October 15, 2015

Dr. Andrew Rawicz

School of Engineering Science

Simon Fraser University

Burnaby, British Columbia

V5A 1S6

RE: ENSC 440 Functional Specification– E-Garden

Dear Dr. Rawicz:

In regards to the course requirement of ENSC 305W/440W, enclosed to the letter Smart Garden Incorporation's functional specification for our product: E-Garden. We are designing and implementing an auto-watering system which enables people to get real time information of their lovely plants and maintain their plants through Internet.

The purpose of this functional specification is to present an overview of the functionality of the product at various development stages. This functional specification provides detailed system overview, the system requirements, and detailed test plan. Our team will use this functional specification as the guideline through the entire project.

Smart Garden Incorporation is a well-balanced team by six SFU senior engineering students: Timmy Kwok, WeidiZhai, Duling Lai, Siyan Chen, Bo Sun and Tianguang Zhang, who are very reasonable and motivated students, with various engineering backgrounds. If you have any further questions or concerns about the functional specification, please feel free to contact our CEO Timmy at 778-316-2022 or e-mail sumyuek@sfu.ca.

Yours Sincerely,

Timmy Kwok

CEO

Smart Garden Incorporation

Enclosure: Functional Specification for E-Garden System

Functional Specification
E-Garden System

Project Team members: Timmy Kwok
Duling Lai
WeidiZhai
Siyan Chen
Bo Sun
Tianguang Zhang

Contact Person: Timmy Kwok
sumyuek@sfu.ca

Submitted to: Dr. Andrew Rawicz
Steve Whitmore
School of Engineering Science
Simon Fraser University

Date: Oct 19, 2015

EXECUTIVE SUMMARY

Our product, E-Garden, is based on the idea of saving time and money on maintaining garden. With this idea in mind, we come up with E-Garden, which enables people to get real time information of their plants and maintain their plants anytime from anywhere. In order to bring the best convenience to the user, our E-Garden is designed with the following parts and functions: temperature and moisture sensors to acquire the real time data of the plants, microcontroller to collect data and send it to web server, as well as a web APP to display the information and schedule watering.

The development of this product will be done in three phases: two prototyping phases and a final product stage. The detailed stages are shown as following:

Prototyping stage I:

- Build the main functionality
- Use the microcontroller to collect data from sensors
- Develop database to store the data

Prototyping stage II:

- Create a user interface through HTML5
- Control the watering system through microcontroller

At the end of the second stage, a working proof of concept should be delivered no later than 1st December 2015. Considering the time and resource limitations, our targets within the next months are to meet the proof of concept features. If time permits, additional features may be added to the product.

This document will describe the functional specification for E-Garden with details of the individual components. Other topics will also be covered, such as sustainability and the associated engineering standards. Our team will confirm that the system meets all the standards and safety guidelines. Our team will follow all the requirements in this document.

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GLOSSARY

APP	Short for application; a program which runs in user space
CAD	Canadian dollars
CSA	Canadian Standards Association
ICES	Industry Canada Electric Standards
PCB	Printed Circuit Board
GPIO	General-Purpose Input/Output
%RH	Relative humidity
SSE	Server-Sent Event; update real time data on website
UI	User Interface
FAQ	Frequently Asked Questions
OS	Operating System

1. INTRODUCTION

The E-Garden is aimed to bring the best convenience to maintaining garden. Aside from automatically watering the plant, our product also collects and displays soil humidity and temperature data of your garden. Our web APP, which includes web server and web interface, will enable you to maintain your garden anytime from anywhere. E-Garden is a system embedded with the following main parts (as shown in Figure 1):

- Humidity and Temperature sensors: DHT-11
- Microcontroller: Raspberry Pi-2
- Servomotor: MG995 High Speed Digital Metal Gear
- Web APP: Internet interface

This document lays out the functional requirement for our E-Garden system in order to provide a comprehensive reference for this user friendly product.

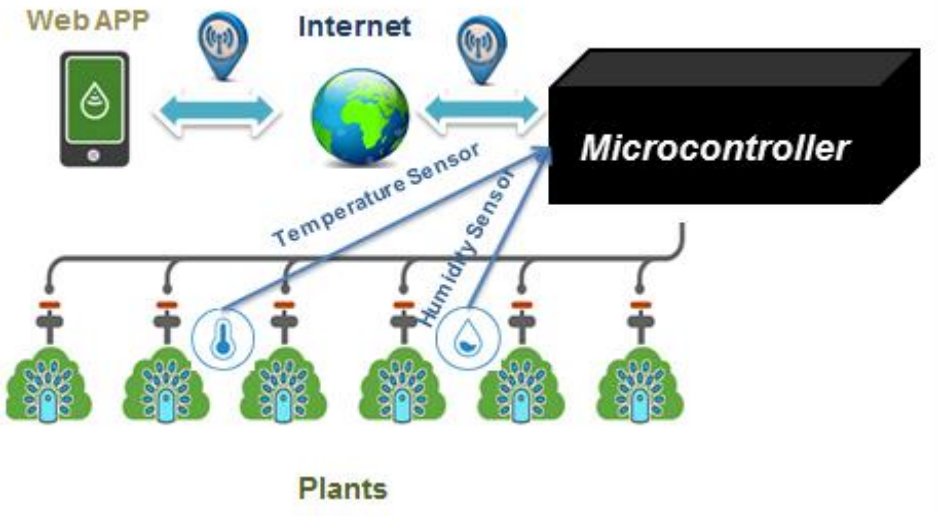

Figure 1 Product Figure

1.1 SCOPE

This document outlines a list of functional requirements that should be met by E-Garden. It also provides a complete system overview for E-Garden. Furthermore, the sustainability and safety requirements are also outlined in this document.

1.2 INTENDED AUDIENCE

The functional specification is a guideline for the design and implementation of our product, E-Garden. The management team, CEO and CTO, will use this document as a measure for the compliance for E-Garden. The hardware design engineers will use this document as a measure to ensure their design meet the hardware functions and align with our goals. The software design engineers will ensure their design meet the web APP requirements. Moreover, all engineers should consider compatibility between hardware and software during the design process. Furthermore, the test team will use this document to measure all the function specifications are met as outlined.

1.3 REQUIREMENT CLASSIFICATION

This document uses the following convention to number and prioritize the functional requirements:

[Reqx.y.z-pn]

Where 'x', 'y', 'z' indicates the functional requirement number and section; 'p' represents the priority of the functional requirement. The priority is divided into three levels:

- P1 - These requirements are high priority and apply to the proof-of-concept system
- P2 - These requirements are medium priority and apply to both the proof-of-concept system and the final product
- P3 – Low priority. These requirements apply to the final product only.

1.4 INTENDED USER

The intended user for this product is defined as a person who is at least 8 years old and capable of using internet. Any person not fitting in this category is beyond the scope of this document.

2. System Overview

2.1 SYSTEM INFORMATION

Our product consists three major parts for users to interact with, which are web APP, microcontroller and servomotor. The figure below shows how users interact with the components.

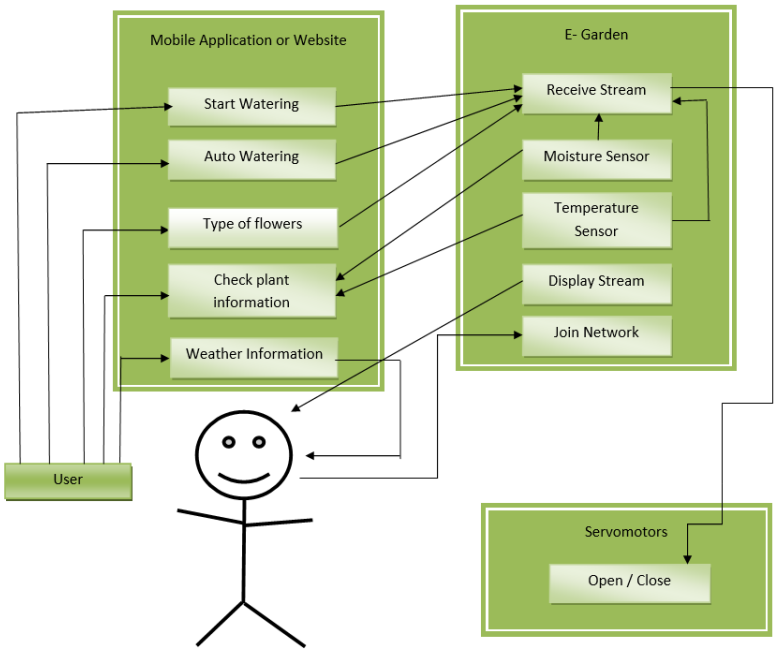

Figure 2 System Specification

2.2 SYSTEM SPECIFICATION

The E-Garden uses a microcontroller, raspberry pi 2, to control the multiple inputs and outputs of the system. The microcontroller is connected to a USB Wi-Fi adapter, temperature sensors, moisture sensors, display screen and a servomotor to collect data and water the plant. The block diagram of the entire system is shown below:

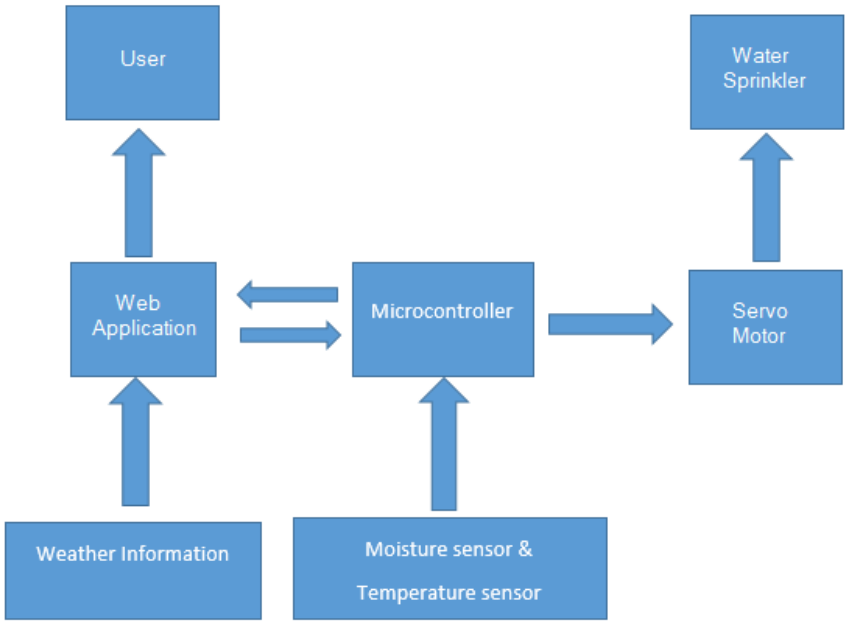

Figure 3 System Block Diagram

The system design contains three major parts which are software, hardware and firmware:

1) Hardware system is to provide data of temperature and moisture level, and send the information to the raspberry pi 2 to be sent to web server and web APP. Hardware system also aimed on timing the spin of servomotor, in order to control the amount of water.
2) Firmware system is on the raspberry pi 2 controller that streams the data to web APP through the Wi-Fi network.
3) Software system is a web APP which provides information to users and feedback the watering schedule from user to the microcontroller.

2.3FUNCTIONALITY JUSTIFICATION

The function of the E-Garden System is designed to satisfy the users who want to monitor and automate watering their plants instantly, conveniently and cost-efficiently. Therefore, our E-Garden system has to include the following features: low cost, real-time and cross-platform. To achieve these properties, we chose the following components to satisfy these goals: DTH11 sensors, the Raspberry Pi-2microcontroller, and web server. The selected sensors, DTH11, will allow the system directly collect the moisture and temperature information at the same time, the information collection will be completed by only one sensor. The Raspberry Pi-2 is a powerful microcontroller, it can process the

information efficiently, and response to the users' orders quickly. With the designed web server, users can control the system by Internet Browsers through the Internet; they do not need any other special apps for the system. Also, the system notification can be sent immediately by the Internet.

With our market research, we did not see any similar products with all three functions above, especially web application. The fast developing pace of Internet makes our product a bright future in the market.

3. System Requirements

This section demonstrates the requirements for the E-Garden. The system consists of three main design parts: hardware, software and watering system.

3.0.1 GENERAL REQUIREMENT

[Req 3.0.1-P1]	This system can be appropriate for any circumstances. It can be used in both indoor and outdoor
[Req 3.0.2-P1]	The final product's plant data base can be updated by using Internet
[Req 3.0.3-P3]	The cost of entire set of final product should be less than $200 CAD
[Req 3.0.4-P3]	The dimension of the product should be as small as possible
[Req 3.0.5-P2]	Customer can proficiently use the product after reading the manual

3.0.2 ENVIRONMENTAL REQUIREMENT

[Req 3.0.6-P1]	The product can operate properly in a normal indoor environment (5°C – 35°C)
[Req 3.0.7-P1]	The product can operate properly in a normal outdoor environment (0°C-50°C)
[Req 3.0.8-P1]	The water pipe should be able to operate in extremely cold winter without freezing
[Req 3.0.9-P1]	All the components in the product have to be waterproof

3.0.3 SAFETY REQUIREMENT

[Req 3.0.10-P2]	The system should not have flammable components
[Req 3.0.11-P2]	The system should be encapsulated well
[Req 3.0.12-P1]	The system should not be overheated
[Req 3.0.13-P1]	The system is able to stop operating when problems occur

[Req 3.0.14-P1]Ensure no electricity leakage occurs

3.0.4 STANDARD

[Req 3.0.15-P2] The final product should conform to CSA standards

[Req 3.0.16-P2] The whole devices should comply with the ICES

3.1 FIRMWARE REQUIREMENTS

This section identifies the firmware requirements of E-Garden. For the proof of concept model the firmware will be run on the Rasoberry-Pi2 Model B.

3.1.1SETUP REQUIREMENTS

[Req 3.1.1-P2] The system will time out of WPS connection after 2 minutes

[Req 3.1.2-P1] The firmware shall manage data communication to sensors

[Req 3.1.3-P1] The firmware should be able to control the servomotor

[Req 3.1.4-P1] The firmware shall manage data communication to web APP

[Req 3.1.5-P1] The firmware requires Debian Linux as the microcontroller OS

3.1.2 NETWORK REQUIREMENTS

[Req 3.1.6-P1] The system will transfer data only under Wi-Fi network connection

[Req 3.1.7-P2] The network server shall be stable to store real time data

[Req 3.1.8-P1] The system will attempt to connect to wireless router using Wi-Fi

[Req 3.1.9-P3] The system automatically reconnects to network it has been connected to previously known wireless networks

3.2 HARDWARE REQUIREMENT

Several hardware components are needed in order to accomplish the expected system functionalities. The main controller is Raspberry-Pi 2 and the main sensor is DHT-11humidity and temperature sensor. The sensor is placed in the flowerpot in order to detect the outside temperature and the soil moisture level. After acquiring the data on the external environment, the microcontroller will receive the output signal from the sensor, and it will send the data to the database in the server. As a result, web APP can read the data and decide whether to water the plants.

3.2.1 GENERAL REQUIREMENT

[Req 3.2.1-P2] The dimension of the product should be as small as possible

[Req 3.2.2-P2] The cost of entire hardware should be less than $100 CAD

3.2.2 ELECTRICAL REQUIREMENT

[Req 3.2.3-P1] The main controller is a raspberry-Pi 2 PCB [1]

[Req 3.2.4-P2] It has a GPIO Ribbon Cable that creates a connection between sensors and microcontroller

[Req 3.2.5-P1] The system should use a typical wall power outlet and it should be capable withgeneral North American power outlets which is 60Hz and110V/120V AC in indoor environment

[Req 3.2.6-P3] The system should be powered by battery cells in outdoor environment

[Req 3.2.7-P1] Raspberry-Pi 2 microcontroller should not have analog input more than5 volts from the sensor to prevent damage

[Req 3.2.8-P2] 4.7k resistor (one per sensor) is needed to avoid damage on the sensor

[Req 3.2.9-P2] Several DHT-11 humidity and temperature sensors are used in the Circuit

3.2.3 PHYSICAL REQUIREMENTS

[Req 3.2.10-P2] The flowerpot should have appropriate size and it cannot be larger than 100 x 100 cm^2

[Req 3.2.11-P2] The water tank, the water pipe and the switch should be integration

[Req 3.2.12-P1] All the components in the product have to be waterproof

[Req 3.2.13-P1] The product can operate properly in the temperature range between 0°C to 50°C

[Req 3.2.14-P3] The final product should be small in size

3.2.4 OPERATION REQUIREMENTS

[Req 3.2.15-P1] The sensor can sense the temperature from 0 °C to 50 °C

[Req 3.2.16-P2] The temperature measurement accuracy is ±2.0 degree C

[Req 3.2.17-P1] The sensor can sense the humidity from 20% to 90%RH (0°C-50°CTemperature compensation) [2]

[Req 3.2.18-P2] The humidity measurement accuracy is ±5.0%RH

[Req 3.2.19-P3] All installation must be operated after reading manual guide

[Req 3.2.20-P2] All operation must be operated in safe environment

3.3 SOFTWARE REQUIREMENTS

E-Garden has a firmware which runs on the microcontroller to collect data and manage controller-server communication. E-Garden also has a software which is a web APP to interact with the user who will use the data for watering. User can use their smartphone to scan a QR code access to the web APP of their E-Garden. As E-Garden uses browser-supported web APP, the users do not have to install any application. In addition, the users can access their E-Garden on phone, tablet, and laptop.

3.3.1 GENERAL REQUIREMENTS

[Req 3.3.1-P1] The firmware should be out of work when the microcontroller is unplugged

[Req 3.3.2-P1] Microcontroller shall remain dry at all the time for firmware to work properly

[Req 3.3.3-P1] The browser shall support SSE for real time data (such as Safari, Chrome, IE) [3]

[Req 3.3.4-P2] The user interface of web APP should provide two watering modes: to be manual or automatic

3.3.2 USABILITY REQUIREMENTS

[Req 3.3.5-P1] The UI shall have intuitive and contents are clearly displayed

[Req 3.3.6-P1] Most of the users should find the system intuitive to use and be able to configure the entire systems within 10 minutes

[Req 3.3.7-P2] The entire system's reset button shall be visible and easy to access

3.4 WATERING SYSTEM REQUIREMENTS

Watering the plant is the main function of our product, E-Garden, thus we have to control the amount of water be dispersed. This section will describe the watering system requirements for E-Garden that includes the servomotor and water tubes. A sample way to control the water flow is to time the servomotor spinning in order to open or close the water tap.

3.4.1 GENERAL REQUIREMENTS

[Req 3.4.1-P1] The system is designed for house owner

[Req 3.4.2-P1] The system is turned on when the power supply is plugged in

[Req 3.4.3-P1] The system can control the servomotor to spin clockwise or counter clockwise

3.4.2 SETUP REQUIREMENTS

[Req 3.4.4-P1] The servomotor has to be tied with the water tap

[Req 3.4.5-P1] The servomotor has to connect to the microcontroller “raspberry pi 2”

[Req 3.4.6-P2] The water tap has to be in circle around 2.5-3.0 cm in radius

Figure 4 Tap Diameter Displayed

[Req 3.4.6-P2] Ensure the water tube has to be 1cm in radius in order to have a Better accuracy of the amount of water used

3.4.3 ELECTRICAL REQUIREMENTS

[Req 3.4.7-P1] The servomotor will require 4.8 – 5.25 Voltages power supply

[Req 3.4.8-P1] The power plug are of North American standard

[Req 3.4.9-P1] The circuit is capable to connect with the raspberry-pi

3.4.4 SAFETY REQUIREMENTS

[Req 3.4.10-P1] The servomotor should not use in under 0 °C

[Req 3.4.11-P2] All components must be kept away from children and pets

[Req 3.4.12-P2] All components should not be compressed or stepped on

[Req 3.4.15-P3] All components should be kept away from extreme heat

3.4.5 PHYSICAL REQUIREMENTS

[Req 3.4.16-P1] Ensure the water tap not be too tight

[Req 3.4.17-P1] Ensure the water pressure not be too high

3.5 DOCUMENTATION REQUIREMENTS

The user documentation will include the product of E-Garden. It will provide detailed information of the system functions, web interface, and simple user guide.

3.5.1 GENERAL REQUIREMENTS

[Req 3.5.1-P3] User document will include text, table, pictures, and step by step instructions on how to operate E-Garden system

[Req 3.5.2-P3] The safety, sustainability, and warranty information should be included in user document

[Req 3.5.3-P3] The FAQs and troubleshooting sections should include both hardware and software questions.

3.5.2 USER MANUAL REQUIREMENTS

[Req 3.5.4-P3] The user manual should teach users how to operate the device

[Req 3.5.5-P3] The user manual shall be written for an audience with minimal technical background

[Req 3.5.6-P3] The user manual contains the information on how to maintain the product

[Req 3.5.7-P3] The user manual includes the limitations of the device and its usability

[Req 3.5.8-P3] The user manual includes the safety information about the device

3.5.3 SOFTWARE REQUIREMENTS

[Req 3.5.9-P3] E-Garden system web application will update by itself.

4. Sustainability/Safety

Our final product, E-Garden, composes of several key parts, which are microcontroller, servomotor, sensors, web server, and wires. In order to make our product sustainable and safe, we are trying to make each of the individual parts to meet a cradle to cradle design philosophy. Most of the key parts, such as microcontroller and sensors, are purchased online with carefully consider the sustainability and

safety for everyone. With regards to minimise the waste, we also do a wide research for individual part to ensure that each of them meets our design and functional specifications.

Social equity, restorative environmental impact, and profitability are the three primary pillars in this project [4]. Profitability is the bottom line in this project, but we will not compromise other primary pillars during our decision-making processes. Each decision in this project should fairness and neutrality for all three pillars.

We will share wires, water pipe, and some hardware parts, such as Arduino board and servomotor, with our other projects to minimise cost and waste. For the portion of outdoor parts, such as pipes and plant pot, we will consider these materials as sustainable as possible. Moreover, the ideal of using wireless application, such as web application, to adjust water schedule is sustainable and safe, because this idea will reduce hardware materials that might have environment hazards, and meet all the three primary pillars.

With regards to the organic part of our project, such as plants, our E-Garden is very sustainable and safe. Since our E-Garden collects information from the surrounding area and adjust the environment, the condition for the surrounding area will be in an optimal condition for organisms to live in.

5. Conclusion

This document clearly and concisely defines the functional requirements for E-Garden, and highlights the expected functions by priorities. The proof-of-concept and prototype device are currently under development. The system design consists of three major parts:

1) Hardware design aimed to provide accurate real time information from the target environment with an acceptable tolerance;
2) Software design aimed to receive and send information from both users and microcontroller without delay and errors;
3) Firmware development aimed to build a communication channel between microcontroller and web APP with Wi-Fi.

This document includes five major sections. It will allow hardware and software development team to allocate resources accordingly. In this functional specification, the high priority functions are given to microcontroller collects information from sensors and sends/receives information to/from web APP. whereas low priority gives to some materials, such as flowerpot and pipes.

With completion of each stage, our prototype product will meet functional requirements outlined above and expect to be demonstrated by December 15, 2015.

6. References

[1] No author. “DHT11 Humidity and Temperature Digital Sensor.” Internet: http://www.microbot.it/en/product/74/DHT11-Humidity-and-Temperature-Digital-Sensor.html, Oct., 2011 [Oct. 19, 2015].

[2] No author. “Raspberry Pi 2, Model B” Internet: http://www.adafruit.com/pdfs/raspberrypi2modelb.pdf, Feb. 19, 2015 [Oct. 19, 2015].

[3] S. Smith. “'Pushing Updates to the Web Page with HTML5 Server-Sent Events | Developer Drive.” Internet: : http://www.developerdrive.com/2012/03/pushing-updates-to-the-web-page-with-html5-server-sent-events, Mar 13, 2012 [Oct. 19, 2015].

[4] C. B. Fledderman. *Engineering Ethics,* 2nd edition. Upper Saddle River, N.J.: Prentice Hall, 2004