WaterWise
Smart Hydroponic System

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Abstract — **The WaterWise Smart Hydroponic System is a versatile and personal hydroponic garden that utilizes modern technologies in order to bring hydroponic gardening to the 21st century, metropolitan and urban dwelling user. By incorporation of a mobile application and automation, the WaterWise will modernize the typical DIY hydroponic system and, accordingly, simplify monitoring of the subject plants as well as proper ecosystem requirements for optimal growth.**

Index terms* — *agriculture, control equipment, application software, printed circuits, wireless sensor networks

I. INTRODUCTION

The motivations behind the WaterWise are rooted in the idea to design a product that gives the ability to efficiently and effectively grow produce to people who would not normally consider such an undertaking due to space limitations and/or inexperience. We believe that providing the ability for people to grow plants in an atypical environment such as a Manhattan high-rise or college apartment in a way that utilizes modern technology would be a game changer. More people are becoming aware of where their food is coming from and are consequently becoming increasingly interested in having their produce come from their very own home. In addition to this motivation, the WaterWise will aim to promote a healthy lifestyle via homegrown produce.

The WaterWise system will consist of several subsystems that bring the typical DIY system up to the standards of the everyday tech user. This will allow the WaterWise to be more accessible to those who will benefit from a small gardening system in a transient, urban environment. The subsystems will consist of the hydroponic components, the MCU and ICs for control, the power system, and several sensors for system monitoring. Most importantly, these subsystems will be controlled and monitored by a mobile application. Integration with a mobile application will be essential to achieve an easily adoptable system for a wide range of consumers.

Overall, the WaterWise team believes that this product, due to its modern control and monitoring capabilities, will be able to bring hydroponics to atypical environments and allow many people who do not currently grow their own produce the opportunity to do so easily and effectively.

II. GOALS AND OBJECTIVES

The main goal of the WaterWise system is to develop and construct a proper hydroponics system that has a focus on automation and mobile control. For the construction of the hydroponic system, it is important that it is compact, durable, and convertible for use in various environments, namely indoors or outdoors. In addition, it is important that the stand-alone hydroponic system is manageable by the end user without automation. Since the focus is on the automation of the system and the ability to monitor the system away from home, there is an obligation to deliver a well-constructed stand-alone hydroponic system that the user will have very limited interaction with. In the case that the user must do so, it should only be a minor issue.

Post construction of the hydroponic system, we aim to provide real-time system monitoring in order to aid the user throughout the growth cycle of their desired produce by way of communication with various sensors and peripherals via on-system control as well as a mobile application. These interactive features will provide a user-friendly experience with the system as well as a simple way of monitoring and controlling the needs of the WaterWise in real-time. These features will be what separates the WaterWise from the common DIY hydroponic enthusiast and will be what makes hydroponic gardening accessible to the general tech user.

Most importantly, the goals of this project will be to develop a system that can be used by both entry-level and expert hydroponic users as well as educate and inspire users to continue to foster an interest in hydroponics as a way to grow their very own food, no matter their living situation.

III. HARDWARE DESIGN

The hardware design of the WaterWise system will consist of five main components including the physical structure, hydroponics system, power system, sensor interface, and the system-controlling PCB. This section will look to give a detailed overview of each component and its design.

A. Structural Design

The structural design of the WaterWise will aim to be compact compared to many hydroponics systems but large enough to yield a generous amount of produce. The size specification that will be given to the WaterWise is that it must be contained within a space that is 2.5'x 3.5' x 6' (width x length x height). This was determined by coordinating with the hydroponic system design and typical spaces inside apartments in order to design the optimal size for optimal output.

The structure will consist of two major areas. One area is the cabinet, which will house the water reservoir for the hydroponic system, nutrient control system, and the PCB controller in a waterproof casing. The cabinet is the heart of the WaterWise and is essential to achieve the goal of enclosing the components of the system from outside visibility as well as localizing most of the components for user interaction. By keeping the most important components together, the WaterWise will provide a more user-friendly interaction. In addition, the cabinet design allows the WaterWise to be treated more like a visual piece for the home, such as an aquarium, instead of something that should be kept outside.

The second major area is the canopy above the cabinet. The canopy will be the home of the grow channels as well as the 225 LED grow light. The system will consist of three grow channels in which four plants can grow in each and the LED grow light features the four major colors used in all portions of the growth cycle in proper balance. This proper balance is required so there is no need to change the lighting depending on how far along the user's plants are in the growth cycle.

To build the structure, the main material used was treated wood. This was necessary due to the interaction with water at all levels. Granted, the WaterWise is not supposed to leak but there are various cases where the system can become wet and in the case of a catastrophic failure, the structure won't be compromised. Wood was used because it is easily manipulated and therefore our design is easily achievable. Unfortunately, wood is also heavy and therefore a solution had to be developed for easy transport. This was accomplished by adding caster wheels to the bottom of each post that create the boundaries of the structure (as seen in Figure 1). They can be locked to restrict movement and unlocked for free mobility of the system and each wheel is rated for 225 pounds of weight, which far exceeds what is required.

The cabinet section is constructed using two 2'x 3' frames that are used as the base and top. Each frame is made using 4 2"x4" sections cut to size and fastened together. Those frames are then directly fastened to their respective 4"x4" posts. By using 3/4" thick plywood sheets, the frames are enclosed and a cabinet is formed. Access to the cabinet is accomplished by having a simple locking door on a piano hinge with a chain for support while open. By only having one door that acts more like a hood, access to the inside of the cabinet can be maximized.

For the canopy, the growth channels will simply rest on the top of the cabinet and given a slight incline. Additionally, the top of the structure will feature the grow light centered on the roof and screwed down with nylon spacers so that the back of the light does not get too hot.

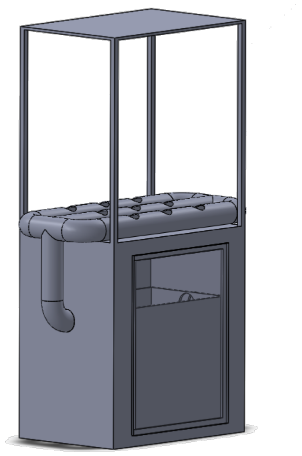

Fig A. Physical Structure CAD Rendering

B. Hydroponic System

For the hydroponic system, it was desired that a design be chosen that could maximize growth output, be relatively compact, and easily manageable for the end user. There are many different types of hydroponics systems and they come in many different configurations but it was narrowed down that WaterWise would feature a nutrient film technique (NFT) design. The NFT hydroponic style is what most people think of when they hear the word "hydroponics" so not only would it be something people are familiar with but there are several upsides to choosing this method. Due to the use of gravity, smaller pumps are required to do the same work that other hydroponic systems use. This, in-turn, yields a more efficient system consuming less power. Additionally, NFT designs generally have the ability to grow more plants in smaller spaces, which is why it is one of the most common methods implemented by DIY users and because it is so common, the online hydroponics community gave very valuable information during research for how to design the system as effectively as possible.

The hydroponic system is a standalone subsystem in the WaterWise, meaning if some of the other peripherals were to fail, the WaterWise would not stop growing plants and therefore only the automation components would need troubleshooting in case of failure. An NFT system (and most hydroponic methods) consists of a few main components including the water reservoir, submersible pump, air pump, air stone, nutrient pumps, and growing medium. For the water reservoir, it is desired that enough water is available to properly provide water to the system such that it stays fairly clean. The decision was made to have a 25 gallon reservoir because the water will constantly be cycling and there will be limited old water running through the grow trays too often.

Inside the reservoir there will be two key components: the submersible pump and air stone. The submersible pump was specified to be the Active Aqua PW250 and it was chosen due to its ability to cater to a desired range of flow rate. This pump can go up to 250 gallons per hour (GPH) and down to 87 GPH. The flow rate is dependent on what the current state of the system is inside the grow trays so it was desired to have the ability to adjust the flow rate to optimize the system. Further along in the growth cycle when the roots become much larger, the flow rate will need to be increased in order to keep consistent to the rate at the beginning of the growth cycle. In addition to the submersible pump is the air stone. The main goal of the air stone is to provide the proper amount of dissolved oxygen in the water so the plants are receiving oxygen properly. The air stone is powered by an air pump that sits outside of the reservoir and it is also adjustable similar to that of the submersible pump. The air stone that was chosen is actually an air "disk" and is the EcoPlus 728418 Airstone. In a disk shape, air stones generally yield higher bubble output yielding the ability to achieve higher oxygen levels. The air pump, which will be providing the air to the air stone, is the EcoPlus 728355 Air Pump and it features a 4-channel output and a maximum output of 253 GPH. Choosing these two together ensures that the WaterWise has the ability to get the most output required at any given time using simple adjustments.

The submersible pump and air pump are not the only pumps in the WaterWise. The first breakthrough with automation of the system will come via the peristaltic nutrient pumps that will deliver exact nutrient amounts required by the system at any given time. The nutrient pump array will consist of three pumps each designated with its own job. One pump will deliver pH Up, the second will deliver pH Down, and the final pump will deliver a nutrient concentration to the system. The pH Up and Down will control the pH as needed (determined via pH readings) and the nutrient concentration will deliver to the reservoir a proper mixture of nutrients for the produce being grown. Peristaltic pumps are extremely valuable in that they require no maintenance. This is achieved by separation of the compression roller and motor wall with a tube that carries the liquid nutrient concentration to the reservoir. This configuration keeps any liquid away from the gears of the motor, keeping them clear of any grime buildup.

Finally, the hydroponic system will consist of the growing medium. For this NFT system, a feeder line will come from the reservoir off of the submersible pump and split to go into three growing channels made of poly-vinyl chloride (PVC). These 4" PVC grow channels will each include four 2-3/4" holes for the grow cups to be placed for each plant. The 4" PVC pipes will then connect to a return manifold that returns the nutrient solution back to the reservoir in one pipe. The nutrient solution will then continue the same path in a cyclic manner during the entire growth cycle of the produce.

C. Power System

For the power system of the WaterWise, a few considerations had to be made regarding the various demands of the system. There were several components that demanded various DC voltages such as 12V, 5V, 3.3V, and even 120V AC. To effectively design a power system that can suit all of the needs of the system, a way to localize all of these various demands was sought. It was determined that the best way to accomplish this was simply to use a power strip and have the smaller voltage demands (5V and 3.3V) be powered directly from the PCB. In addition to the smaller voltages, the PCB also powers the 12V peristaltic pumps by use of two Darlington driver integrated chips.

In addition, the system needed various components to have power control (e.g. lighting). After doing some research, it was found that by connecting some small relays within the power strip circuit in order to act as a controllable switch to each outlet, this could be done. The localization method was decided to be a relay-controlled power strip that can be controlled using the mobile application and LCD control panel on the WaterWise (more on that in a future section).

The struggle with using newer power strips for this project was the challenge of finding one that used conventional receptacles instead of brass busses to distribute power. For this reason, it was decided that a power strip was built using conventional in-home receptacles found at a local hardware store and using gang boxes to house them. In total, there are three receptacles totaling six outlets that will be used for each desired component. In Figure B, the wiring configuration can be seen for the relay-receptacle circuit. Power is brought from a home outlet into the power strip via the switch so there is manual control of the strip. From the switch, the circuit is grounded using the power cord from the home outlet. The hot wire is then wired to the first receptacle where no control is required (these two outlets are always on). From the first receptacle, power is distributed to three different relays using the hot wire connected to three new hot wires via a wire nut. From each relay's output channel, hot wires are then run to their respective outlets. The outlets are made independent of one another by simply splitting the brass tab that connects the two on the hot side of each receptacle. It is important to understand that this was not done in the case of the receptacle that is always on. Additionally, the neutral wires for each receptacle come from the first receptacle but no splitting is required, as they do not require control. From the power strip, the various components requiring power can simply be plugged-in as most of these components use simple AC to DC adapters for power.

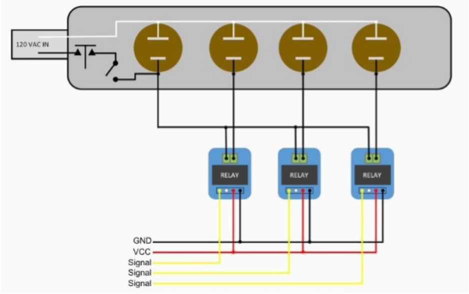

Fig B. Relay-Controlled Power Strip [1]

D. Sensor Interface

The sensor interfacing of the WaterWise includes various sensors in order to allow proper monitoring of the system on many levels. A goal of the sensor interface is to expose the sensors as little as possible and only to the extent required to achieve proper readings. Of course, connections back to the board will be safely housed along with the PCB in a waterproof casing.

The sensors included in the WaterWise cover pH, electric conductivity (EC) meter, water temperature, air temperature and humidity, and water level in the reservoir. Each of these sensors must be able to return data to the user via the mobile application so that the user can then properly manipulate the system as needed.

***pH Sensor*:** For any hydroponic system, actively tracking the pH level of the nutrient solution is pertinent to the relative health and speed of growth of the produce. The pH sensor to be used in the WaterWise was required that it can be submersed for an extended period of time such that real-time data can be collected. Additionally, sufficiently wide operating temperature range and measurement accuracy within ±0.1 pH is required.

The pH sensor that was chosen is the DFRobot Analog pH Meter kit. This sensor properly operates at 5 volts and satisfies all of our requirements. The sensor will be interfaced with the PCB via an intermediate circuit that will connect to an analog pin on the PCB. When a reading is taken by the pH sensor and consequently sent back to the PCB, the PCB will decide whether or not the pH falls within a preset value range. If the pH does indeed fall within the range, the system will do nothing and continue to take readings until further action is required. If the pH reports back a value outside of this range, the PCB will command the peristaltic pumps to appropriately distribute pH Up or pH Down in order to control the level. This is accomplished by the PCB reading in the value and doing a calculation based on water volume of the system to determine how long the pump needs to run in order to distribute the proper amount of solution.

***Electrical Conductivity and Water Temperature Sensor*:** The electrical conductivity (EC) sensor is used to measure the salinity of the nutrient solution for purposes of water quality tracking. This, in conjunction with the pH of the nutrient solution, is important to understanding the current state of what food is being provided to the produce. Optimizing the nutrient solution is essential to a successful growth cycle. For the EC meter, it is a matter of determining whether or not the nutrient solution is too concentrated and needs to be diluted or vice versa.

The sensor chosen is the Analog EC Meter DFR0300 from DFRobot. Again, this sensor properly operates at 5V and at a temperature range that satisfies our system. In order to properly operate this sensor, a nominal conductivity value of is required to be set. If the EC meter returns a conductivity reading of less than 70% of the nominal value, then more nutrient solution will be required. Similarly, if the conductivity reading is above the nominal value, more water will need to be manually added to the reservoir. The user will be properly notified of this case.

Attached to the EC Meter is the water temperature sensor. The user will have real time monitoring and any measures that should be taken by the user to mitigate issues such as high water temperature will be to their discretion.

***Reservoir Water Level*:** The reservoir water level must be monitored to ensure the system is not operating at an insufficient amount of nutrient solution. Monitoring this reservoir water level is accomplished by using an intermediate circuit similar to the pH sensor that then communicates with the PCB. The intermediate circuit consists of three (3) NPN transistors that form a connection between the reservoir and the PCB. Three leads at preset "High", "Medium", and "Low" levels in the reservoir are connected to the base of their respective transistor which then has a jumper wire coming off the collector to the PCB pin that is reading the level. The level is determined if the lead that is in the reservoir is receiving a voltage from a 5V signal that is going directly into the water. If each lead is reading a voltage, then the reservoir is considered "High". If the water goes below the "High" lead, the lead will not be reading the voltage supplied to the reservoir and thus the highest lead reading the voltage will be "Medium" and the PCB will return "Medium" as the level. This same method continues to the "Low" level.

Air Temperature and Humidity**:** The air temperature and humidity will need to be monitored for the sake of fully understanding the current conditions of the WaterWise. For these two readings a simple four pin, all-in-one sensor, the Adafruit DHT11, will be used. This sensor is extremely low cost but unfortunately, the readings cannot be done in real time like some of the other system sensors. However, since temperature and humidity fluctuations tend to not be as volatile as some of the other readings that are required, this real time data return is not extremely necessary. The temperature range of the sensor is 0-50ºC with an accuracy of ±2ºC. The sensor will send data back to the PCB about once every two seconds with careful timing. Obviously, there is nothing that can truly be done about the air temperature and humidity unless the user manually adjusts their home air conditioning unit but if the home is run at a normal range of 70-74 degrees Fahrenheit, the WaterWise should be considered in good growing conditions.

E. Wi-Fi Module

The ESP8266 Wi-Fi module was implemented in the design to communicate data between the Android application and the microcontroller. This module is implemented in our design with the Atmega 2560 as Serial communication to Wi-Fi. The Atmega 2560 communicates via its serial pins through a logic level shifter to the serial pins of the Wi-Fi module. A logic level shifter is required because the ESP8266 serial pins transmit and receive using a 3.3V logic whereas the Atmega 2560 uses 5V logic.

The microcontroller software communicates with the Wi-Fi module through the module's firmware AT commands. There are many different open source versions of this firmware available, and we chose to use the latest release from the organization Espressif. The firmware AT commands provide abilities to configure any setting pragmatically from the microcontroller code. This allows our design to dynamically utilize all of the features provided by the Wi-Fi module. Wi-Fi module also communicates via serial when a host is communicating with the module via HTTP 1.1 messages. This data received can be parsed by the microcontroller to interpret communications from outside hosts, i.e. the Android application. The timing of communication between the microcontroller and Wi-Fi module is fragile, as the Wi-Fi module does have an operational latency. If the module is busy transmitting or receiving data, and is accessed by the microcontroller, the module will become interrupted and the data reception/transmission is lost. This requires our microcontroller to include the use of short delays to wait for the Wi-Fi module to become available.

The module features two different modes of operation. The first, "Access Point" (AP) mode, allows for the module to host its own network and allow other devices to connect to its network. The second, "Station" mode, allows the device to connect to a broadcasted Wi-Fi network in range with the correct SSID and password. Both of these operational modes can be active simultaneously. Our design utilizes both of these modes to provide add a higher level of usability in the design. The AP mode is utilized to allow users to connect the WaterWise system to the users' home network from their smartphone or laptop. This process is similar to configuring a wireless router. The user enters the factory IP address of the WaterWise system, 192.168.4.1 in their browser and a network configuration page is provided to receive an SSID and password to connect the system. This page is a simple HTML form that is sent via an HTTP response to the client's request of the Wi-Fi modules factory IP address.

Once the module is configured with a correct SSID and password, the module is reports the assigned IP address from the home network. The microcontroller will then issue AT commands to set the module only in Station mode to act as a device on the home Wi-Fi network. Once this is complete the Wi-Fi module will be able to receive HTTP requests at its current IP address on the wifi network.

F. Printed Circuit Board

All of the sensors, pumps, LCD, and Wi-Fi module interface directly to our printed circuit board design. The PCB implements the Atmega 256016AU chip without error. The board is programmed using the Arduino bootloader, and an FTDI programming cable. This design includes distribution at different voltage levels of 12V, 5V, and 3.3V. There are a total of 16 pin outputs to drive signals to relay components and peristaltic pump components. The design includes the use of two Darlington drivers to process signals to the relays and pumps and activate voltage to these components. The use of Darlington drivers adds a layer of protection for the microcontroller from back EMF when signaling the relays and pumps high and low. LEDs were also incorporated into the design to indicate when pins on the Darlington drivers were activated to operate our pumps and relays.

The PCB is manufactured by OSH Park with 87 nets and 123 parts. The board features 2 layers and measures 3.1 inches by 2 inches. The board will be mounted inside a waterproof encasement using standoffs. The surface mount components are soldered using a pick and place machine at Quality Manufacturing Solutions in Lake Mary, FL.

IV. SOFTWARE DESIGN

A. Microcontroller Software

The microcontroller software was built using Arduino IDE to program the Atmega2560. The Arduino IDE contains many built-in features to support the different functionalities required by our project. The built-in library manager allows developers to easily import the required libraries for their projects. This proved to be very useful to obtain the necessary libraries for the Wi-Fi and LCD functionalities. Also, the Arduino IDE is an open source product available on multiple operating system platforms, whereas other IDEs like Code Composer Studio by TI are not. Arduino code also has an object-oriented feel as it is based off of C++ code. This feature adds simplicity to the development process.

The microcontroller program begins by initializing all of the different objects needed throughout operation; these include: sensor pins, Wi-Fi module serial communication, LCD communication pins, and the hydroponic component pins. The Wi-Fi module is first initialized by setting it in 'Access Point Mode' to allow hosts to connect and configure the SSID and password. Next the LCD is initialized to begin displaying the main menu options 'Power' and 'Sensors'.

The main loop structure of the code cycles through different functions each with their own purpose and delays. The first function calls are made to each sensor measurement to obtain each initial measurement and establish the timer delay to obtain the next set of measurements. Each time a measurement function is called, the respective global variable for that measurement is updated. Next, the system attempts to receive HTTP requests from connected hosts. If the system is still configured in AP mode, then it will respond to the host with a HTML form to receive the SSID and password for the network a user intends to connect WaterWise. Once the SSID and password are received the system attempts to connect and reports back the status on the HTML form, either with an invalid message or with a success message and the newly assigned IP address and port number which is used to connect the Android application to the system. The system is then placed in station mode as it is now connected to a network acting as a host.

While in station mode, the system setup will receive incoming requests from the app which are formatted with a pre-defined set of parameters in an HTTP 1.1 GET request. The parameters indicate to the microcontroller what information that the mobile application is requesting. The system will parse the parameters and respond with either the latest sensor measurements or component power statuses. These parameters can also instruct the system to turn on or off the hydroponic components, and also indicate the required plant nutrient levels of the current plant being grown.

The system's main automation feature is its ability to automatically dispense plant nutrient into the reservoir to meet the needs of the current plant growing in the system. When a user selects a plant in the mobile application that he/she will grow in the system, the application communicates the required EC level for that specific plant. The microcontroller saves this value, and will begin to monitor the EC measurement every 15 minutes. If the EC measurement is found to be too low than required, then the microcontroller will calculate the correct amount of nutrient to dispense. It will activate the nutrient peristaltic pump for a specific duration to dispense the right amount of nutrient. The system will check the reading again after another 15 minutes to ensure the measurement is at the correct level. If the system finds the EC measurement to be at the correct level, then it will wait for one hour to check the reading again. These wait times are very important because adding too much nutrient solution will create toxic water conditions. On the other hand, dispensing too little nutrient solution will starve the plants. Of course, all of this automation is contingent on the user staging the nutrient solution hopper to be dispensed into the water reservoir.

Additionally, there is an LCD interface configured to allow for direct user interaction with the hydroponic system. The LCD interface consists of a 16x2 character LCD, and five push buttons, 'Left', 'Right', 'Up', 'Down', and 'Select'. The LCD displays a menu to allow a user to toggle power to the hydroponic subsystems and also view the most recent sensor measurements. The menu control code allows the user to scroll left and right through the current menu. The user may also use the 'Up' and 'Down' buttons to select the menu options presented on the screen. The 'Select' button is used to return to the previous menu. The microcontroller software receives user input from the interface buttons and determines from the current menu displayed and a sequence of input processing what to action to perform.

B. Mobile Application Software

The mobile application for *WaterWise* was designed for the Android mobile operating system. It was created in the Android Studio IDE on Windows using a Motorola XT1095 for development testing. The mobile application utilizes the Java language for program functionality, and XML for the UX and UI design.

The goal for the mobile application is to allow the user to control the system from the mobile application while connected to the same wifi network as the system. The system was designed to achieve this by enabling the different components of the system to be controlled using HTTP GET requests sent to the wifi module connected to the microcontroller by the mobile application. The secondary goal for the mobile application was to provide a pleasant user experience to ensure that the user will want to use the mobile application as much as possible.

With this goal in mind, the UI for the mobile application was designed using the Google Material Design specification. This is a UI specification provided by Google to ensure the highest levels of user satisfaction. By choosing to follow this specification, the mobile application was designed with a style that is identical to the most popular android applications. In addition to Material Design, the UX design of the mobile application as designed in line with the most common UX designs for Android in order to guarantee that most Android users would be comfortable utilizing the mobile application from the beginning.

The structure of the mobile application centers around using a few activities, with many more fragments that attach to these activities. This approach allows for the reuse of certain elements that are persistent throughout the mobile application. Such as the activity bar and the navigation menu. Because of the nature of fragment activities within the Android operating system, this approach also enables a faster, less resource dependent ability to create and destroy the different views as the user travels through the application. The breakdown of these activities and fragments is as follows.

The splash activity is the opening animation that is displayed when the user launches the app. This standalone activity displays a pleasant animation while the mobile application loads the user object from system memory, connects with the Kinvey database, and loads other application data from system memory. The splash activity also determines whether the user is moved to either the welcome activity or the system activity, by checking to see if the user object has already been logged in.

The welcome activity is the next activity to be launched if the user has not already logged in to the Kinvey server. This activity displays a log in screen with two text fields for the user to enter their e-mail and password. In addition to the two text fields, this screen also contains three buttons; one for the user to use their Google+ account to sign in/up, one to sign up using the entered credentials, and one to sign in. Depending on which choice is selected by the user, the welcome activity does the necessary background tasks to complete the transaction with the Kinvey database. While these transactions are processed, the welcome activity displays a rotating loading wheel dialog to inform the user that their interaction is being processed. Afterward, the user is transported to the system activity.

The system activity is the final activity that is used in the mobile application. This activity controls both the action bar and the navigation drawer that are accessible throughout the rest of the user experience. The system activity also acts as a container to which the many fragments used in the application may attach to. Beyond displaying the action bar and navigation drawer, the system activity launches and closes the fragments in the background, unseen by the user.

The fragments that will be attaching to the system activity are the multiple different views that will be displayed to the user in the mobile application. These views are the: system view, plant view, sensors view, account view, settings view, and help view. These fragments are selected using the navigation drawer. Each of these views uses the fragment structure to display information, and allow interaction for the user.

The system view displays the current power state of each of the system components. It also includes a floating action button that allows the user to open a floating menu to toggle power to the different components of the system.

The plant view allows the user to see the current plant they have selected, along with information related to growing that plant in our system. The plant view also uses a floating action button to enable the user to open a floating search window that allows them to search our Kinvey database for a specific plant type.

The sensors view lists the different sensors that are implemented within the system, and allows the user to get the readings for these sensors from the system. The view implements a swipe-to-refresh interaction that displays a rotating refreshing animation before updating the sensor value and timestamp fields for each sensor.

The account view gives the user options to change different values related to their account. Such as: changing their registered e-mail, resetting their password, and changing the IP address and port number to use when connecting to the system.

The settings view was created to give the user options to toggle settings for the mobile application. Currently, it allows the user to enable or disable push notifications for their device, and to sign out of their current account. The settings view also provides an about section with our logo, team name, and licensing

The help view provides the user with some frequently asked questions, a button to take them to our website where more questions and answers can be found, and a link for a support e-mail that user can touch to e-mail us directly.

V. CONCLUSION

The WaterWise Smart Hydroponic System is a product that tackles the issue of home gardening for the urban dweller and 21st Century commuter. By integrating an up-and-coming gardening practice with modern technology, we believe that having a green thumb will no longer be restricted to people living with a plot of acreage. This, we hope, can be the beginning of people gaining more self-dependency when it comes to their food and providing themselves healthier alternatives direct from their very own home.

THE WATERWISE TEAM

Joe Bender is a Computer Engineering major from UCF. Through his personal projects and four internships, he has acquired much experience with a range of software and programming languages. He enjoys developing small projects focused on personal and home automation. Joe has signed a full-time employment offer from Tallan Inc. as a Software Consultant, pending his graduation.

Joseph Johnson IV is a Computer Engineering major at UCF. He is a CompTIA A+ certified PC Technician and has much experience with PC assembly, troubleshooting, and consulting. He is also experienced in Android development and UX/UI design. Joseph is currently employed as a contracted Software Engineer with Coded, Inc. which he hopes will become a permanent position with a focus on UX/UI design.

Matt LaRue is an Electrical Engineering major at UCF. Throughout three internships, Matt has gained much experience in the power distribution and MEP facilities design fields. Post graduation, Matt will continue design work for C&S Engineers, Inc., an engineering consulting firm in Orlando, and hopes to obtain his EIT certification in the near future.

Akeem Liburd is an Electrical Engineering major from UCF. Through his person projects, he has gained a great deal of experience in circuitry and software development. He enjoys working along with others solving problems. He hopes to get a full-time job as an Electrical Engineer after graduation.

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REFERENCES

[1] Instructables.com, KDLaun. Relay-Controlled Power Strip. http://www.instructables.com/id/Relay-Controlled-Power-Strip/