StratOs

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Re: ENSC 440 Functional Specifications for EasyHome

Dear Dr. Rawicz,

In regards to the course requirement of ENSC 405W/440, please find attached the document outlining the functional specifications for EasyHome, a device for visually challenged individuals to control electronic/electrical devices at home.

This requirement specification document aims to lay out the functions that our product and each subcomponent must perform from proof of concept to the production stage. The high priority elements of the product have been drafted and the scope of the system's functionality has been defined. This document includes a detailed system overview, system requirements and standards for safety, reliability and sustainability. The requirements established in this document will shape the development and design phase of the EasyHome system.

If you would like more information or have any questions regarding our proposal, you can contact me at 604-600-8496 or via e-mail at kamalk@sfu.ca.

Sincerely,

Kamal Kaur
Chief Executive Officer
StratOs Technologies

Enclosure: Functional Specifications for EasyHome by StratOs Technologies

StratOs Technologies

Functional Specifications-EasyHome

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Submitted On

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Abstract

The purpose of this document is to specify the requirements of EasyHome, a product to help visually disabled individuals in facing the everyday challenges at home. EasyHome will allow a visually disabled user to monitor and control home appliances including kitchen stove-top, door locks and body temperature measuring device from their phone.

EasyHome consists of a hub that will control all the devices, a user interface, internet cloud and peripheral devices. With EasyHome mobile and web application the user will be able to check the status of appliances with voice input. Through API commands, the hub queries the data from the switches and sensors attached to the appliances, and format that information appropriately for use on the Internet cloud. Since the ZigBee standard is the one of the most common technologies used in wireless automation, we will use ZigBee as the primary wireless network for our smart devices.

Smart sensors and switches will be embedded into existing ordinary appliances to sense the state of the device. First peripheral device designed as a part of EasyHome solution is an attachment to normal stovetop. This device will monitor temperature of the burners and deliver a voice notification when the user forgets to turn off the burner. The second peripheral device will be a system for detecting the status of door lock. The user will use the phone or web application to monitor and control door locking. EasyHome also includes a smart device to measure body temperature using audio input and output. In addition to above mentioned devices our phone application will have functionality for identifying colours of clothes.

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Glossary

API	Application Program Interface
AWS	Amazon Web Services. An internet cloud service
Cloud	A way of sharing computing resources on the internet
Hub	Primary gateway between the smart devices and the cloud
PCB	Printed Circuit Board
Smart Sensor	A device that can measure and sense a physical occurrence
Smart Switch	A device that can control how an appliance behaves
UI	User Interface
WI-FI	A wireless communication standard, also called IEEE 802.11
ZigBee	A wireless communication specification based on IEEE 802.15.4

1. Background

Home automation has been present ever since the industrial revolution of the 1920's which brought up products such as the vacuum cleaner, and the washing machine. It was not until the early 2000's that 'smart' homes became feasible from a technological and economical point of view [1]. With the ever-expanding number of home automation solutions provided in the market today, one would ask why StratOs Technologies? The answer is simple, we aim at making smart homes a revolution for visually impaired people. A revolution that would erase the hassle that was once encountered by blind people in determining what is the temperature of the oven, what stove top was turned on, checking if the lights are on or not, and even obtaining feedback about their body temperature.

2. Introduction

StratOs technologies is a company dedicated to providing a home automation platform that meets the demands of visually impaired people. This platform is called EasyHome. EasyHome would cover the entire spectrum of home automation from building the wireless connectivity and feedback from the components that reside within home appliances to building our exclusive hub that acts as the brain of our platform, controls connectivity, and establishes communication. Feedback and monitoring are made possible by using XBee modules within home appliances to communicate with each other and with our hub.

EasyHome would not simply act as another home automation platform, but would be specifically designed to revolutionize a blind person's home experience and provide independence and comfort. Another important component of EasyHome is the User Interface which acts as the main feedback tool to enable monitoring of home appliances for ease of use and reliability. Figure 1 presents a schematic of EasyHome.

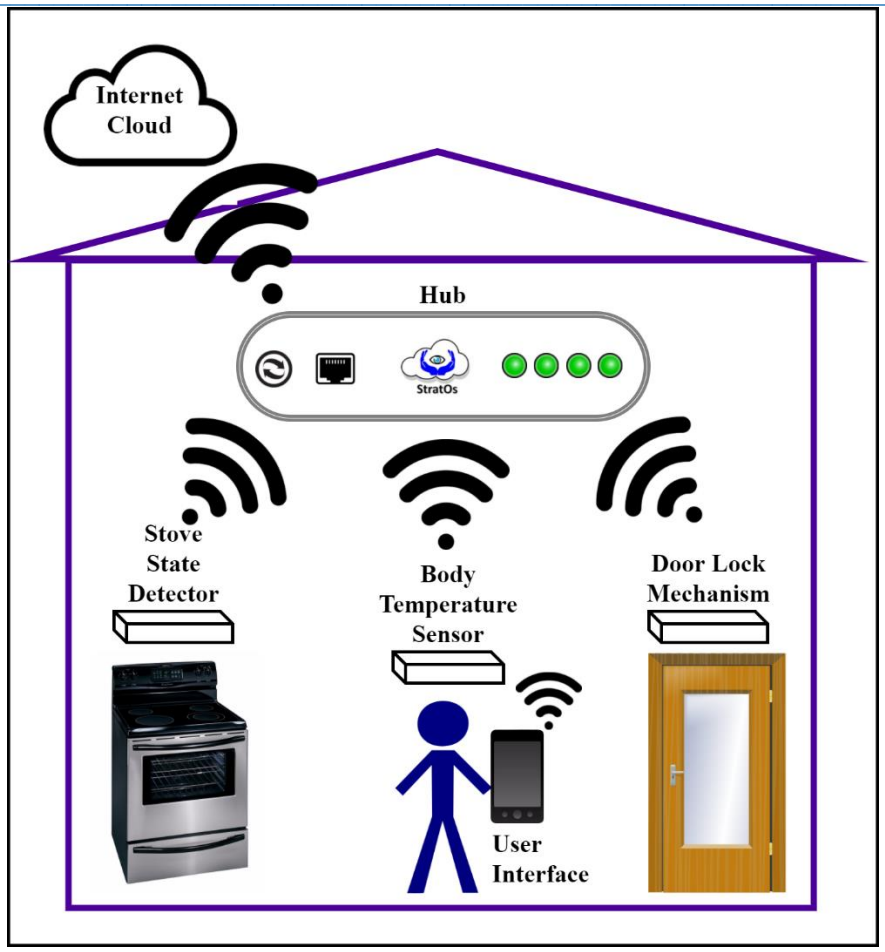

Figure 1: System Overview

As seen in the above figure, each appliance has its own sensor where ZigBee connectivity has been embedded upon by our engineering team using the XBee modules. The cloud provides connectivity of EasyHome to the internet. The User Interface would be designed to target blind people such that it provides on-demand feedback, monitoring and control of every single supported home appliance on the spot. Finally, the hub enables communication between the appliances, the cloud and the UI using Raspberry Pi microprocessors.

EasyHome is composed of multiple features which are run by sensors such as thermostats/thermocouples, magnetic open/close sensors, motion sensors, and others. The Raspberry Pi microprocessor in the hub is used to enable ZigBee communication from within the hub to the sensors, and from an Arduino microcontroller back to the hub for controlling appliances.

3. Functional Requirements

Features will be categorized into three sections corresponding to every requirement in the system:

I - The requirements starting with (I) will be seen in the first iteration of the system deployment
II - The requirements starting with (II) will be seen in the second iteration of the system deployment
III - The requirements starting with (III) will be seen in the final iteration of the system deployment

The functional requirements of the whole system have been divided into the following categories:

- HUB
- Peripheral devices
    - Stove State Detector
    - Door Lock
    - Body Temperature
- Cloud Server
- User Interface

3.1. Hub (refer Figure 2 and 3 for system overview)

3.1.1-I It shall have 4 LEDs that indicate the following:

1st LED= Power
2nd LED= Ethernet
3rd LED= Wi-Fi
4th LED= ZigBee *tentative*

LEDs will indicate the state of the hub.

3.1.2-I It shall have the capability to connect to the internet and a way to indicate to the technician that device has connected to internet using 2nd LED (refer 1.1 for more details).

3.1.3-I It shall be able to connect to at least 4 different EasyHome-Components at a time to increase the user's control over the home appliances.

3.1.4-I It shall store the EUI numbers of the paired devices and they shall be deleted after de-provisioning command is sent.

3.1.5-I It shall support a ZigBee Cluster and attribute an information exchange mechanism to support wireless communication between itself and the components.

3.1.6-II It shall have a Cloud application that will allow the remote connection to the cloud for remote monitoring. The information that will be exchanged is listed as follows:

1. Online/Offline status of the hub. (online: when HUB can ping server).
2. The connectivity status of the components with the hub. Possible status can be Paired, not in network or Never Paired.

3.1.7-II It shall allow the local connection to User Interface for feedback. The information that will be exchanged is listed as follows:

1. Online/Offline status of the hub. (Online: when the internet application can ping the Hub).
2. The connectivity status of the components with the hub. Possible status can be Paired, not in network or Never Paired.

3.1.8-**II** It shall be able to continuously monitor the components at the defined rate of the developer through configuration files (JSON).

3.1.9-**III** It shall have a button that will be held for 5 seconds to reset the hub to default state. The pattern of LEDs will indicate if the reset was successful.

3.1.10-**III** It shall have an auto update property which updates the device through a remote update server.

3.1.11-**III** It shall have a rechargeable battery pack as an alternative power source.

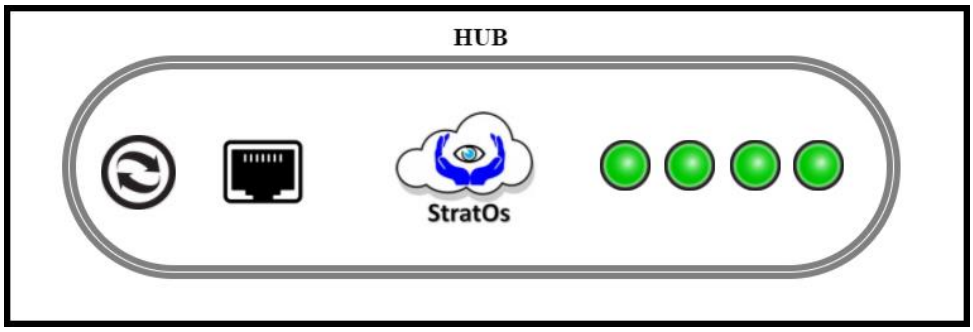

Figure 2: Hub Overview

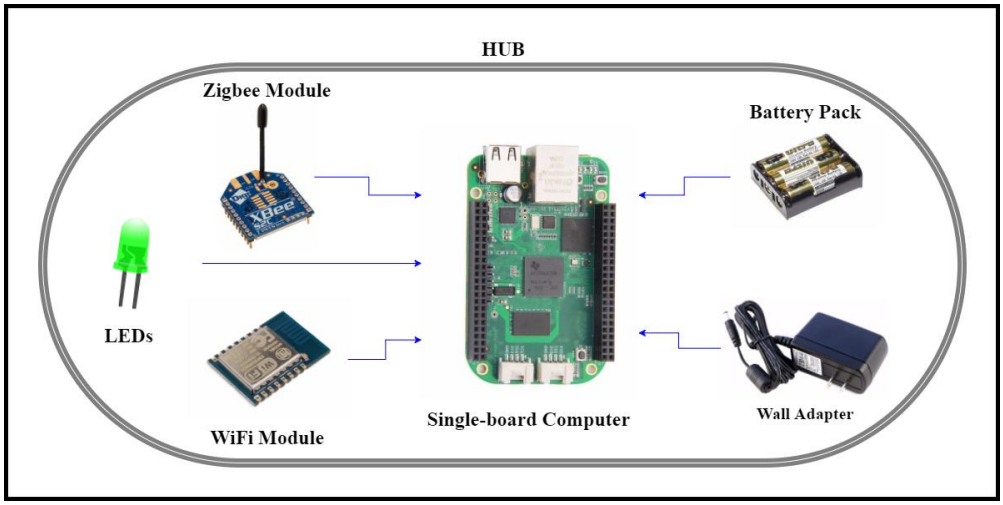

Figure 3: Hub Component

3.2. STOVE STATE DETECTOR (refer Figure 4 for system overview)

3.2.1-**I** It shall have the capability to maintain a secure connection to the Hub so that it can send feedback to the user.

3.2.2-**I** It shall support a ZigBee Cluster and attribute information exchange mechanism to support wireless communication.

3.2.3-**II** It shall have a state store mechanism that will store connectivity status so that it survives the power cycle.

3.2.4-**III** It shall have a connection state indication on the hardware.

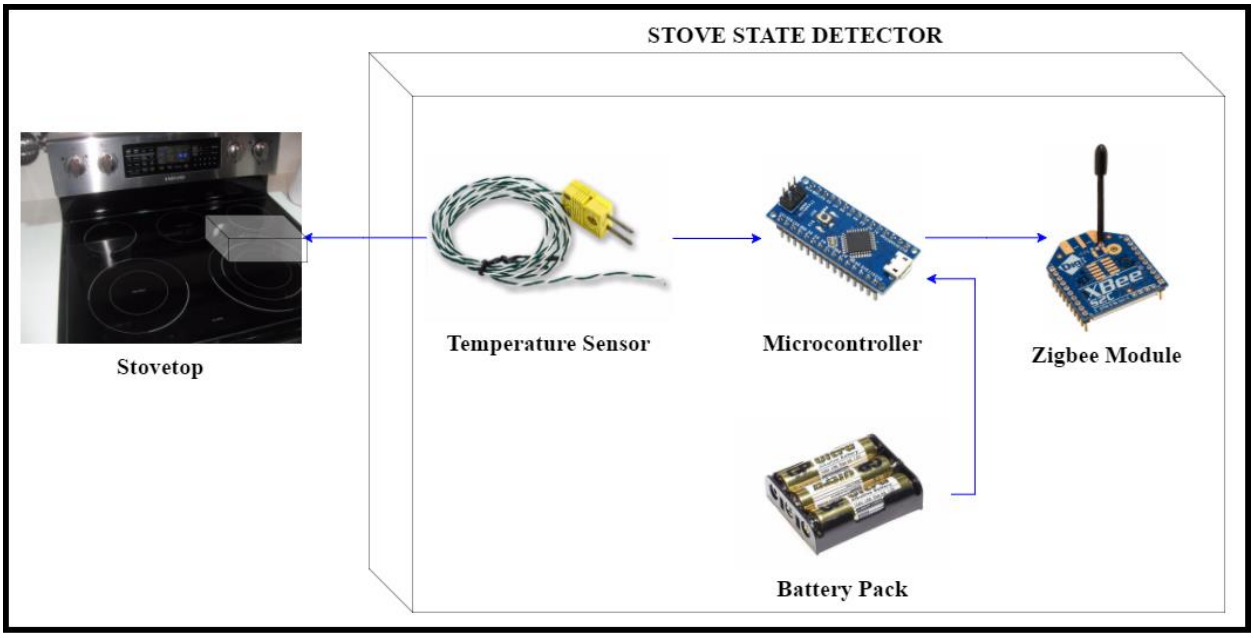

Figure 4: Stove State Detection

3.3. Door Lock (refer Figure 5 for overview)

3.3.1-**I** It shall be able to lock and unlock via voice command.

3.3.2-**I** It shall have the capability to maintain secure a connection to the Hub.

3.3.3-**II** It shall have the capability to send the status of the door to user.

3.3.4-**II** It shall have three LED lights for the following

1st LED= Power
2nd LED= Ethernet
3rd LED= Wi-Fi

To indicate the status of hardware.

3.3.5-**III** It shall have a rechargeable battery as an alternative power source.

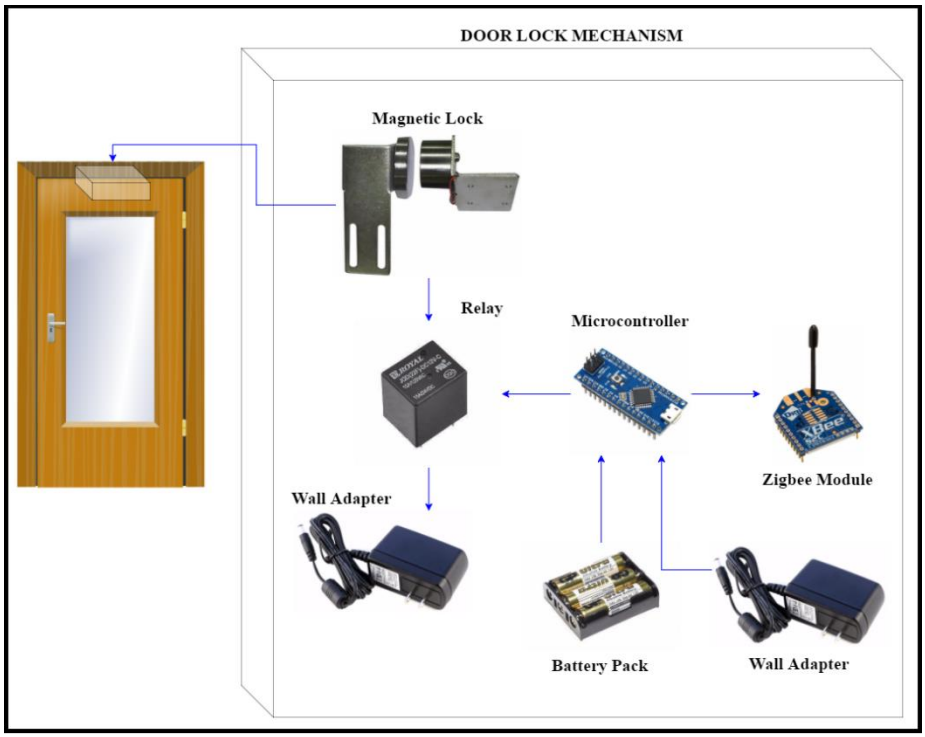

Figure 5: Door Lock Mechanism

3.4. BODY TEMPERATURE SENSOR (refer Figure 6 for overview)

3.4.1-**I** It shall have the capability to maintain a secure connection to the Hub so that it can send feedback to the user.

3.4.2-**I** It shall have a connection state indication on the hardware.

3.4.3-**I** It shall support a ZigBee Cluster and attribute information exchange mechanism to support wireless communication.

3.4.4-**I** It shall have the capability to receive a request for temperature from the hub.

3.4.5-**I** It shall have the capability to send the status information to the hub.

3.4.6-**I** It shall have the capability to refresh the data when the temperature of the body changes.

3.4.7-**II** It shall have the capability to detect temperature with 95% accuracy at the minimum.

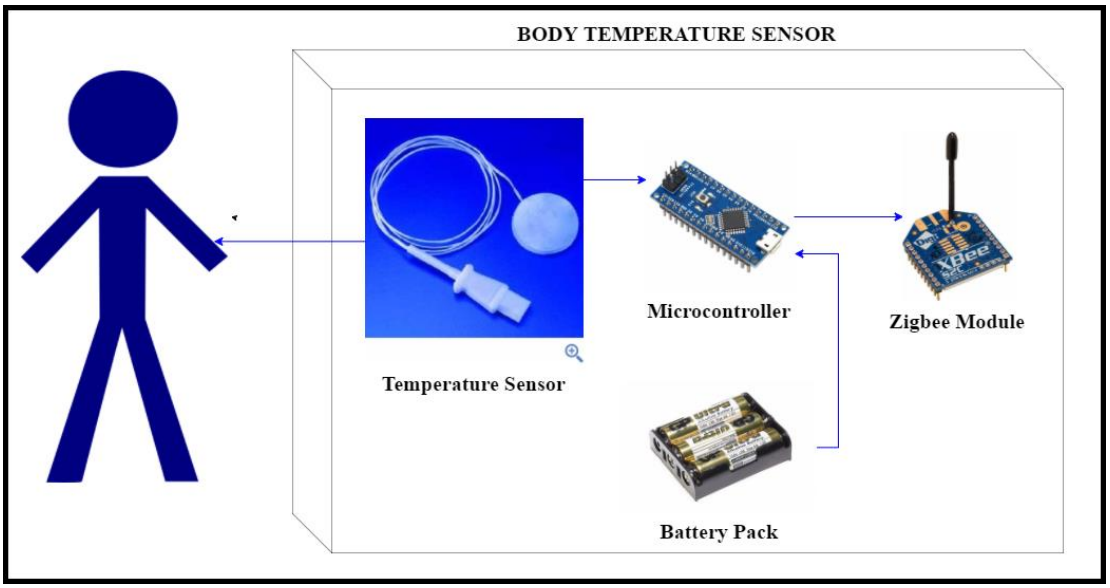

Figure 6: Body Temperature

3.5. CLOUD SERVER

3.5.1-**I** It shall authenticate with the hub using unique Install code on the device.

3.5.2-**I** It shall be integrated with MongoDB database and the cloud server should have the capability to store the user data.

3.5.3-**I** It shall be able to store the user information, including: user email, password, address, phone number and the ID of the device purchased.

3.5.4-**I** Several API calls shall be exposed to access the information from the server. Few examples are listed below:

- GET /user: It shall provide the list of the users in our database
- POST /user: It shall add new user to the system
- PUT /user: It shall modify the information of the existing user in the database
- DELETE /user: It shall delete the user from the database

More API will be introduced in the process of making data parsing easy to support the system integration with the User Interface.

3.5.5-**I** It shall run on AWS server.

3.5.6-**I** It shall be up and running for at least 95% of the year.

3.5.7-**II** It shall be able to store the history of a device up to a year.

3.5.8-**III** It shall have a private key that will allow other users to authenticate and any request from an IP without the clouds private key will be ignored and blocked from further attacks.

3.6. USER INTERFACE- STRATOS APPLICATION

(iPhone and Android)

3.6.1-**I** All the operations shall be supported using voice input and voice output. The app shall talk to the user using following keywords (the use case demonstration has been shown in Fig 7 and 8 respectively):

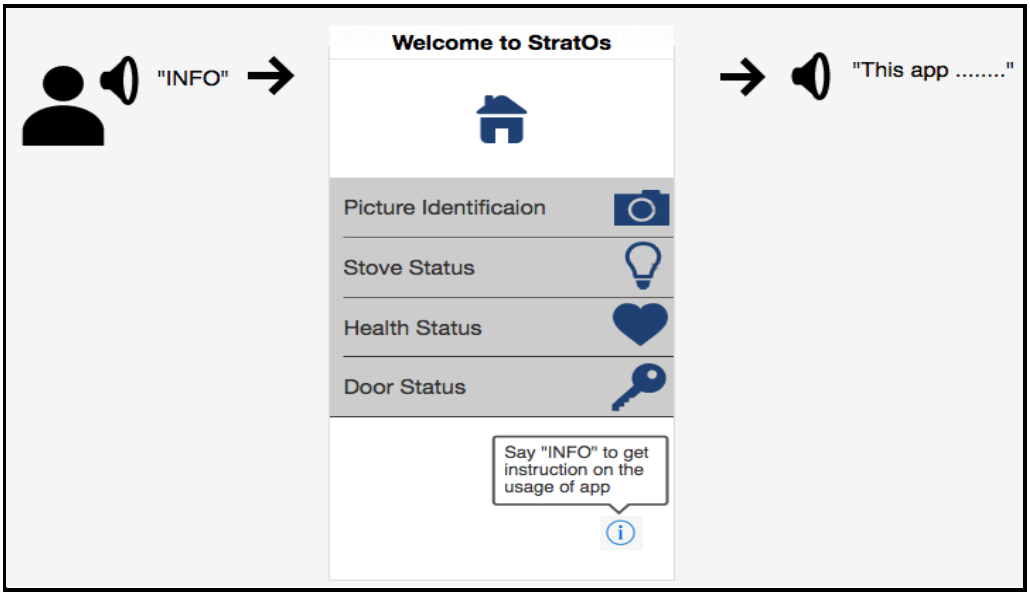

Figure 7:Mobile App Overview

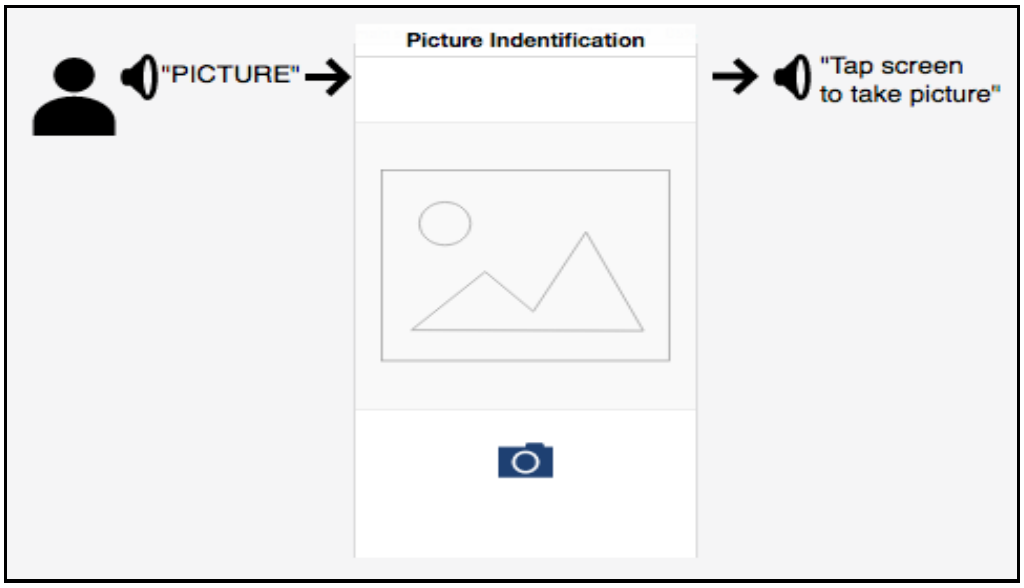

Figure 8: Mobile A-color detection layout

1. INFO This instruction shall read the customized information page of our application
2. PICTURE This instruction shall open the camera and inform the user that picture identification page is open and double tap to take a picture
3. STOVE This instruction shall read the temperature of the stove for the user
4. HEALTH This instruction shall read the temperature of the user's body

3.6.2 -**I** It shall have the real-time reporting capability of the state of the hub and the components.

3.6.3-**I** The app shall have a feature to take an image and report the color and shape of the image. Color detection decreases the dependence of our users on others.

4. Non-Functional Requirements

4.1-**I** The cost of each product will be cheap to make it affordable for disabled people.

4.2-**I** The casing will be made of conductive material to avoid any short circuit.

4.3-**I** The electronic components of the device shall not cause interference with other devices.

4.4-**II** The casing of the product will be Nano micro porous for excessive heat dissipation.

4.5-**III** Size of hub's and other product's casing shall be small so it does not occupy a lot of space.

4.6-**III** All product casing will have polystyrene to avoid any damage if it fell from the wall or ceiling.

4.7-**III** All the product shall be powered via rechargeable batteries, so in case of emergency, such as electricity shortage the system is up and running.

4.8-**III** Battery should be easily accessible so user can change it by when a replacement is required.

4.9-**III** Micro-processors will be connected via Ethernet as well as a backup if WIFI is out of service.

5. Engineering Standards

HUB

The hub shall comply with the WI-FI/IEEE 802.11 standard [1] to communicate with the internet cloud.

The hub shall comply with the ZigBee/IEEE 802.15.4 specification [2] to communicate with the components.

The hub's Micro-USB interface shall comply with the USB2.0 standard [3] to ensure compatibility with any 5V USB wall adapter.

Stove State Detector

The detector shall comply with the ZigBee/IEEE 802.15.4 specification [2] to communicate with the hub.

The detector shall comply with the appropriate Temperature Measurement Standards [4] for accurate and reliable results.

Door Lock

The lock shall comply with the ZigBee/IEEE 802.15.4 specification [2] to communicate with the hub.

The lock mechanism must comply with PC95.1 standard [5] for safe human exposure to electromagnetic fields.

Body Temperature

The sensor shall comply with the ZigBee/IEEE 802.15.4 specification [2] to communicate with the hub.

The sensor must comply with the IEC 60601-1-11:2015 standard [6] for the performance and safety of the medical electronic equipment for home environment use.

Cloud Server

The cloud server shall have security features outlined in AWS Cloud Security Resources [7]

The cloud server shall conform to the The NIST Definition of Cloud Computing [8]

User Interface

The user interface shall follow Android Core App Quality guidelines [9]

The user interface shall follow iOS Human Interface guidelines [10]

Common to Hub and Components

The hub and the components shall comply with the Canadian Electrical Code Part I [11] to ensure the safety of electrical equipment and their installation.

The hub and the components shall comply with the Canadian Electrical Code Part II, NO. 61508-2:17 [12] for the functional safety of the electronic components

The hub and the components' materials shall be RoHS compliant [13] to reduce the exposure of the user to hazardous materials found in electronic products.

The hub and the components' power circuitry shall conform to the IEEE- 1625-2008 standard [14] for the reliable operation of the system with rechargeable batteries

6. Sustainability

EasyHome was analysed on the following 5 criteria as required by Cradle to Cradle Design [15].

- Kinds of materials used in production of components.
- Recycling of material at the end of product life
- Amount of energy required for production
- Quality and quantity of water used
- Social responsibility including fair labor practices

Table below shows the breakdown of materials used, energy consumptions and material recycling methods during each stage in life cycle of the product[16].

Table 1: Design Life Cycle

	Types of materials used	Energy Cost	Wastage & Material Reutilization
Raw Material	**Hub casing** • Recyclable plastic **Circuit Board & CPU** • Sand • Copper **Electrical parts** • Tin • Silver • Palladium • Hard Gold	**Plastic production:** 54 mJ **Mining Copper** - 85 million Btu/ton **Silicon** - 14 kWh/kg	**Mining waste** – waste rock & other materials that overly the ore **Drilling waste** - high salt content, chemicals, heavy metals, radioactive material
Manufacture	• Epoxy Resin • Photo Resin • Tin	Manufacturing one chip requires 1.6 kg fossil fuels	• **Plastic manufacture:** Trichloroethane, Acetone etc. • **Manufacture of 6 inch Silicon wafer:** 25 lbs of Sodium

			Hydroxide, waste water & 7 lbs hazardous waste • **Assembly:** Greenhouse gases
Transportation	• Fossil fuels used in gas engines of vehicles • Paper for cardboard box	• Dependent on distance	• Greenhouse gases from trucks and planes
Usage	• Mice, USB, camera, LEDs etc. can be connected	• Max - 1 W/hour	• Small amount of greenhouse gases
Recycle	• N/A	• Plastic: recycling cost is 60% of the energy cost of production • Copper: recycling cost is 10% of the energy cost of production	• Silicon • Heavy metals
Waste	No new materials	Depends on waste management companies	• Plastics • Untreated electronic components

Recycling and Waste Management:

1. In order to minimise the electronic waste generated at the end of life of EasyHome devices StratOs Technologies will arrange for taking discarded systems from consumer to a recycling facility.
2. Consumer returning their older devices will receive a discount when purchasing new units.
3. In order to minimise waste, we are planning on using minimal amounts of plastic in our design. All the plastic used in the product will be recyclable plastic.
4. Information on e-waste recycling options will be included in the device documentation
5. StratOs Technologies will consider manufacture of new PCB boards from recycled material.
6. StratOs Technologies will bear the costs of treatment of radioactive waste produced during manufacture of our products.

Usage and Discharge of Water:

Semiconductor manufacturing is a water intensive industry. "To create an integrated circuit on a 30cm wafer, can require approximately 2,200 gallons of water"[17]. With the intention of water conservation StratOs Technologies will purchase Integrated Circuits only from companies with policies on water conservation and use of recycled material. Also, StratOs will incur any costs related to treatment of water for chips manufacturing for our products.

Social Responsibility:

StratOs Technologies will strive for top level of business, labour and environmental practices, and prioritize health and safety of employees. We will ensure to treat our employees and contractors fairly with appropriate salaries and safe working conditions. To meet Canada's Labor Code and environmental laws and international best practices Stratos Technologies will do the following:

1. Conduct Internal and external audits
2. Establish employee code of conduct
3. Provide all the employees access to policies and rights.
4. Hire contractors for short term work rather than hiring employees for short term.
5. Provide proper employee training.

6. Ensure that vendors and suppliers from countries where labour laws are not stringent don't employ children and follow fair labour practises.

7. Safety

1. All components will be enclosed in casings.
2. No casings will have sharp edges
3. Ensure proper insulation of wires, which are a part of our product.
4. Proper fuse levels at required points to prevent electric shock
5. Case for hub and peripheral devices shall be strong to endure physical stress
6. Harder passwords and strict settings to prevent any cyber-attacks or unauthorized access to user data
7. Fail proof electronic components

8. Reliability

1. An efficiency of at least 80% shall be achieved to minimize power losses.
2. The microprocessors and microcontrollers shall be in a low-power consumption mode, when not in use mode.
3. Devices shall be able withstand fluctuations in functional temperature.
4. Power dissipation in Hub and peripheral devices in form of heat should be minimum i.e. devices shall not become too hot to touch.
5. A fuse will be present in the circuit to prevent any damage to components

9. Conclusion

In conclusion, our EasyHome platform is composed of a wide variety of requirements needed for its optimum operation. This includes our EasyHome Components, EasyHome Hub, EasyHome Cloud, and EasyHome UI. Components are the devices that take the input needed to provide feedback to the user through an XBee module, and our hub. The hub acts as the brain of our platform by establishing the communication between components and the UI.

The UI is the key element of StratOs Technologies' EasyHome products as it is what provides feedback and monitoring to the customer, especially when our target audience are visually impaired people. Feedback and monitoring is established through the UI as our components send data to our hub, which reroutes them to the user's device. The data appearing on the UI would be the component's current status, the appliance's state such as an oven's temperature, or a door's lock status, which would be read out loud to the user by the application on the smartphone.

Finally, the cloud acts as an alternative route for the component's data to direct to before heading back to the UI. This would increase the options through which feedback could be provided such as through the internet for remote access (outside the house), or simply to store data history on the cloud for future reference. Our team has provided a list of each of the requirement specifications needed for our platform with a set priority level to indicate its importance and necessity for our platform.

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