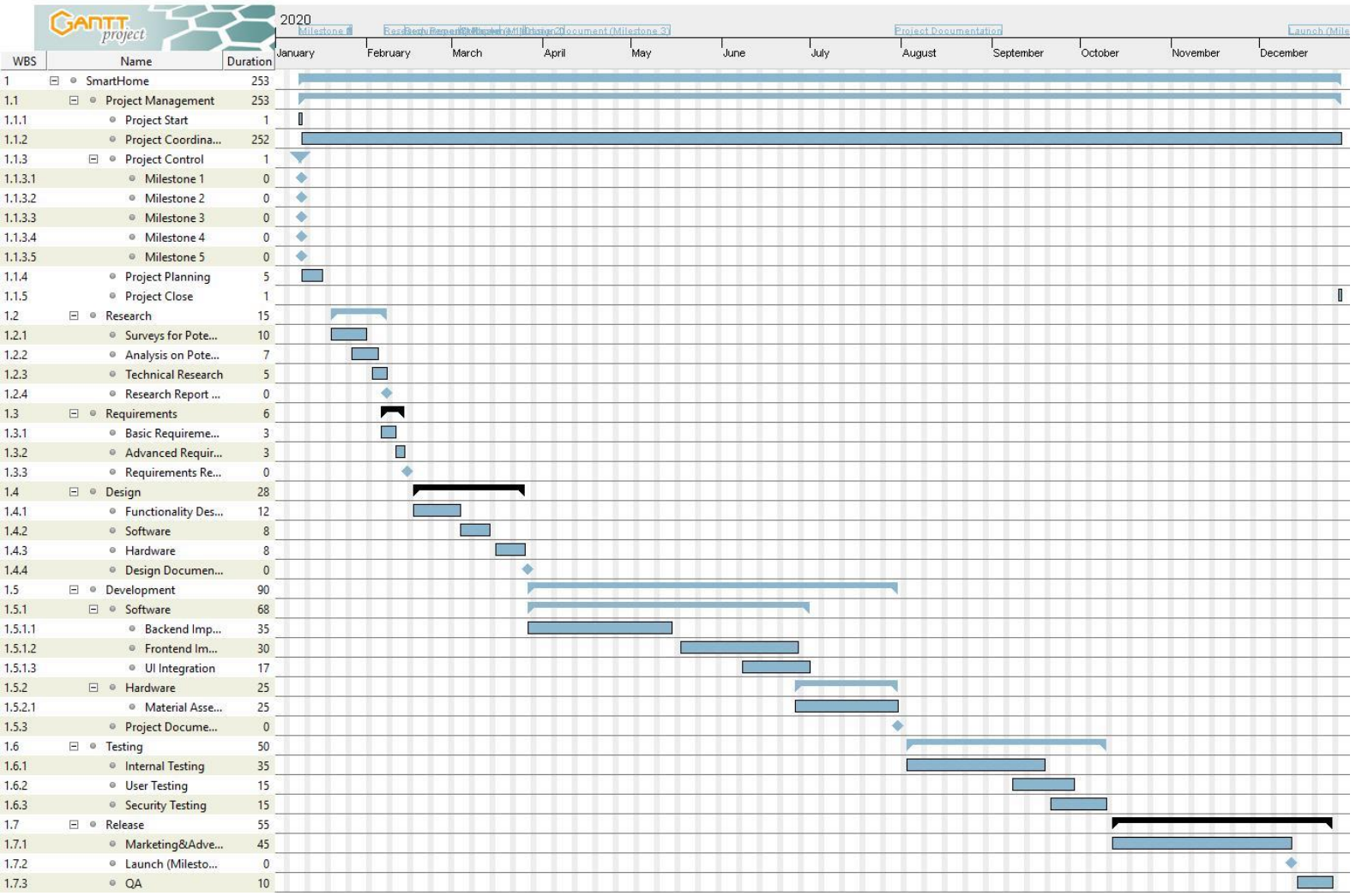


Fishbone diagram

WBS


1 Smart Home
1.1 Project Management
1.1.1 Project Start
1.1.2 Project Coordination
1.1.2.1 Milestone 1
1.1.2.2 Milestone 2
1.1.2.3 Milestone 3
1.1.2.4 Milestone 4
1.1.2.5 Milestone 5 (FINAL)
1.1.3 Project Planning
1.1.4 Project Close
1.2 Research
1.2.1 Surveys for Potential Customers
1.2.2 Analysis on Potential Competitors
1.2.3 Technical Research
1.2.4 Research Report (MILESTONE 1)
1.3 Requirements Specifications
1.3.1 Basic Requirements
1.3.2 Advanced Requirements
1.3.3 Requirements Definition Report (MILESTONE 2)
1.4 Design
1.4.1 Functionality Design
1.4.2 Software
1.4.3 Hardware
1.4.4 Design Document (MILESTONE 3)
1.5 Development
1.5.1 Software
1.5.1.1 Backend Implementation
1.5.1.2 Frontend Implementation
1.5.1.3 UI Integration
1.5.2 Hardware
1.5.2.1 Materials Assembly
1.5.3 Project Documentation Deliverable (MILESTONE 4)
1.6 Testing
1.6.1 Internal Testing
1.6.2 Limited User Testing
1.6.3 Security Testing
1.7 Release
1.7.1 Marketing & Advertising
1.7.2 Launch (MILESTONE 5)
1.7.3 QA

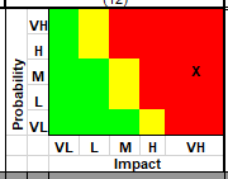
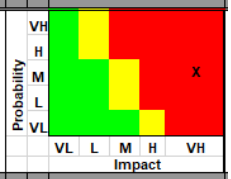
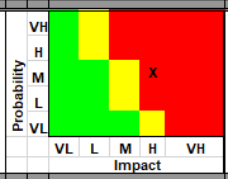
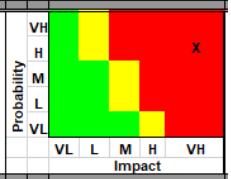
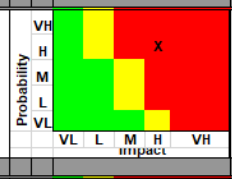
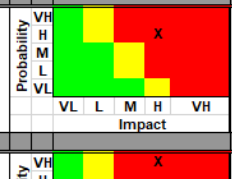
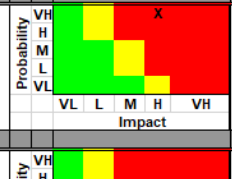
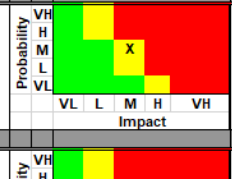
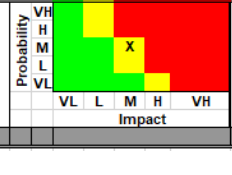
Gantt Chart



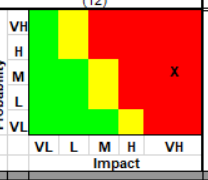
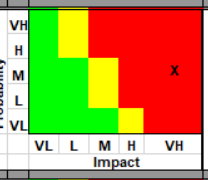
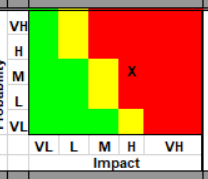
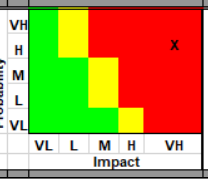
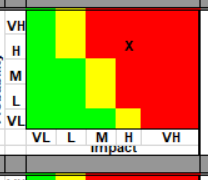
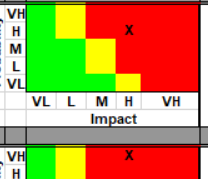
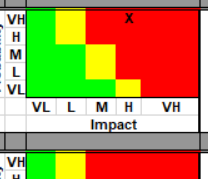
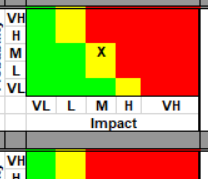
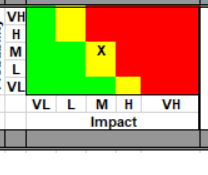
WBS	Name	Duration
1	SmartHome	253
1.1	Project Management	253
1.1.1	Project Start	1
1.1.2	Project Coordina...	252
1.1.3	Project Control	1
1.1.3.1	Milestone 1	0
1.1.3.2	Milestone 2	0
1.1.3.3	Milestone 3	0
1.1.3.4	Milestone 4	0
1.1.3.5	Milestone 5	0
1.1.4	Project Planning	5
1.1.5	Project Close	1
1.2	Research	15
1.2.1	Surveys for Pote...	10
1.2.2	Analysis on Pote...	7
1.2.3	Technical Research	5
1.2.4	Research Report ...	0
1.3	Requirements	6
1.3.1	Basic Requireme...	3
1.3.2	Advanced Requir...	3
1.3.3	Requirements Re...	0
1.4	Design	28
1.4.1	Functionality Des...	12
1.4.2	Software	8
1.4.3	Hardware	8
1.4.4	Design Documen...	0
1.5	Development	90
1.5.1	Software	68
1.5.1.1	Backend Imp...	35
1.5.1.2	Frontend Im...	30
1.5.1.3	UI Integration	17
1.5.2	Hardware	25
1.5.2.1	Material Asse...	25
1.5.3	Project Docume...	0
1.6	Testing	50
1.6.1	Internal Testing	35
1.6.2	User Testing	15
1.6.3	Security Testing	15
1.7	Release	55
1.7.1	Marketing&Adve...	45
1.7.2	Launch (Milesto...	0
1.7.3	QA	10

Risk management plan

PROJECT RISK MANAGE

Priority	Identification							Qualitative Analysis			
	Status	ID #	Date Identified Project Phase	Functional Assignment	Threat/Opportunity Event	SMART Column	Risk Trigger	Type	Probability	Impact	Risk Matrix
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Retired	1	Project Management	Management	Lack of management or control after sharing tasks	Limited resources can cause best practices skipping.	- The project manager doesn't know how to enhance the business administration plan in order to adapt it to the available resources. - underestimate costs for equipment, bad team leading, wrong assignment of roles within the team, wrong estimation of deadlines, expectations too high	**scope**	Moderate	very high	
	Active	2	Research	Research	Team misunderstands the requirements of the system.	Gap between expectations, requirements and work duties.	Not enough time to understand the requirements and the issues.	**Scope**	Moderate	Very High	
	Active	3	Design	Design	User-Interface	Poor design choices lead to difficult changes.	Not user friendly,hard to navigate, old fashion design, too complex, too many components, bad structure, bad placement of sensors and electronic equipment	**quality**	moderate	High	
	Active	4	Design	Design	Hardware	Design products lead to high production price	Wrong choice of technical equipment	**cost**	High	Very High	
	Active	5	Development	Development	Code	The code is not optimised, and there are some situations that may cause errors and exceptions.	Bugs that are found during development phase.	**Quality**	high	High	
	Dormant	6	Marketing	Market	Missunderstanding if the survey results	Wrong analysis of customer needs.	Wrong interpretation of the market research results.	**Quality**	High	high	
	Active	7	Testing	Internal	testing not possible on all functionalities.	Important functionalities not included in the use cases.	Misunderstanding of the business documentation	**Quality**	Very High	high	
	Active	8	Release	Marketing & Advertising	Weak marketing strategy.	Wrong choices of the team.	Bad market placement, lack of clients, wrong promoting techniques, distribution channels wrong chosen	**Quality**	moderate	Moderate	
	Dormant	9	Release	QA	Bugs found after release.	The customers will be dissappointed when the problems will occur.	Resource consuming and bad reviews received from the users.	**Quality**	Moderate	Moderate	

ECT RISK MANAGEMENT PLAN

Analysis	OPTIONAL Quantitative Analysis			Response Strategy			Monitoring and Control		
Risk Matrix	Probability (%)	Impact ($ or days)	Effect ($ or days)	Strategy	Response Actions including advantages and disadvantages	Affected WBS Tasks	Responsibilty (Task Manager)	Status Interval or Milestone Check	Date, Status and Review Comments
(12)	(13)	(14)	(15) =(13)x(14	(16)	(17)	(18)	(19)	(20)	(21)
	50%	90	45	Avoidance	Business analysis is required before starting the project in order to know the exact possibilities of development.	1.1.Project Management	Project Manager	1m	
	50%	50000$	25000$	Avoidance	Better communication in order to make other people understand the ideas.	1.2 Research	Whole Team	1m	
	45%	1400$	1200$	Mitigation	Redesign the interface to make it more accessible.	1.4 Design	Designers and developers	3 weeks	
	60%	70000	45000	Avoidance	Reduce the functionality of the product.	1.4 Design	Designers and Hardware Delevopers	3 weeks	
	70%	2500$	1500$	Transference	Find the bugs and fix them	1.5 Development	Developers	3 weeks	
	50%	2000$	1500$	Mitigation	Better understanding of the surveys and better implementation of the results.	.1.2.1 Research - Surveys for Potential Customers	Business analysts	2 weeks	
	85%	7000$	6000$	Avoidance	Try to test the app as much as possible.	1.6.1 - Testing - Internal Testing	Testing Team	2 weeks	
	30%	3000$	1500$	Mitigation	Change the strategy.	1.7.1 - Release - Marketing & Advertising	Advertising Team	2 months	
	50%	4500$	2300$	Avoidance	Communication between devs and testers.	1.7.3 - Testing - QA	Development & Testing Team	2 weeks	