Department of Computer Science and Engineering
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System Requirements Specification

Project: Home Irrigation Control System

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Document Revision History

Revision Number	Revision Date	Description	Rationale
0.1.0	10/01/14	Initial draft	
0.1.1	10/19/14	Draft revisions to TA’s specifications	GTA and peer review notes
0.1.2	10/20/14	Unified formatting	To give the SRS a consistent look and feel
0.1.3	10/25/14	Updated Use Cases section	
0.1.4	10/26/14	Revisions for Professor O’Dell’s notes	Update SRS to reflect suggestions from Professor O’Dell’s review
0.1.5	10/29/14	Updated calculations (COCOMO, Jones 1st Order, Weiss & Wysocki Sanity Test)	Updating calculations to reflect more accurate estimation
0.2.0	10/30/14	Updated sections 1, 2, 3, 5, and 11 to reflect project changes	Updating sections to describe new product design
0.2.1	10/31/14	Updated sections 10 and 12 to reflect project changes	Updating sections to describe new product design
0.2.2	11/1/14	Updated sections 7, 8, and 9 to reflect project changes	Updating sections to describe new product design
0.2.3	11/2/14	Minor formatting changes made	Uniform look and feel
0.3.0	11/3/14	Restructuring of requirements into more concise sections	Break big requirements into more manageable sections and vice-versa
0.3.1	11/3/14	Revisions made to sections based on peer review	Incorporate feedback from Team TimeKeepers
0.3.2	11/4/14	Revisions made based on team conference call	Get any last minute input from team members incorporated into SRS
1.0.0	11/4/14	Minor tweaks made during final walk through of SRS document	Final inspection and walkthrough of document

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1. Product Concept

This section describes the purpose, use, and intended user audience for the Home Irrigation Control System, abbreviated HICS. HICS is an intelligent home irrigation system that collects readings from soil moisture and other local environment sensors and analyzes the data to determine the necessary amount of water needed for the user's lawn. The purpose of this product is to make home irrigation systems easier and smarter by providing customers with an automated watering solution that helps with water conservation and provides remote access through an easy to use web application.

1.1 Purpose and Use

HICS is designed to take advantage of soil moisture sensors to provide a smart watering system for users with an existing sprinkler system. All watering activities will be governed by a smart controller which will be able to collect information about current soil moisture levels and allow the user to adjust watering amounts and times based on those readings.

Our smart controller integrates seamlessly into the users existing sprinkler system to allow users to remotely control and monitor their home's irrigation through a web interface. Users will be able to set watering schedules manually or allow HICS to water based on the current soil moisture levels.

1.2 Intended Audience

The target audience for HICS is primarily home owners that either have or plan on installing a sprinkler system on their property and the irrigation/landscaping companies that install those systems for their customers.

Our product would mainly be marketed towards audiences with water conservation in mind. Water conservationists will appreciate the various ways of utilizing soil moisture readings to water their lawn only when necessary and to ensure that over watering does not occur.

Another targeted audience for HICS would be individuals who find themselves away from their homes for extended periods of time. Once installed, the HICS system will communicate through a web application to allow users to view data from their soil moisture sensors, set and control the watering of their lawn, and control the monitoring features of their system remotely.

2. Product Description and Functional Overview

This section provides the reader with a product description and functional overview of HICS. The aspects of our product that are described in detail include its primary operation(s), core functionality, and the key individual features and functions required that make HICS work.

2.1 Features and Functions

Our product will consist of a central control unit, soil moisture sensors, and a web application that work and communicate effectively with each other. See Figure 2-1 for a high-level concept of the components.

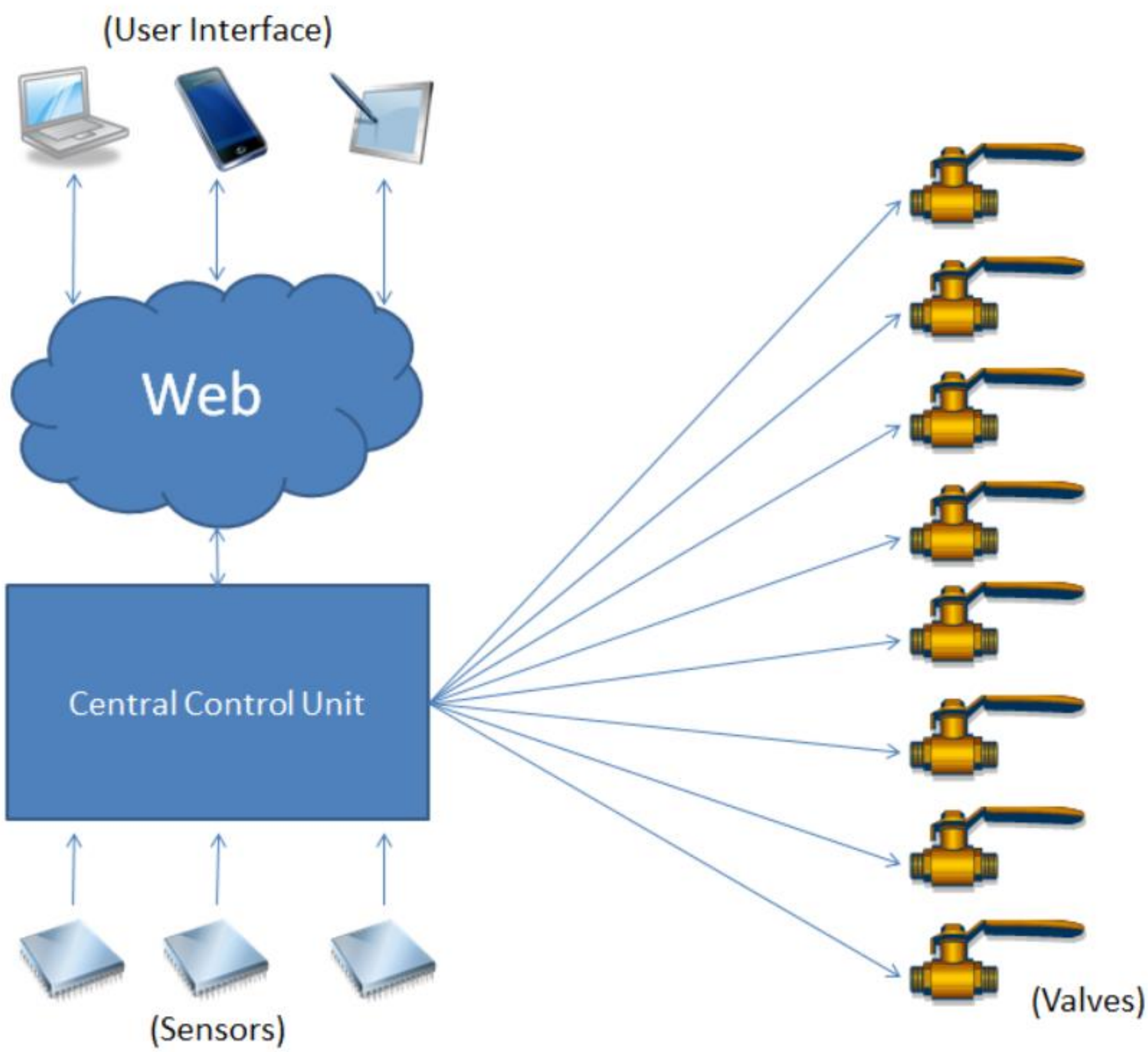

Figure 2-1 High-level concept diagram

2.1.1 - Intelligent Central Control Unit: The most important component of HICS is the intelligent central control unit which is responsible for all communication between the sensors, water valves, and web application. The control unit relays input from the sensors to the web application and also receives control commands as input, from the web application, to control the water valves.

2.1.2 - Soil Moisture Readings: The most important components that will contribute to the effectiveness of HICS are the soil moisture sensors. The sensors monitor soil moisture levels in the user's lawn and sends the information to the central control unit. This data is processed by the microcontroller in the control unit and uploaded, via the internet, to the HICS web application.

2.1.3 - Web Services: One of the features that makes HICS smarter than other home irrigation systems is its ability to analyze soil moisture readings and set watering schedules effectively. The HICS web application provides a web service that the central control unit communicates with to store all soil and temperature readings into a database. These readings are then analyzed to determine what water amounts the lawn requires and allows the user to adjust their watering schedules accordingly.

2.1.4 - Remote Control: A main component of HICS is a web application that can be used to monitor and control the irrigation system from a computer or smart phone. This application will provide control features to adjust watering schedules, read and record data collected by the moisture sensors, and turn the sprinkler valves on and off. This will allow the user to maintain complete control over their home irrigation system regardless of their physical location.

2.1.5 - Scheduling: Users will be able to create and change watering schedules for the HICS via the web application. HICS will provide its own suggested watering schedule that will be created based on soil moisture levels, current weather conditions, and previous watering history. In addition to automated scheduling, users will be able to manually set or change schedules based on personal preferences or to adhere to local community water restrictions.

2.1.6 - Local Weather Analysis: HICS provides a weather monitoring feature that the user can set to override watering schedules based on reports from an included rain sensor. To optimize water usage, HICS will not operate when it is raining at the systems location. This information will be transferred between the rain sensor and the central control unit to override any scheduled watering that occurs while it is raining. In addition to rain detection HICS also provides a temperature monitoring feature that monitors local temperature via a sensor to override watering in the event of freezing weather.

2.1.7 - Web Application with Scalable Interface: HICS will include a web application that is designed to allow users to access their home irrigation system on any device that is connected to the internet and has access to a web browser. The web application will be built with scalability in mind to enable the same functionality on a mobile device as it would on a desktop computer. This approach will provide a similar look and feel across different interface devices and will enable our software to be used on a wide array of platforms.

2.1.8 - Registration and Account Management: To ensure the integrity of our system, each user must create an account and register their HICS device before being able to access the features of the web application. Each HICS device will be given a unique serial number that will be used for registration purposes. Once the user creates an account and registers their device they will be granted full access to interface with their device via the web application.

2.2 External Inputs and Outputs

2.2.1 - Inputs: HICS will require multiple inputs and outputs across each of its components. Analog data signals will be transferred from the soil moisture sensors to the central control unit. This input provides the information about the soil moisture levels. When using the web application, users requests information about their home irrigation system. Users can also use the application to send information to the central control unit to control the system. These inputs are made from end users and will be sent as a digital signal to turn on and off the water valves.

2.2.2 - Outputs: When users request information from the web application, the output will be defined as the response information about the home irrigation system. This information could include current soil moisture readings, history of watering, and current watering schedules. When HICS is remotely operated, the output will be defined as the signals sent to the water valves to open and close as dictated by the user.

Name	Data Flow	Description	Use
Soil Moisture Sensors	Input	The sensors send soil moisture readings to the central control unit.	The moisture levels are used to determine the amount of water the lawn needs.
Rain Sensor	Input	The sensor sends an alert signal to the central control unit when it detects rain.	The rain sensor is used to alert the central control unit of rain so that the valves can be shut off to conserve water.
Temperature Sensor	Input	The sensor sends an alert signal to the central control unit when the temperature falls below freezing.	The temperature sensor is used to alert the central control unit of freezing conditions so that the valves can be shut off to prevent hazardous conditions.
Control Unit	Input/Output	The central control unit relays data between the web application, sensors, and valves.	The unit sends the sensor readings to the web application and receives control commands for the water valves.
Web Application	Input/Output	The application communicates with central control unit and stores information to the database.	The application relays data between the user, the central control unit, and the database.
Database	Input/Output	The database holds all information for the application.	Information will be stored in the database and fetched upon request.
Create/Update Account	Input	The user will be able to create/modify an account associated with a device.	The user account is used to login and monitor/control a device.
Create/Update Schedule	Input/Output	The user will be able to communicate with the central control unit to start/stop watering.	The watering schedules are used to determine when to water the lawn and for how long.
Login	Input	The user must login with their registered username and password to access the web application.	The user login is required to provide security for controlling a HICS device.
Toggle Water Valve	Input	The user inputs an action to immediately start or stop watering.	The water valve will toggle between open and closed to start or stop watering.
Reports	Input/Output	The user inputs parameters to display specific data about their HICS.	The user can generate reports to display information about current/past soil readings and watering schedules.

Table 2-1 External inputs and outputs

2.3 Product Interfaces

2.3.1 - User Registration

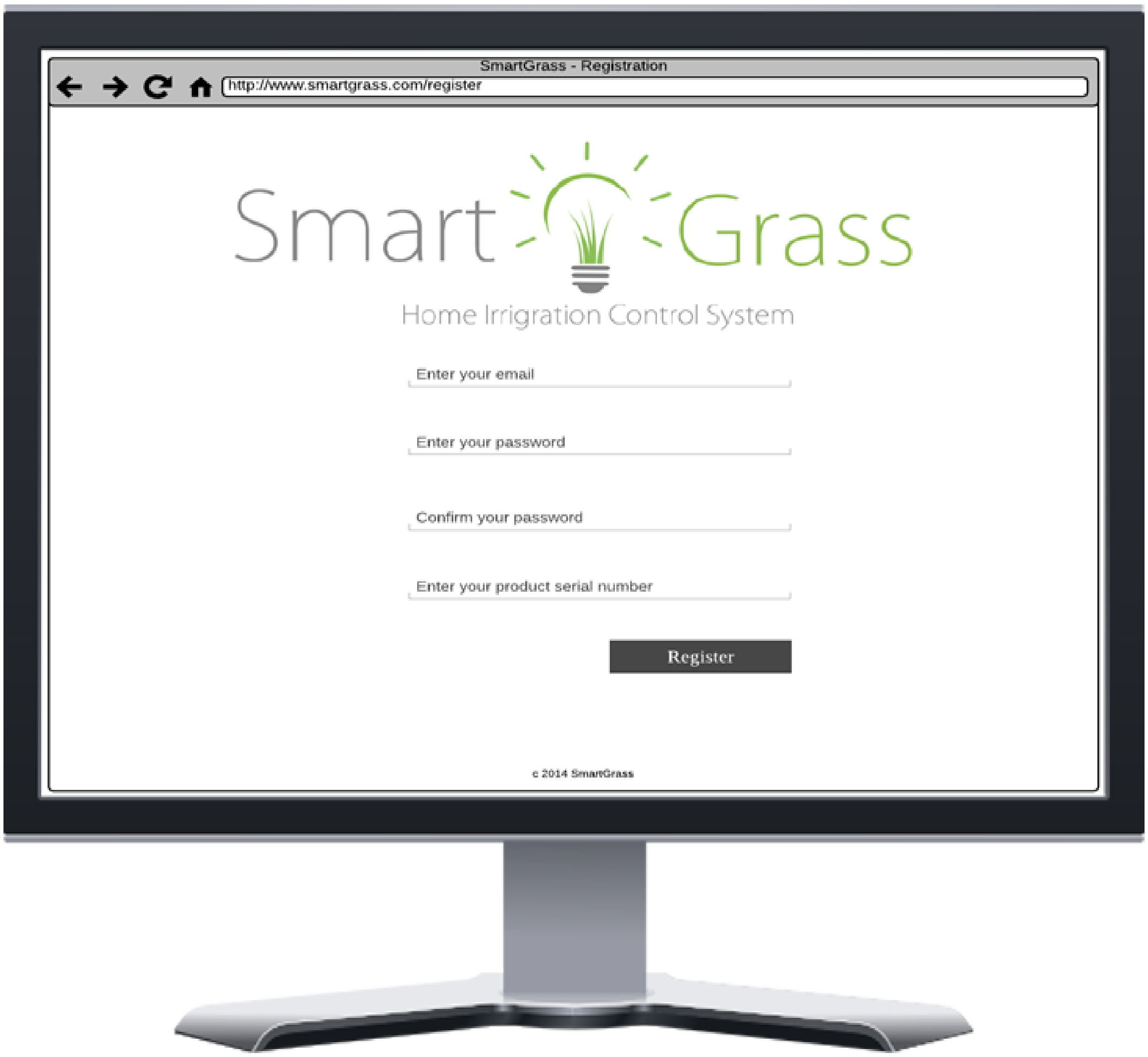

Figure 2-2 User registration interface

2.3.2 - User Login

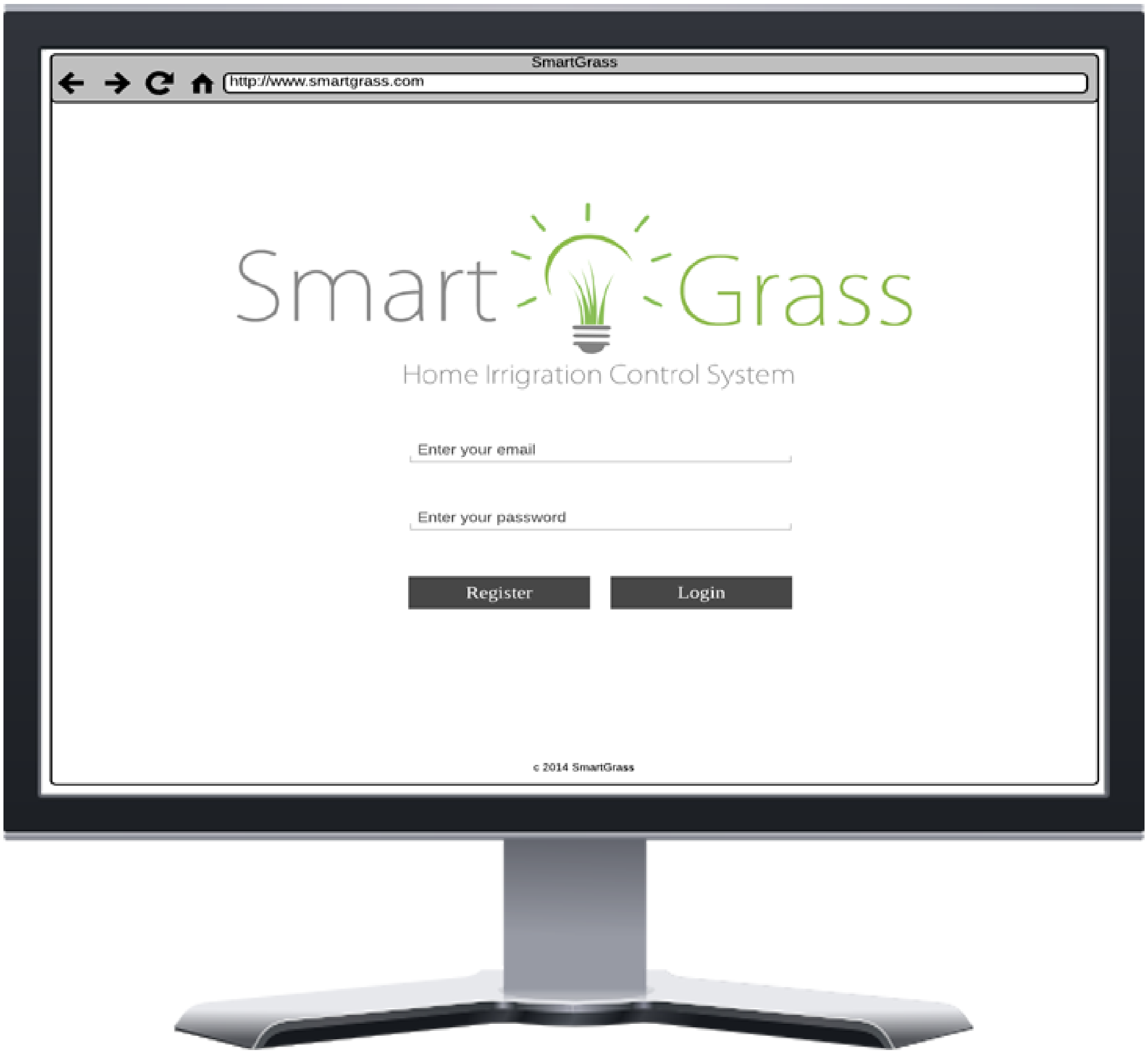

Figure 2-3 User login interface

2.3.3 – Home Dashboard

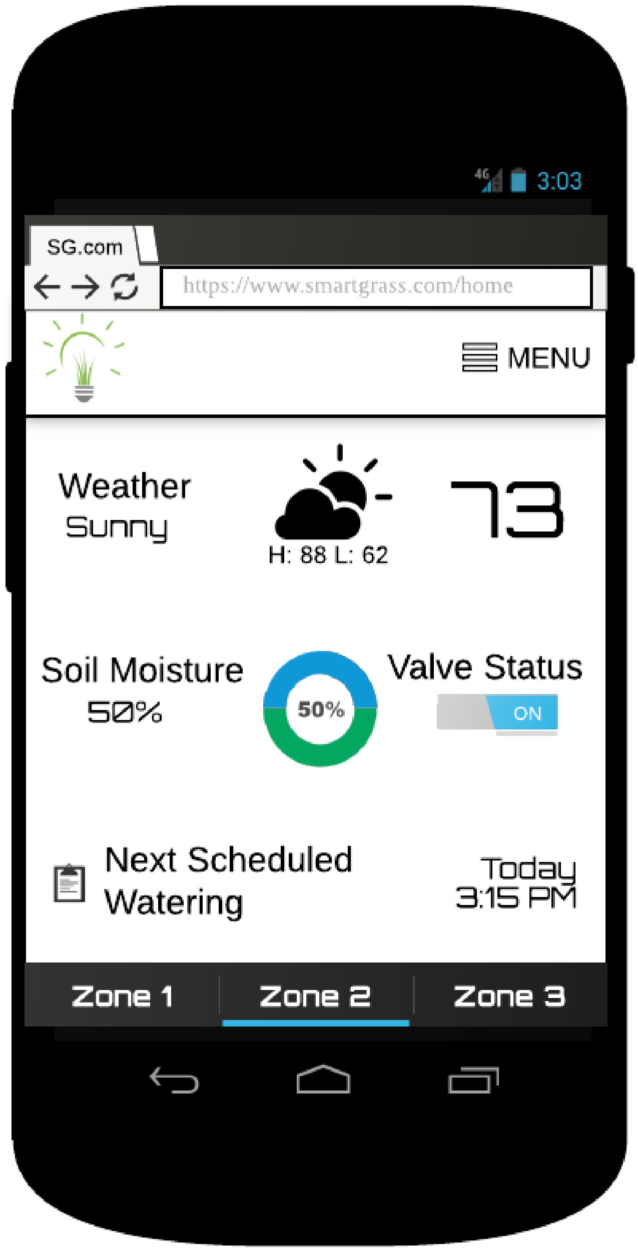

Figure 2-4 Home dashboard interface

2.3.4 – Watering Scheduler

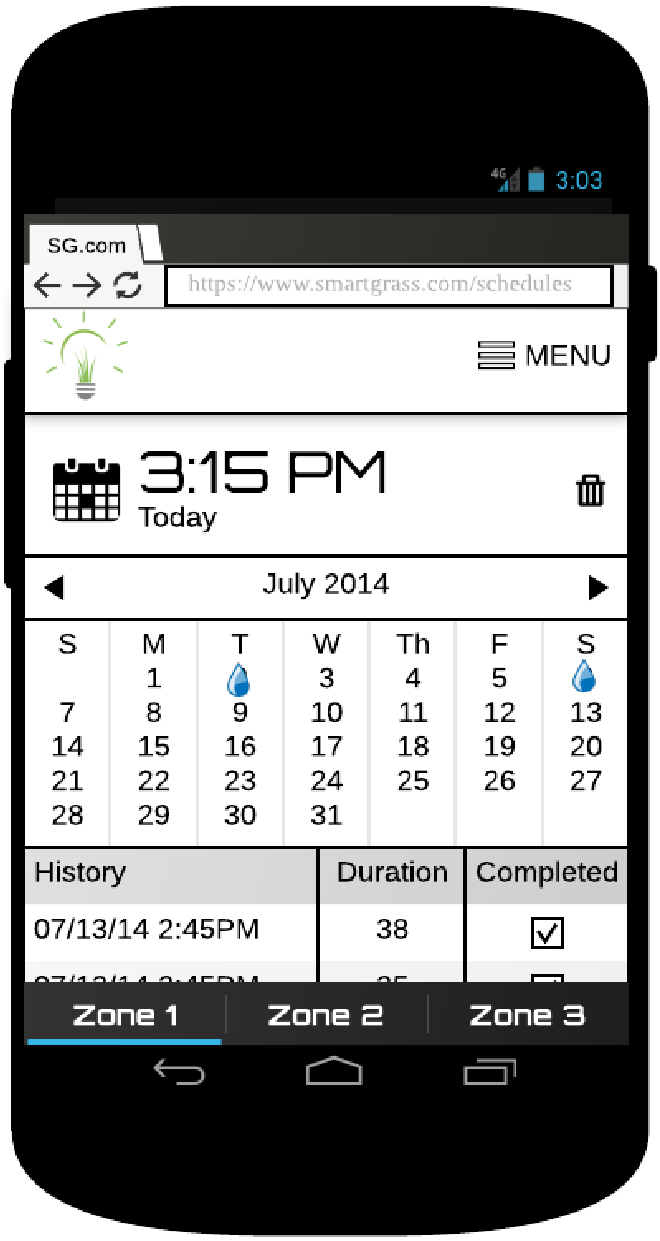

Figure 2-5 Scheduler interface for sprinkler system

2.3.5 – Region Creation

Figure 2-6 Region creation dialog

2.3.6 – User Settings

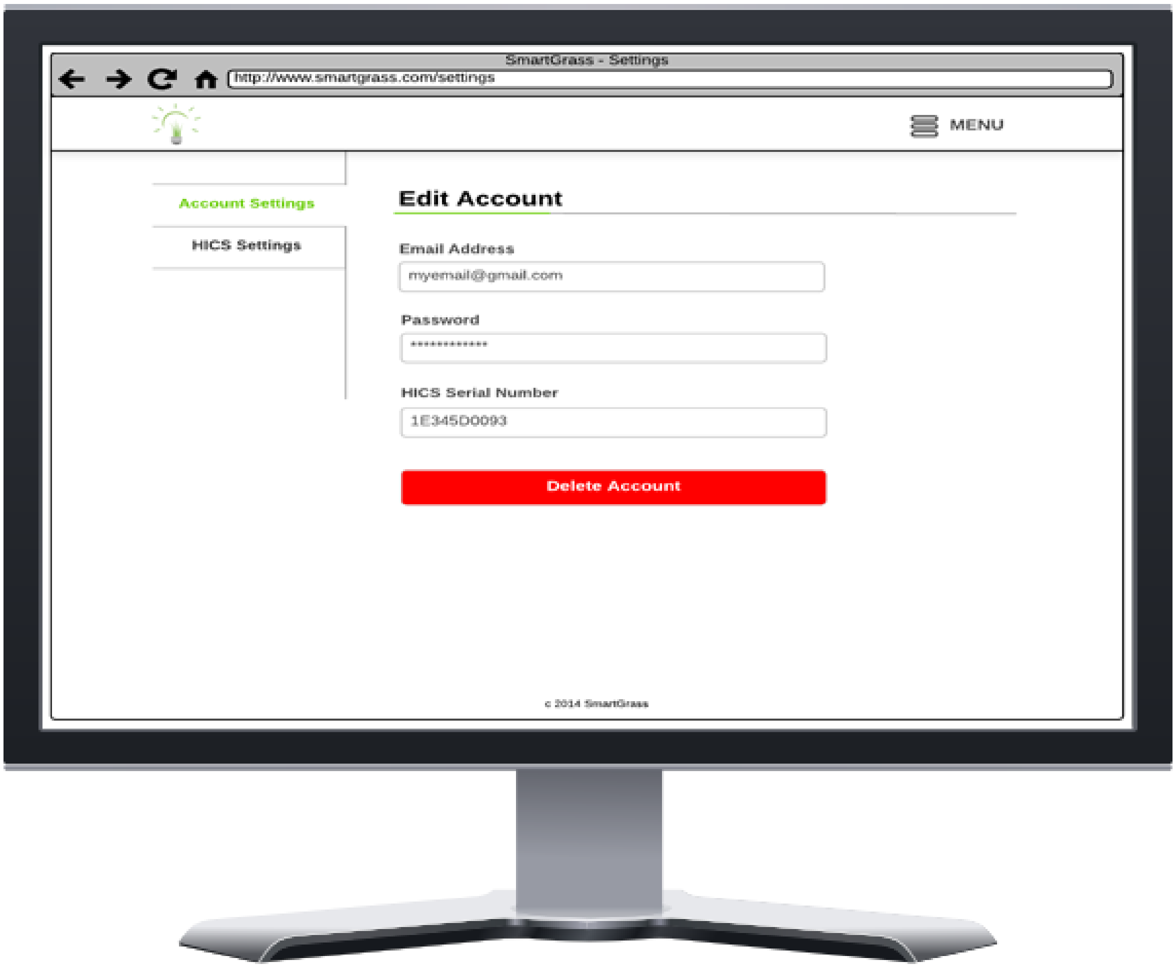

Figure 2-7 User settings interface

2.3.7 – Administrator Settings

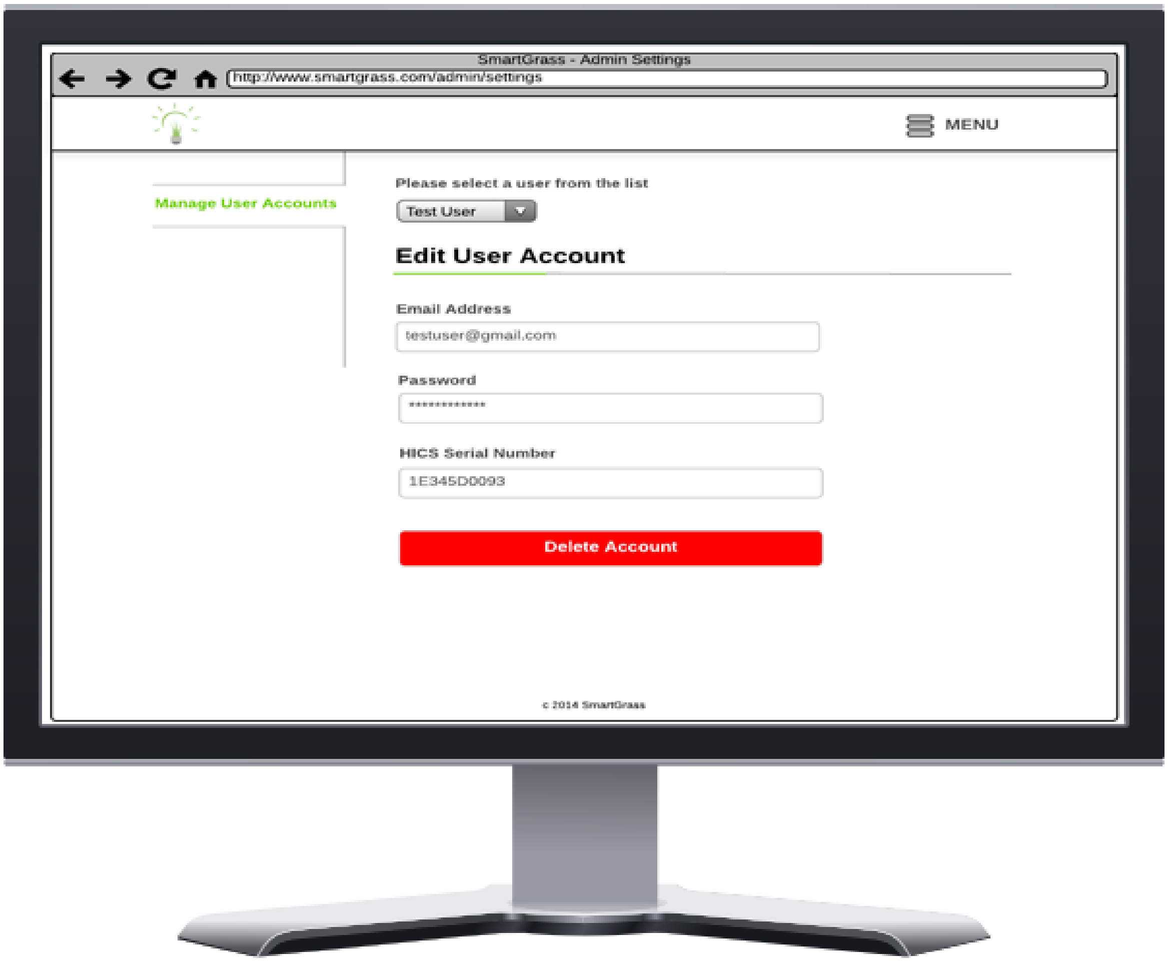

Figure 2-8 Administrator settings interface

3. Customer Requirements

This section details the hardware and software requirements set by the customer for HICS. Each item listed will review in detail the description, source, constraints, standards, and priority necessary for complete functionality.

3.1 Central Control Unit

3.1.1 - Description: The central control unit is responsible for all communication between the web application, soil moisture sensors, and water valves. The control unit will transmit the readings from the soil moisture sensors and report the data to the web application. The control unit also controls the water valves, which sets the flow of water to the sprinkler system.

3.1.2 - Source: Team SmartGrass

3.1.3 - Constraints: Wires from the water valves must be plugged into the control unit. The control unit also requires power from an outlet and must be connected to the internet.

3.1.4 - Standards: NEMA 5–15R power connector, cat5e Ethernet connector

3.1.5 - Priority: 1 – Critical Priority

3.2 Soil Moisture Sensors

3.2.1 - Description: In-ground sensors that monitor and report soil moisture levels.

3.2.2 - Source: Team SmartGrass

3.2.3 - Constraints: Must be connected directly to the central control unit and must be placed in the ground in close proximity to an irrigation zone. Power must be provided to the soil moisture sensors via the central control unit.

3.2.4 - Standards: None

3.2.5 - Priority: 1 – Critical Priority

3.3 Web Application

3.3.1 - Description: The web application will be used to interface with the central control unit. The application is responsible for scheduling watering times as well as interfacing with the central control unit to control the water valves. The web application will be built with a scalable interface to enable the same functionality on a mobile device as it would on a desktop computer while maintaining a similar look and feel.

3.3.2 - Source: Team SmartGrass

3.3.3 - Constraints: Must be hosted online by a web hosting service provider and maintain a maximum uptime. Access to the application requires an internet connection, a supported web browser, and an active subscription to the hosting service provider.

3.3.3 - Standards: None

3.3.5 – Priority: 1 – Critical Priority

3.4 Watering Scheduler

3.4.1 - Description: The web application can schedule watering times and durations for the sprinkler system on a soil moisture percentage basis. These schedules are determined by other environmental conditions as well such as temperature and time of year. The scheduler will display upcoming watering schedules and allow users to manually create, edit, or delete them.

3.4.2 - Source: Team SmartGrass

3.4.3 - Constraints: None

3.4.4 - Standards: None

3.4.5 - Priority: 1 – Critical Priority

3.5 Soil Moisture Reports

3.5.1 - Description: The web application will generate visual reports of the current soil moisture levels. The reports will be generated as graphic representations of the data and will be filterable by zone, year, month, and day.

3.5.2 - Source: Team SmartGrass

3.5.3 - Constraints: Must have a minimum of one soil reading from the control unit.

3.5.4 - Standards: None

3.5.5 - Priority: 3 – Moderate Priority

3.6 User Login

3.6.1 - Description: The user must login to the web application using the correct credentials to be able to remotely control features of HICS.

3.6.2 - Source: Team SmartGrass

3.6.3 - Constraints: The user must have an active internet connection and access to a supported web browser on their device. Additionally, a user account and correct credentials must be provided in order to login.

3.6.4 - Standards: None

3.6.5 - Priority: 1 – Critical Priority

3.7 Active Status

3.7.1 - Description: The web application will have a status indicator on the home dashboard to display whether a zone is actively being watered or not. (see Figure 2-4)

3.7.2 - Source: Team SmartGrass

3.7.3 - Constraints: None

3.7.4 - Standards: None

3.7.5 - Priority: 4 – Low Priority

3.8 Rain Sensor

3.8.1 - Description: An external rain sensor will monitor the weather conditions and will send an alert to the central control unit in the event of rain. The user preferences will dictate whether this event will turn the sprinklers off or not.

3.8.2 - Source: Nuts and Bolts Hardware

3.8.3 - Constraints: Rain sensor must be mounted outside and connected to the control unit.

3.8.4 - Standards: None

3.8.5 - Priority: 2 – High Priority

3.9 Web Hosting Service

3.9.1 - Description: There will be a web service that hosts our web application with an associated URL for domain user access.

3.9.2 - Source: Team SmartGrass

3.9.3 - Constraints: A subscription to a web hosting service must be acquired. A URL must also be registered and associated with the domain.

3.9.4 - Standards: None

3.9.5 - Priority: 1 – Critical Priority

3.10 Database Management System

3.10.1 - Description: There will be a DBMS provided by our web hosting service provider that will store all data from soil sensor readings as well as all the information for the web application. This information includes user account information, settings, reports, and weather data necessary for the application to perform as expected.

3.10.2 - Source: Team SmartGrass

3.10.3 - Constraints: None

3.10.4 - Standards: None

3.10.5 - Priority: 1 – Critical Priority

3.11 Device Registration

3.11.1 - Description: A user must register their HICS device with their account in order to interface with it via the web application. The central control unit will have a unique serial number on it that will be used to register the device to a user account.

3.11.2 - Source: Team SmartGrass

3.11.3 - Constraints: The central control unit must have a valid serial number on it in order for a user to register the device.

3.11.4 - Standards: None

3.11.5 - Priority: 2 – High Priority

3.12 Region Grouping

3.12.1 - Description: In HICS each zone is individually controlled however a user may group their sprinkler zones into regions through the web application. This functionality will allow the user to setup watering schedules for multiple zones at once without having to configure each individual zone.

3.12.2 - Source: Nuts and Bolts Hardware

3.12.3 - Constraints: Each zone will have exactly one valve and each region must contain a minimum of one zone.

3.12.4 - Standards: None

3.12.5 - Priority: 3 – Moderate Priority

3.12.5 - Priority: 3 – Moderate Priority

3.13 Auto Off

3.13.1 - Description: The user can set an auto off timer via the web application that terminates watering if the duration lasts longer than the set time.

3.13.2 - Source: Team SmartGrass

3.13.3 - Constraints: None

3.13.4 - Standards: None

3.13.5 - Priority: 3 – Moderate Priority

3.14 Temperature Sensor

3.14.1 - Description: A temperature sensor will monitor the temperature conditions central control unit's location. If the sensor detects temperatures around freezing (34° F), the HICS will shut off the watering valves and notify the user to prevent freeze hazards.

3.14.2 - Source: Nuts and Bolts Hardware

3.14.3 - Constraints: The temperature sensor must be installed outside and must be connected to the central control unit.

3.14.4 - Standards: None

3.14.5 - Priority: 2 – High Priority

4. Packaging Requirements

This section will detail the specifics of the packaging requirements for HICS. The packaging will relate to the final overall look and feel of the hardware and software, as well as how the finalized product is delivered to the user (i.e. the form factor).

4.1 Control Unit Housing

4.1.1 - Description: The components of the control unit, including its accessories, will be contained inside a mountable hard plastic container.

4.1.2 - Source: SmartGrass

4.1.3 - Constraints: This component needs to be wall mountable and must be packaged in a convenient form factor for the user. The central control unit housing is intended to be mounted inside in a location sheltered from external weather conditions, and thus will not be waterproof or weather resistant.

4.1.4 - Standards: None

4.1.5 - Priority: 1 – Critical Priority

4.2 Soil Moisture Sensors Packaging

4.2.1 - Description: (4) Soil sensors will be included in the final packaging of HICS. They will be located within their own boxes and will have corresponding documentation that describes their proper installation. The user will be able to purchase additional soil moisture sensors and add them to their system.

4.2.2 - Source: Nuts and Bolts Hardware

4.2.3 - Constraints: The user will be responsible for the proper installation of the soil sensors according to the included instructions.

4.2.4 - Standards: None

4.2.5 - Priority: 3 – Moderate Priority

4.3 Rain Sensor Packaging

4.3.1 - Description: (1) Rain sensor will be included in the final packaging of HICS. It will be located within its own box and will have corresponding documentation that describes its proper instillation.

4.3.2 - Source: Nuts and Bolts Hardware

4.3.3 - Constraints: The user will be responsible for the proper installation of the rain sensor according to the included instructions.

4.3.4 - Standards: None

4.3.5 - Priority: 3 – Moderate Priority

4.4 Connecting Cables

4.4.1 - Description: (1) Power cable and (1) Ethernet cable will be included in the final packaging of HICS. Their intended purpose is to be used with the central control unit.

4.4.2 - Source: Team SmartGrass

4.4.3 - Constraints: None

4.4.4 - Standards: NEMA 5–15R power connector, cat5e Ethernet connector

4.4.5 - Priority: 3 – Moderate Priority

4.5 Software Application

4.5.1 - Description: The HICS software should be a stand-alone web application that requires no set up from the user. The user must register an account with a valid product serial number to access the web application. Once they are logged into their account and their device has been connected, they will be able to access the features of the HICS.

4.5.2 - Source: Team SmartGrass

4.5.3 - Constraints: The user needs an active internet connection in order to interface with the web application. The central control unit must be connected to the internet via the included Ethernet cable and registered with the user's account before it can be controlled.

4.5.4 - Standards: None

4.5.5 - Priority: 1 – Critical Priority

4.6 User Manual

4.6.1 - Description: A user manual will be presented to the user that details the use and operation of HICS. It will be provided in the final packaging as a CD-ROM and will also be made available online via the web application.

4.6.2 - Source: Team SmartGrass

4.6.3 - Constraints: The manual will only be provided in English

4.6.4 - Standards: None

4.6.5 - Priority: 3 – Moderate

4.7 Temperature Sensor Packaging

4.7.1 - Description: (1) Temperature sensor will be included in the final packaging of HICS. It will be located within its own box and will have corresponding documentation that describes its proper instillation.

4.7.2 - Source: Nuts and Bolts Hardware

4.7.3 - Constraints: The user will be responsible for the proper installation of the temperature sensor according to the included instructions.

4.7.4 - Standards: None

4.7.5 - Priority: 3 – Moderate Priority

5. Performance Requirements

This section specifies the requirements necessary for the optimal performance of HICS. These requirements are in place to ensure that watering schedules are resourceful and efficient to optimize water conservation. Performance requirements are also in place to encompass overall responsiveness and reliability of the system.

5.1 Sensor Accuracy

5.1.1 - Description: Proper sensor readings of soil moisture levels must be captured to ensure accurate and efficient watering schedules. This requires solid construction of the sensor modules and proper software analysis of the data provided by the sensors.

5.1.2 - Source: Team SmartGrass

5.1.3 - Constraints: Soil moisture sensors must be properly installed according to the provided instructions.

5.1.4 - Standards: None

5.1.5 - Priority: 2 – High Priority

5.2 Rain Detection

5.2.1 - Description: In the event of rainy weather, the rain sensor must quickly transmit an alert to the control unit to interrupt or delay any active watering.

5.2.2 - Source: Team SmartGrass

5.2.3 - Constraints: The rain sensor must be properly placed and installed in order to ensure this functionality.

5.2.4 - Standards: None

5.2.5 - Priority: 3 – Moderate Priority

5.3 Communication Between the Web Application and Central Control Unit

5.3.1 - Description: The user will be able to set watering schedules through the web application to send a signal to the central control unit to initiate watering. This must happen in a timely manner to ensure consistency between the scheduled start/end times and the actual start/end times.

5.3.2 - Source: Team SmartGrass

5.3.3 - Constraints: None

5.3.4 - Standards: None

5.3.5 - Priority: 2 – High Priority

5.4 Communication Between the Soil Moisture Sensors and Central Control Unit

5.4.1 - Description: The soil moisture sensors will communicate with the central control unit to relay information about soil moisture levels. This must be accomplished periodically in an accurate and timely manner in order to avoid errors and to ensure consistency throughout the system.

5.4.2 - Source: Team SmartGrass

5.4.3 - Constraints: None

5.4.4 - Standards: None

5.4.5 - Priority: 2 – High Priority

5.5 Device Power Malfunction

5.5.1 - Description: If the web application fails to receive communication from the central control unit for a specified period of time, it will notify the user that the system is offline.

5.5.2 - Source: Nuts and Bolts Hardware

5.5.3 - Constraints: Control unit must be without power for a specified period of time.

5.5.4 - Standards: None

5.5.5 - Priority: 3 – Moderate Priority

6. Safety Requirements

This section specifies the various safety requirements associated with HICS. The minimization of possible risk and/or injury to our customers is a top priority. Special attention is being applied to this section due to the nature of this project dealing with electricity and water.

6.1 Soil Moisture Sensor Insulation

6.1.1 - Description: The electronic components of the soil moisture sensors must be properly insulated against external environmental conditions. This is to ensure that they do not malfunction while in use.

6.1.2 - Source: Team SmartGrass

6.1.3 - Constraints: None

6.1.4 - Standards: None

6.1.5 - Priority: 2 – High Priority

6.2 Central Control Unit Temperature

6.2.1 - Description: Efficient air flow and low temperatures must be established while the central control unit is in operation. Computer fans and proper ventilation in the housing container will be used to cool the device and prevent it from overheating and possibly starting a fire.

6.2.2 - Source: Team SmartGrass

6.2.3 - Constraints: None

6.2.4 - Standards: None

6.2.5 - Priority: 2 – High Priority

6.3 Proper Wiring of Central Control Unit

6.3.1 - Description: The central control unit will be powered from an external wall plug. The source will be 120v and improper wiring could leave the user exposed to currents in the range of 15-20 amps. It is crucial that the control unit is wired properly to accept this input and cause no harm to the device or the user.

6.3.2 – Source: Team SmartGrass

6.3.3 - Constraints: None

6.3.4 - Standards: NEMA 5–15R power connector

6.3.5 - Priority: 1 – Critical Priority

7. Maintenance and Support Requirements

This section details the requirements for ongoing use of HICS after its final delivery to the user. Achieving maximum long-term performance is the key to reducing product maintenance. These requirements aim to minimize system errors and hardware failures.

7.1 Sensor Maintenance

7.1.1 - Description: The soil and rain sensors will be replaceable in the event of hardware failure.

7.1.2 - Source: Nuts and Bolts Hardware

7.1.3 - Constraints: Replacement sensor must be compatible with the device.

7.1.4 - Standards: None

7.1.5 - Priority: 2 – High Priority

7.2 Software Maintenance

7.2.1 - Description: All source code files and relevant documentation must be available for software maintenance and troubleshooting. The required files and documentation will be available via the GitHub repository. The software will be split into loosely coupled parts so it would be easier to make changes and improvements to the system over time.

7.2.2 - Source: Team SmartGrass

7.2.3 - Constraints: None

7.2.4 - Standards: None

7.2.5 - Priority: 3 – Moderate Priority

7.3 Source Code Documentation

7.3.1 - Description: All source code files required for HICS will be extensively commented to support future updates and troubleshooting.

7.3.2 - Source: Team SmartGrass

7.3.3 - Constraints: None

7.3.4 - Standards: None

7.3.5 - Priority: 3 – Moderate Priority

7.4 Scalability

7.4.1 - Description: The central control unit will support adding additional valves or soil sensors.

7.4.2 - Source: SmartGrass

7.4.3 - Constraints: The central control unit will support up to thirty-two valves and thirty-two corresponding soil sensors.

7.4.4 - Standards: None

7.4.5 - Priority: 2 – High Priority

7.5 Troubleshooting Guide

7.5.1 - Description: A troubleshooting guide will be presented to the user that details some possible problems that they might encounter in typical use and their appropriate solutions. Similar to the user manual, it will be provided in the final packaging as a CD-ROM and will also be made available online via the web application.

7.5.2 - Source: Team SmartGrass

7.5.3 - Constraints: The troubleshooting guide will only be provided in English

7.5.4 - Standards: None

7.5.5 - Priority: 3 – Moderate

8. Other Requirements

This section details all additional requirements for the project that do not directly fit in previous sections. All of the following requirements should be completed for the project to be deemed complete. Requirements not listed in this section or in previous sections will not be part of the overall implementation of HICS.

8.1 Mapping the Soil Moisture Sensors to Irrigation Valves

8.1.1 - Description: HICS requires that the user properly maps the soil moisture sensors to the irrigation valves. The central control unit will feature a diagram showing the one-to-one relationship between soil moisture sensor inputs and irrigation valve inputs.

8.1.2 - Source: Team SmartGrass

8.1.3 - Constraints: The user must follow the included diagram and instructions to properly map the sensors and valves.

8.1.4 - Standards: None

8.1.5 - Priority: 1 – Critical Priority

8.2 Browser Support

8.2.1 - Description: The web application should be scalable and responsive in all of the latest versions of Mozilla Firefox, Google Chrome, and Internet Explorer.

8.2.2 - Source: Team SmartGrass

8.2.3 - Constraints: Versions of Internet Explorer older than IE9.0 will not be supported. Browsers other than the ones listed above may not necessarily be supported.

8.2.4 - Standards: None

8.2.5 - Priority: 3 – Moderate Priority

8.3 Central Control Unit Mounting

8.3.1 - Description: The central control unit must be mounted in a location where it can interface with wires from the water valves and soil moisture sensors. It must also be within range of Ethernet and power outlets.

8.3.2 - Source: Team SmartGrass

8.3.3 - Constraints: Mounting location must be within range of Ethernet and power outlets.

8.3.4 - Standards: None

8.3.5 - Priority: 2 – High Priority

8.4 Rain Sensor Mounting

8.4.1 - Description: The rain sensor must be placed outdoors in a location where there are no obstructions directly above it. The best placement for this sensor is on the roof of the user's home in a location where other water sources will not interfere with it.

8.4.2 - Source: Team SmartGrass

8.4.3 - Constraints: Rain sensor must be mounted in a location free from obstructions and must be properly connected to the central control unit.

8.4.4 - Standards: None

8.4.5 - Priority: 3 – Moderate Priority

8.5 Application Security and Privacy

8.5.1 - Description: All user data and account information will be stored in a secured DBMS. Users will only be allowed to access their HICS devices and account information if they provide the correct login credentials. In addition, all user passwords will be encrypted and stored only as hash values.

8.5.2 - Source: Team SmartGrass

8.5.3 - Constraints: User passwords are required to be six characters in length and contain one upper case and numerical character.

8.5.4 - Standards: OWASP Web Application Security Standards

8.5.5 - Priority: 3 – Moderate Priority

8.6 User Administration Account

8.6.1 - Description: The web application will allow for administrative accounts to create, edit, and delete user accounts and their associated devices.

8.6.2 - Source: Team SmartGrass

8.6.3 - Constraints: None

8.6.3 - Standards: None

8.6.5 - Priority: 2 – High Priority

9. Acceptance Criteria

This section specifies the requirements related to each product function as it is to be demonstrated to the customer. Each criteria defined in this section is required for in order for HICS to be accepted.

9.1 Verify User Account

9.1.1 - Requirement(s) addressed:

Requirement Number	**Name**
3.3	Web Application
8.6	User Administration Account
3.6	User Login
3.10	Database Management System

9.1.2 - Verification Procedure: The user will open a web browser where they will create an account by clicking on the “Register” button on the login page (see Figure 2-3). The user will then enter their credentials into the form. The system will validate the information provided by the user and successfully create the account if the information is valid.

9.2 Verify Water Control

9.2.1 - Requirement(s) addressed:

Requirement Number	Name
3.1	Central Control Unit
3.3	Web Application

9.2.2 - Verification Procedure: After the user successfully logs in, they are directed to the home dashboard screen (see Figure 2-4). The user will tap/click the "On/Off" toggle under the heading "Valve Status" to toggle the water for that zone on and off.

9.3 Verify Soil Sensor Readings

9.3.1 - Requirement(s) addressed:

Requirement Number	Name
3.1	Central Control Unit
3.2	Soil Moisture Sensors
3.3	Web Application
3.5	Soil Moisture Reports

9.3.2 - Verification Procedure: The soil sensors will provide the user with the details regarding the moisture conditions of their soil. Once the user is successfully logged in they will be redirected to the home dashboard screen (see Figure 2-4) where they can view the soil moisture levels for each zone in their lawn.

9.4 Verify Rain Detection Control

9.4.1 - Requirement(s) addressed:

Requirement Number	Name
3.1	Central Control Unit
3.8	Rain Sensor

9.4.2 - Verification Procedure: If the rain sensor detects rainfall it will signal the central control unit to close all watering valves. To verify the user can turn on watering in a zone (see Section 9.2) and pour water into the rain sensor to trigger a watering stoppage.

9.5 Verify Valve/Region Control

9.5.1 - Requirement(s) addressed:

Requirement Number	Name
3.1	Central Control Unit
3.2	Soil Moisture Sensors
3.3	Web Application
3.10	Database Management System
3.12	Region Grouping

9.5.2 - Verification Procedure: Each valve will have a soil sensor that detects the moisture of that zone. The user can water any individual zone or region any time via the web application (see section 9.2). Users will have the ability to create “Regions” which are groups of zones. For example the user could group all zones where the valves lead to backyard and they could define that region as “backyard”. This allows users to control watering for multiple zones by regions.

9.6 Verify Watering Schedule

9.6.1 - Requirement(s) addressed:

Requirement Number	**Name**
3.1	Central Control Unit
3.3	Web Application
3.10	Database Management System

9.6.2 - Verification Procedure: Users have the option of scheduling watering time instead of manually toggling their sprinkler system as seen in section 9.2. To create or modify a schedule the user must successfully login to the application and navigate to the schedules page (see Figure 2-5). From the schedules page users can create, edit, or delete watering schedules for each zone. This page also provides the user with past watering events and displays their duration and completion. To verify a watering schedule the user must create a schedule by clicking on the calendar icon seen in Figure 2-5. They must then select a date and time for watering and select whether the event should reoccur. Once a time has been scheduled they must simple visit to scheduled zones during their watering time and observed the activity.

10. Use Cases

This section specifies how the end-user will interact with HICS at home and remotely through the web application. A brief scenario on how each use case will be performed is also included. Use case diagrams are found at the very end of the section and are grouped by function. Each use case listed below will identify the scenario, the actor, when the use case begins (TUCBW – The Use Case Begins With), and when the use case ends (TUCEW – The Use Case Ends With).

10.1 Device and User Registration

10.1.1 - Scenario: After installing a HICS product at home, users are required to register their device via the web application. The user will access the web application from a web browser and be directed to the login screen (see Figure 2-3). After clicking on the "Register" button the user will be directed to the registration page (see Figure 2-2) to register their product and create an account. After registering, the device will be activated for the user to start controlling and interacting with.

10.1.2 - Actor(s): User

10.1.3 - TUCBW: The user clicks on the "Register" button on the home screen.

10.1.4 - TUCEW: The HICS product is registered and the user logs into the web application using their account credentials.

10.2 View/Change HICS Settings

10.2.1 - Scenario: The user will access the mobile web application from a web browser. After logging in successfully, the user will be taken to home dashboard (see Figure 2-4). From this page, the user must click/tap on the menu dropdown and select the "Settings" option. The user will be directed to the account settings page where they can view or update their HICS settings for auto-off time and alerts opt-in.

10.2.2 - Actor(s): User

10.2.3 - TUCBW: The user clicks/taps on the menu button and selects the "Settings" option.

10.2.4 - TUCEW: If any settings were changed the information is updated in the database and the changes are displayed on the settings page.

10.3 User Sign In

10.3.1 - Scenario: The user will access the web application from a web browser and be directed to the login screen (see Figure 2-3). At the login screen the user will enter their username and password and click/tap the login button.

10.3.2 - Actor(s): User

10.3.3 - TUCBW: The user enters their login credentials and clicks on the "Login" button on the home screen.

10.3.4 - TUCEW: The user logs in with their account credentials and is directed to the home dashboard (see Figure 2-4).

10.4 Check Status of HICS

10.4.1 - Scenario: The user will access the web application from a web browser. After logging in successfully, the user will be taken to home dashboard (see Figure 2-4) of their HICS and be able to view its current status.

10.4.2 - Actor(s): User

10.4.3 - TUCBW: The user logs in successfully.

10.4.4 - TUCEW: The user will see the status of their home irrigation system. The local weather conditions, active status of water valves, and most recent reading of their soil moisture levels will be displayed (see Figure 2-4).

10.5 Turn On/Off Water Valves

10.5.1 - Scenario: The user will access the web application from a web browser. After logging in successfully the user will be directed to the home dashboard (see Figure 2-4). From this page, there is a switch that allows users to turn on or turns off water valves for each zone.

10.5.2 - Actor(s): User

10.5.3 - TUCBW: The user clicks on the switch to turn on or turn off the water valve.

10.5.4 - TUCEW: The water valve will be turned on or off according to the action of user.

10.6 Check Watering History

10.6.1 - Scenario: The user will access the web application from a web browser. After logging in successfully the user will be directed to the home dashboard (see Figure 2-4). From this page, the user must click/tap on the menu dropdown and select the "History" option. The user will be directed to the schedules page (see Figure 2-5) where they can view watering history by zone, region, or valve.

10.6.2 - Actor(s): User

10.6.3 - TUCBW: The user clicks/taps on the menu button and selects the "History" option.

10.6.4 - TUCEW: The user will be directed to the schedules page (see Figure 2-5) where they can view past watering events.

10.7 Schedule Watering

10.7.1 - Scenario: The user will access the web application from a web browser. After logging in successfully the user will be directed to the home dashboard (see Figure 2-4). From this page, the user must click/tap on the menu dropdown and select the "Schedules" option. The user will be directed to the schedules page (see Figure 2-5) where they can view, create, or change watering schedules for each zone.

10.7.2 - Actor(s): User

10.7.3 - TUCBW: The user clicks/taps on the menu button and selects the "Schedules" option.

10.7.4 - TUCEW: The user will save or change a schedule and the system will update according to the input.

10.8 Create/Change Watering Region

10.8.1 - Scenario: The user will access the web application from a web browser. After logging in successfully the user will be directed to the home dashboard (see Figure 2-4). From this page, the user must click/tap on the menu dropdown and select the "Regions" option. The user will be directed to the schedules page (see Figure 2-5) where they can create, edit, or delete regions.

10.8.2 - Actor(s): User

10.8.3 - TUCBW: The user clicks/taps on the menu button and selects the "Regions" option where they can create, edit, or delete regions.

10.8.4 - TUCEW: The region will be created or updated according to the input and the changes will be displayed to the user.

10.9 User Account Management

10.9.1 - Scenario: The user or admin will access the mobile web application from a web browser. After logging in successfully the user or admin will be directed to the home dashboard (see Figure 2-4). From this page, the user or admin must click/tap on the menu dropdown and select the "Account Management" option. The user or admin will be directed to the account management page where they can view or update their account/device information as well as delete their account.

10.9.2 - Actor(s): User, Administrator

10.9.3 - TUCBW: The user or admin clicks/taps on the menu button and selects the "Account Management" option where they can change the settings for their account.

10.9.4 - TUCEW: The changes to the account will be made and the results will be displayed to the user.

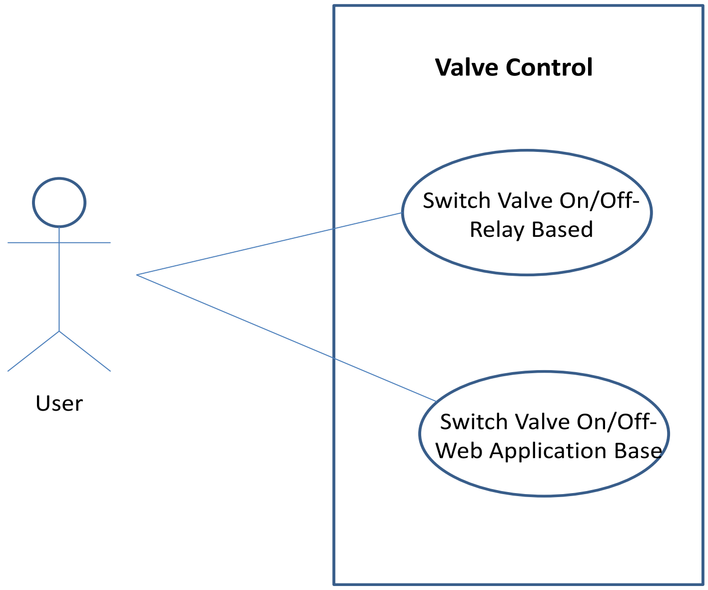

Figure 10-1 Valve control diagram

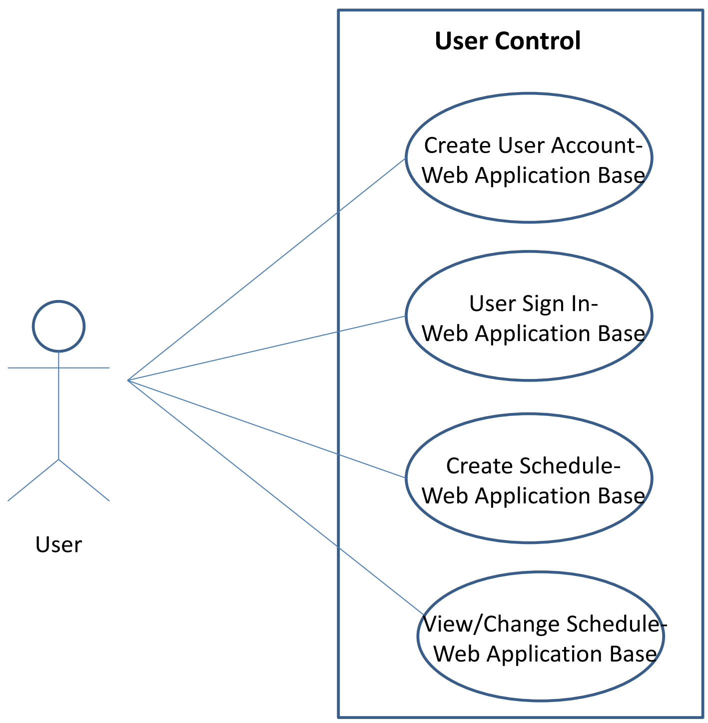

Figure 10-2 User control diagram

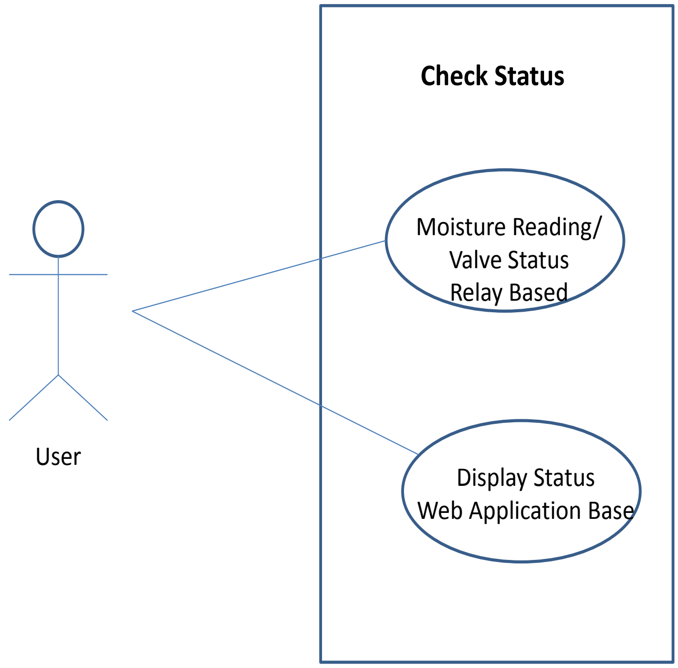

Figure 10-3 Check status diagram

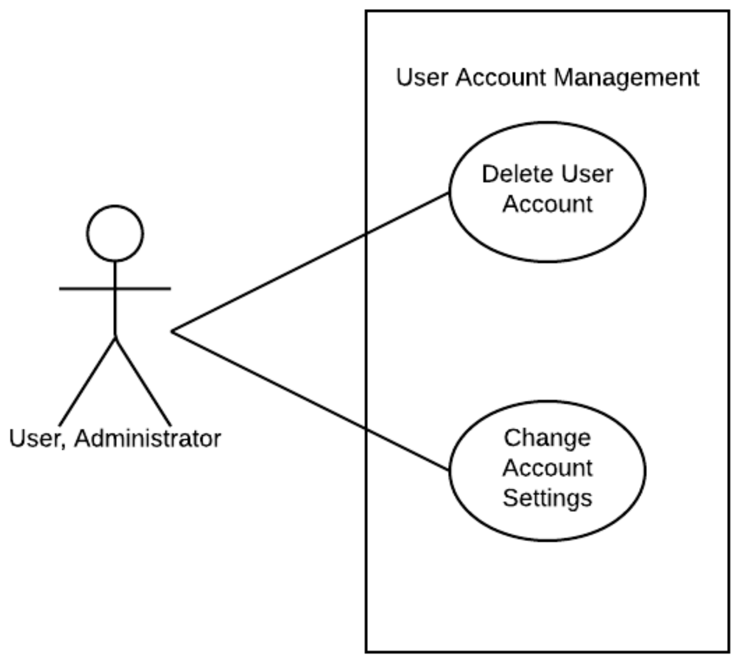

Figure 10-4 User/Admin control diagram

11. Feasibility Assessment

This section evaluates the expectations of HICS and all its components. A careful analysis of each component will determine feasibility assessments for the outcome of the project. In order to provide a more detailed report each individual analysis has been examined below.

11.1 Scope Analysis

The overall scope of HICS has been examined and discussed by all team members and has been determined to be reasonable given the project deadline. After examining the requirements with the highest priorities we determined the majority of the work will be with the web application. Our team has two members that have had years of real world experience developing large scale web applications for companies so the outlook for the web application work schedule is very feasible.

Research on the hardware components of HICS has also provided our team with a positive outlook for the scope. This assessment is based on our research of each individual components and our team's technical background with each of them. While we have a few team members who have great experience in microcontrollers our risk concern is with the interaction between the sensors and microcontroller. This assessment is based on the lack of knowledge and experience with soil and rain sensors. This initial assessment is based purely off the research we have done regarding the sensors and the processes of gathering readings as data. To account for the lack of experience and knowledge in this field we've added to our risk assessment plan an extra meeting time every week, if necessary, to focus entirely on research and information gathering. In conclusion after analyzing the requirements and prioritizing them based off importance we have evaluated that the project is within scope and the probability of completion before the deadline is high.

11.2 Research

Our primary focus on research has been the components we are unfamiliar with. Our team has been researching different soil sensors to determine which will be the best fit for HICS. This research has been evaluated and compared to the other hardware components that will interface with the sensors. We have reviewed tutorials and other projects online to study how the interactions between the sensors and controller take place. This research has aided us in deciding which microcontroller is optimal for the project and our budget.

The information we lack in home irrigation has been another primary focus of our research. Fortunately our sponsor is very knowledgeable and has even provided us with a resource that runs water conservation for the City of Arlington. He has been extremely helpful in gathering information for our team to research and has provided us with multiple resources to help minimize the learning curve.

11.3 Technical Analysis

A thorough technical analysis has been a priority task for our team. We determined before purchasing or finalizing any components we first needed to examine what our technical strengths and weaknesses were.

While no one on the team has had any experience with home irrigation systems we all have had experience with the majority of the individual components that it consists of. The primary hardware components are the central control unit, soil sensors, rain and temperature sensor, and the water valve system. We have carefully diagramed and examined each piece of hardware to determine how they will interact and function together. We have determined that the microcontroller is the component that our team is most familiar with. We have two team members who have had extensive work with microcontrollers primarily Arduino and Raspberry Pi. This experience will enable our team to focus our hardware research on the sensors and water valves system. The central control unit will consist of a microcontroller that will be connected to each water valve and will also be responsible for powering the soil, temperature, and rain sensors. The risks we've evaluated from a hardware standpoint mostly deal with the potential high-complexity of integrating all our various sensors. Since our team lacks experience in working with soil, temperature, and rain sensors we've decided to be conservative in our time estimates where the sensors are involved. These estimates are in place to help avoid these risks having a major impact on our time schedule.

Our team has examined the requirements needed for the web application and our outlook is very positive. We have two members of the team who have worked for major corporations in industry developing very large scale web applications for clients. Their skills in this facet will provide great insight into the development and design of our web application. Their experience with the SDLC will also ensure a smooth transition from conception to prototype.

11.4 Cost Analysis

Our team's estimation of the initial cost of HICS has been determined based on the individual components we have deemed necessary. The primary cost will be the hardware components. Each individual hardware component must be purchased separately. The web application DBMS and hosting can be purchased together as a subscription model.

The cost for the web application will lie only in the online hosting for the application. We determined we will use an online service for hosting to avoid any major costs of purchasing and maintaining a physical server. The cost for hosting is a monthly fee which we have estimated we will need active for remainder of the class, approximately six months. As far as the components that will make up the web application we have decided to use ASP.NET which is a free application system. All other components necessary for the application will be free resources obtained through NuGet and other online venues. See Table 11-1 for our initial estimated cost break down.

Part	Cost
Raspberry Pi microcontroller	$70.00
Soil moisture sensor (3)	$20.00
Water valve (3)	$60.00
Web hosting subscription (6 months)	$60.00
Rain sensor	$15.00
Plumbing materials	$25.00
Microcontroller case	$20.00
Sprinkler (3)	$10.00
Waterproof sensor case (3)	$45.00
Miscellaneous parts (wires, adapters, etc)	$50.00
Temperature sensor	$12.00
Total	$387.00

Table 11-1 Individual Part Cost Analysis

11.5 Resource Analysis

The resource requirements necessary for HICS have been evaluated to determine the outcome of completion. Our team consists of one computer engineer, one software engineer, and two computer scientists. This team balance is conducive to the makeup of the project which is primarily software with a substantial hardware component.

Every team member has had experience in their particular role not only in school but in industry as well. We feel this is a huge benefit to being able to complete our project before the deadline. Not only do our members have experience but we each have experience in different fields within our respective majors. All of this experience coming together will provide valuable insight into the design and work necessary to make HICS a solid product.

We have evaluated that our Computer Engineer will focus primarily on the hardware. Our software engineer and two computer scientists will be focused on the microcontroller programming and the web application. We have decided to assign two programmers on the microcontroller since low level C programming is one of our weakest skills. We feel this tradeoff will not hinder the web application progress because of the experience we have in web development. In order to avoid any risks with overly optimistic schedules for our web development we've decided to scale the amount of microcontroller programming tasks for our Computer Engineer in the event that the web application requires more work than expected.

11.6 Schedule Analysis

For scheduling analysis our first method of estimation used was the Jones First-Order Estimate. Using this method we determined our project characteristics and generated our unadjusted function-point total based off the cumulative totals.

Program Characteristic	Low Complexity	Medium Complexity	High Complexity	Totals
Number of Inputs	5 x 3	2 x 3	0 x 6	21
Number of Outputs	3 x 3	1 x 5	0 x 7	14
Inquiries	2 x 3	0 x 3	1 x 6	12
Logical Internal Files	2 x 7	1 x 10	0 x 15	24
External Interface Files	1 x 5	2 x 7	1 x 10	29
			Unadjusted Function-Point Total	100

Table 11-2 Function-Point Analysis

Table 11-2 displays the various function points required by HICS. Our unadjusted total ended up at 100 with an emphasis on the logical internal and external interface files. Once we had established our unadjusted total we evaluated our adjustment factor by determining our influence values based on a priority rating system.

General System Characteristics	Priority Rating (0-5)
Data Communications	5
Distributed Data Processing	3
Performance	5
Heavily Used Configuration	2
Transaction Rate	3
On-Line Data Entry	3
End-User Efficiency	3
On-Line Update	0
Complex Processing	3
Reusability	1
Installation Ease	3
Operational Ease	3
Multiple Sites	1
Facilitate Change	2
Total	30
Adjustment Factor	1.05

Table 11-3 Adjustment Factors

The adjustment factor was determined by first totaling the rating values. Table 11-3 shows each multiplier and the priority rating it received. The total was used to determine the influence factor:

Adjustment Factor = 0.65(3/100) = 1.05

After finding the adjustment factor we used its value to determine the function-point total by multiplying it by the unadjusted function-point total:

Adjusted Function-Point Total = 1.05 * 100 = 105

According to Jones First-Order Estimation the class averages can be seen in Table 11-3.

Kind of Software	Best in Class	Average	Worst in Class
Systems	0.43	0.45	0.48

Table 11-4 Jones' First Order Estimation Class Averages

We have evaluated our product falls under the Systems software type based on the nature of the product. To calculate the calendar months for estimation we took our function-point total and raised it to the power of the corresponding class averages:

Jones' First Order Estimation			
	Best Case	Average Case	Worst Case
Adjusted Function-Point Total	105^0.43	105^0.45	105^0.48
Total Months	7.40	8.12	9.34

Table 11-5 Jones' First Order Estimation

Table 11-5 shows the estimated number of months for our project for a best, average, and worst case. For the best case estimation our project should take around 7.5 months to complete. At the worst case the project is estimated to be completed in approximately 9 months.

The second method we used for schedule estimation was a nominal, semi-detached CoCoMo evaluation.

Coefficient	a	b	c	d
Semi-detached	3.0	1.12	2.5	0.35

Table 11-6 Basic CoCoMo Estimation Coefficients

As a team we decided to set our SLOC, for our low side, aggressive estimate, to approximately 3,000 lines. To evaluate best and worst case scenarios, as we did with our Jones' First Order estimation, we decided to also set a high side, conservative SLOC to 5,000. Using these values we used the CoCoMo equations to estimate our effort (in person months) and duration (in months) values.

Aggressive Estimate

$$E = 3.0(3^{1.12})$$
$$D = 2.5(E^{0.35})$$

Conservative Estimate

$$E = 3.0(5^{1.12})$$
$$D = 2.5(E^{0.35})$$

The values for aggressive and conservative effort and duration CoCoMo estimations are shown in Table 11-7.

	Low Side (Aggressive)	**High Side (Conservative)**
Effort - person months	10.27	18.20
Duration - months	5.64	6.90
People Required	1.82	2.63

Table 11-7 Semi-detached Basic CoCoMo Estimation

Based on our CoCoMo estimations for duration the number of months required to complete the project will be best case 5.64 months and worst 6.90 months. Given the timeline for our project and the number of members in our team the effort and duration required for completion seem feasible compared to the average case between the aggressive and conservative estimations. The CoCoMo estimations for our project were calculated to be slightly more optimistic than our estimations using Jones' First Order Estimation.

We decided to take our estimation a step further by using the Weiss & Wysocki Sanity Test to average our estimations. The Sanity Test formula is as follows where O is the optimistic estimation, M is the nominal estimation, and P is the pessimistic estimation:

$$E = \frac{(O + 3M + P)}{6}$$

Using the formula above we set our O to be 4.64, our M to be 5.86, and our P to be 6.90 and performed the following calculation:

$$E = \frac{5.64 + 3(6.90) + 9.34}{6} = 5.95\, months$$

Based on the result of the Sanity Test the estimated number of months for competition is 5.95. All estimations for our project were done using overestimated assumptions to ensure our team has enough time given any setbacks. Also our team is still very new at schedule estimation and we are sure there will be some deviation in either direction.

In both estimations the weeks are defined for 40 work hours which isn't possible for every member of our team due to schedule constraints. However, even given the conservative estimation our maximum people required would be around 2.5. Since our team consists of 4 members if we divide the aggressive and conservative times by the additional member we get 2.57 months for an aggressive estimation and 4.55 months for a conservative estimation. If we cut our monthly hours in half to account for our teams schedule restraints our estimation for completion averages out to around 7 months which we feel is a feasible estimation for completion. If we consider the extra team member into our sanity test calculations our estimated months for completion comes to be 4.26. If we cut our monthly hours in half, as before, and factor it in the estimated months for completion is just over 8 months. Given the timeframe for the project deadline along with our teams plan of starting during winter break we believe these times estimations are feasible for completion. Considering all the above factors we believe we can produce a working product that meets all specifications and remains under our given budget.

12. Future Items

This section details the additional future requirements for HICS that may not currently be feasible due to time/money constraints. However, these requirements would serve as valuable additions to HICS given the opportunity.

12.1 Wireless Sensors Network

12.1.1 - Description: Soil moisture sensors could be upgraded to wireless sensors to streamline communication to the central control unit. A wireless sensor network would increase the flexibility in sensor placement and make the installation of the sensors much easier.

12.1.2 - Source: Nuts and Bolts Hardware

12.1.3 - Constraints: Wireless sensors require a wireless power source which limits the sensors lifespan. Replaceable or rechargeable batteries would be needed to ensure the sensors can maximize their uptime.

12.2 Standalone Mobile Application

12.2.1 - Description: The HICS web application is designed to scale to size for users accessing it via a mobile device. A standalone mobile application that is developed separately from the web application would be a more polished alternative to this approach for mobile users.

12.2.2 - Source: Team SmartGrass

12.2.3 - Constraints: Creating a separate mobile application would take valuable time and resources away from the core development of this project. In addition, publishing a mobile application would cut into our budget as there is often a fee associated with it.

12.3 Upcoming Weather Alerts

12.3.1 - Description: The HICS utilizes rain sensors to avoid watering during rainy weather. However, this method is only useful when it is actually raining. A weather alert feature could pull reports from local weather APIs and alert the user if a scheduled watering event conflicts with upcoming rainy weather.

12.3.2 - Source: Team SmartGrass

12.3.3 - Constraints: Weather reports would have to be very accurate to the location of the central control unit.