Intelligent Food Growing System

Deployable Prototype

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Executive Summary

The Intelligent Food Growing System is designed with the capability to assist in eating healthy organic produce while educating the consumer on the importance of growing food. A traditional garden can be full of hard and time-consuming work. Our product addresses these issues by automating the entire growing process while engaging the consumer with a functional user interface and interesting plant data. The future of our product is to increase the access to healthy organic produce, while also curbing the cost of the existing organic market.

The Intelligent Food Growing System has several features, the first being a lighting system that has the ability to illuminate any plant throughout its early stage of seeding and later stage of flowering. The way the system will know when to turn on or off the light is by knowing the time of day. For example, when it is 8 am the light will turn on and at night, roughly 7 pm, the light will turn off. This will mimic the natural sun cycle, which will provide optimal plant lighting. A future feature the lighting system will be able to do is lift the light source up as the plant grows. Our product has a sensor system which is comprised of a temperature, humidity, and soil moisture sensor. Each of the sensors help determine how the system will function. For instance, the soil moisture sensor will help determine when the watering system will be needed. The temperature and humidity sensor can help determine if the system's environment is well suited for the crop or if the system needs to be moved elsewhere. The next feature then leads to the watering system; it is dependent on two factors time and the soil moisture sensor.A water tank is included in our product to provide the user with easy watering. The water pump will directly provide water to the plant whenever it needs it. The watering system has a tank level sensor and a flow sensor so we can monitor how much water the crop is getting as well as the water level in the tank. The growing system will have information on the best growing environment for different plants. The user simply types what vegetable they are going to plant and the grow system will pull the information from a database. Once the user knows what they want to grow, the Intelligent Food Growing System will adjust its functions to grow the plant optimally.

Bringing the intelligent food growing system to the retail market is the ultimate goal for the future of this product. Having a product that is at the right price, which includes all necessary features to create a great product is still unknown. However, the intelligent food growing system has appeal in many different industries such as the organic, education, and recreational industries, which increase the desirability of our product. Bringing access to fresh organic produce was the inspiration for our product, which we hope our system can continue to promote in the future.

The demand for healthy organic food is increasing every year. This is the best indication that the intelligent food growing system is the right product to bring to market. Having a fully automated system that can grow fresh produce, educate, and stimulate interest in organic living, is why our product can succeed over the competition. The intelligent food growing system is a fully versatile system that can grow many different types of product year round. Having a system that will grow your food is a fantastic thing, however having a product that spreads healthy organic living is the major shining point.

Abstract- *The Intelligent Food Growing System is a product that will allow users to grow a single organic crop in the comfort and convenience of their own home. The system will be automated and designed to have little interaction with the process of growing the crop. The automated portion of the product will have several sensors (to monitor humidity, soil moisture, and temperature), an irrigation system, and lights to provide healthy growth. The consumer will be able to watch their crop flourish and enjoy the end product in a delicious meal.*

Keywords
Food Growing, IoT, Intel Edison, Grow Light, Irrigation, Sensors, Prototype, Data Logging, User Interface, Web Application, Smart Agriculture, Organic, Gardening, Smart Devices.

I. INTRODUCTION

The documentation provided in this report will provide an outline of the intelligent food growing system and our teams process over the last ten months. We will provide insight into our assignments and show how they helped us work, grow, and develop the intelligent food growing system. Learning the project process was a large part of senior design and was assisted from assignments such as the design idea, project timeline, risk assessment, and market review, which are all covered in this report. This report will also outline the engineering challenges faced and strategies that were used to find solutions.

II. SOCIETAL PROBLEM

A. Education And Awareness

The agriculture industry is a vital part of the modern society. Agriculture is so vital because of the simple fact that everyone needs to eat. This fact is very clear, which is why we think agriculture education is so important. There is currently a huge push to build interest for the Science Technology Engineering and Math (STEM) subjects among the youth. We think agriculture and STEM are such important fields that we want to promote the two. Our product would be able to develop interest in engineering and agriculture, while educating the user on the fundamentals of growing their own food.

B. Health Hazards

The use of herbicides on food is another health public concern. Herbicides are used to kill the weeds that are hazardous to farm crops. GMO tolerant crops have been developed to allow for the switch of herbicide used, which is now glyphosate. Jennifer Hsaio also states “the world health organization recently announced that glyphosate is a probable carcinogen.” The graph below also shows the increased used of glyphosate through the years, which is a further reason to reduce the intake of crops treated with herbicides.

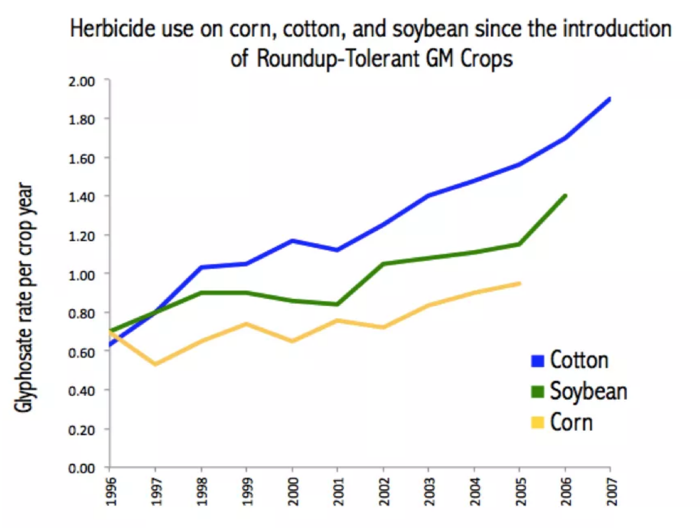

Figure 1: *Timeline of glyphosate-based herbicide use on corn, cotton, and soybean rate per crop year [1].*

C. Giant Corporations And The Effect On Our Food

The majority of produce comes from giant farms. Conventional farming methods have come into question in recent years. Giant corporations spray questionable chemicals without telling the public. This is a problem because those chemicals are horrible for health of all living things. Currently giant corporations are trying to hold a monopoly on certain produce. One of the worst dissensions made by conventional farming is the use of GM crops. The GM crops are patented by big business companies leading to monopolization of our food and controlling distribution of the world food supply. The reason why biotech companies are trying to produce genetically modified crops is because they can be patented, Which can lead to privatization of food. Food is the natural right of all living beings [3][5]. The large Agro-biotech company, Monsanto, has been making its way into becoming a monopoly as planned. This company has taken over small seed companies over the past 10 years and has become the largest Agro-biotech Corporation in the world. Having a patent on food has also hurt the small farmers of the area. Farmers have to sign contracts preventing them from replanting the seeds. This forces farmers to constantly by more seeds created by the biotech company [4]. Privatizing food is the problem in farming today. This problem will continue to happen until we put the growing power in the hands of the people. This is why growing your own food will be the best way to circumvent this problem. The less we depend on giant corporations to feed our communities the better chance we have of a sustainable future.

D. Food Deserts

Most people do not see a problem in accessing their food. Either because they live close to a grocery market or they have a car. Not all communities are so lucky. If a person does not have a car and they are miles away from a market he or she will be more than likely to settle for fast food. Research done by the Economic Research Services, the Food and Nutrition Service, and the Cooperative State Research, Education and Extension Service of the U.S Department of Agriculture have shown evidence of food deserts. Food deserts can be described from three of their findings.

1. Of all households in the United States, 2.3 million, or 2.2 percent, live more than a mile from a supermarket and do not have access to a vehicle. An additional 3.4 million households, or 3.2 percent of all households, live between one-half to 1 mile and do not have access to a vehicle [6].
2. Area-based measures of access show that 23.5 million people live in low-income areas (areas where more than 40 percent of the population has income at or below 200 percent of Federal poverty thresholds) that are more than 1 mile from a supermarket or large grocery

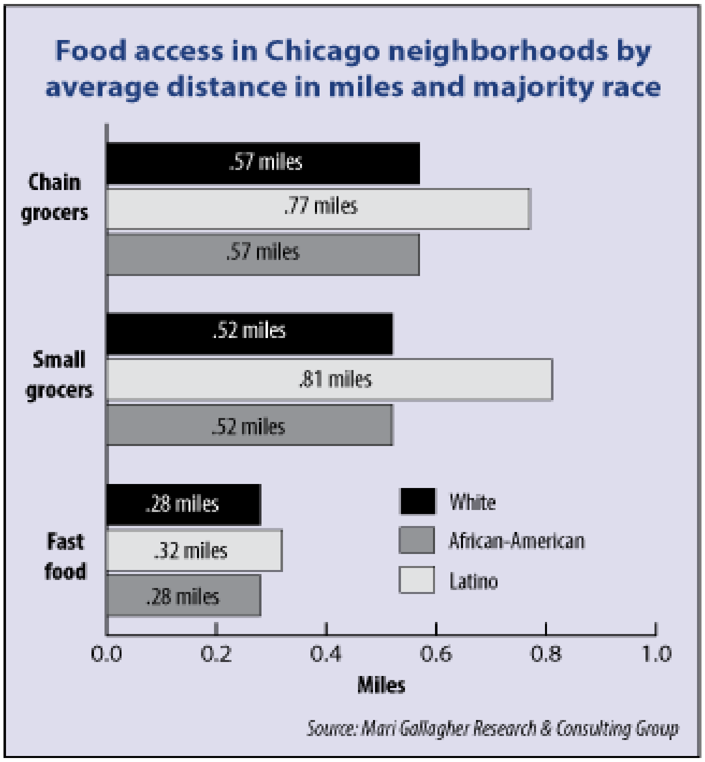

Figure 2: Food access based on miles among different races living in Chicago [2].

store. However, not all of these 23.5 million people have low income. If estimates are restricted to consider only low-income people in low-income areas, than 11.5 million people, or 4.1 percent of the total U.S. population, live in low-income areas more than 1 mile from a supermarket [6].

3. Data on time use and travel mode show that people living in low-income areas with limited access spend significantly more time (19.5 minutes) traveling to a grocery store than the national average (15 minutes). However, 93 percent of those who live in low-income areas with limited access traveled to the grocery store in a vehicle they or another household member drove [6].

E. WORKING HOURS OF PEOPLE

In the United States, Americans are working more hours per week than any other place in the industrialized world. Not only are Americans working more hours per week, they are also are taking less and less vacations as the years go by. With today's style of household, the man is not the only person who works a full workweek of over forty hours. Women are no longer stay at home moms; they also contribute economically to the overall income of the home [16]. When you have the husband and wife accumulating over 70 hours together a week, you can see that there is no time for much extracurricular activities after work.

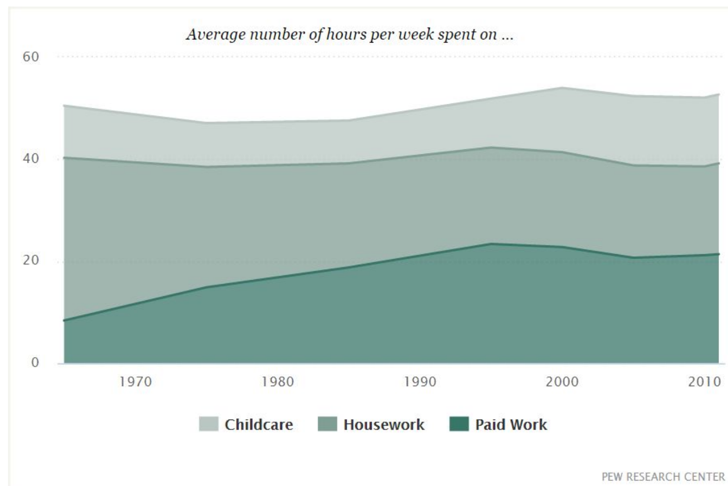

Figure 3: Average number of hours per week spent on work, housework, and child care [3].

With so many combined working hours, parents find it stressful to balance a job, housework and childcare. Stated in the same article "Modern Parenthood", it reads "Feeling rushed is also a part of everyday life for today's mothers and fathers [18]. Among those with children under age 18, 40% of working mothers and 34% of working fathers say they always feel rushed." If families are feeling rushed and don't have enough time in the day to do much, then our intelligent food growing system would be a great asset to their everyday lives. This system would benefit households around the world in a great way. No longer will Americans have to worry about taking care or maintain their fresh produce garden.

III. DESIGN IDEA

A. Design Idea Contract

1) How Does Your Idea Address The Problem?

Bringing access, convenience, interest, and education to families and individuals with a desire for an organic living is the societal problem that is being challenged. Our idea of building an autonomous Intelligent Food Growing System will address this problem on an upfront basis. Allowing people to grow their own food will accomplish bringing easier access to organic food. The convenience of having an automated garden will also help solve the issue of the amount of time a garden requires. Creating an affordable product that is both interesting and functional can boost interest in gardening and eating healthy.

Our product is first and foremost about bringing fresh organic produce to the consumer. The Intelligent Food Growing System will the capability to grow a piece of produce from start to finish. The only input required will be planting the seed of the crop you want to grow and refilling the water tank when needed. The system will be able to solve the problem of access by taking the chain of production out of the equation altogether.

To the average American convenience is a big deal; time is one of the most valuable assets in daily life. We are tackling this problem by fully automating the garden. If the consumer wants fresh vegetables, then there shouldn't be a sacrifice of time to get them. By creating a system that can monitor water needs, relative temperature and humidity, soil health and plant health, there will be no need to invest any extra time the crop's upkeep. The convenience and time-saving ability of our product is what makes our product so valuable. Although it will still take about the same time as a traditional garden for harvest but with little to no maintenance.

Educating the public about growing a garden is accomplished in a few ways. Seeing a crop go from seed to harvest will educate the user on what the plant needs and requires in order to meet that end goal. Since our system is automated the user will be able to learn in a visual and worry free manner. The second way in which our product will educate the user is through the analyzation of the data the system will provide from the many sensors. All of the data is accessible either in real time on an LCD screen or through our Blynk app or through a data logging system that is stored on an SD card or an excel spreadsheet. Through education, we also hope to build interest in consumers.

2) What Is Unique About Your Idea?

Growing food close to home has grown in popularity. There are home growing systems that are being developed by startup companies such as Niwa, as shown in figure 4. With Niwa, they use a hydroponic watering system to feed synthetic nutrients to the plants. We will be using soil as our medium. They used hydroponics because it grows food fast. Another way other products on the market are developing their systems is through the use of aquaponics. The downside to aquaponics is that it's more sensitive to water changes. The water can fall out of balance and easily kill plants within a day. Soil is a much more forgiving medium. In addition, the plants will get its nutrients from the soil instead of from synthetic nutrient solutions. Thinking from an educational standpoint hydroponics is less interactive and hands on. Hydroponics fails to show what gardening entails. That is the reason why our approach of using soil will be more interactive. Having a soil based product also allows for maintaining our goal of emphasizing organic living. Hydroponics and aquaponics are not considered organic. Some households prefer cleanliness but our product will be more hands on. Working your hands in the dirt is part of the fun of having a garden.

Figure 4 : The Niwa product [4]

Most of the home growing systems that are on the market have a light source to provide energy for the plant(s). Our system is different to said products in that the lighting source we decided upon caters to the plant's particular life cycle. What makes our product unique is that it will recognize its environment and accommodate to the plant's needs, whether that be the lighting or any of the other functions our product provides. All the systems we have researched have higher chances for user error, mainly because of the hydroponics and aquaponics systems these products require. Our intelligent system will communicate with the user to make sure that all variables are satisfied. This design sets our product apart from what is available on the market.

3) What Technologies Are Needed?

The Intelligent Food Growing System will incorporate various types of technologies. The idea behind our product is heavily reliant on technology and is based off little to no maintenance by the user. The main technology used during the first semester was the Arduino UNO and an accessory called Open Garden Shield. For the second semester we switched over to the Intel Edison and another shield called the Grove Base Shield by Seeed Studio, this will allow our product and team members to evolve. Technology is the main idea behind the Intelligent Food Growing System. With the help of technology our product has the ability of maintaining a single crop while making it easier and hassle free to grow food that can then be enjoyed in a meal.

4) What Approaches Have Been Taken To Solve The Problem And Why Are You Unique?

Our idea to the solution is not the first attempt to helping people start their own gardens. There have been many attempts to help improve consumers consumption of more homegrown fresh produce, that are also convenient. That is there are some products already on the market with similar concepts but they do not fulfill all the specifications that our product has. A few approaches that have been made to help improve growing produce with convenience and in some cases technology are (as state earlier) Niwa, Tower Garden, Edyn, Veg Plot Irrigation, and FarmBot. Our product is different in the fact that all of the listed products do not tackle all of the functions our does. Most of the products are either a contained system with a hydroponics, aeroponics, or aquaponics medium, an irrigation system, or just an individual sensor. For instance the Veg Plot Irrigation, as seen in figure 4, main function is to regulate irrigation. It only waters the plants every 4 hours. It does not keep track of the amount of water that is being provided is enough or too little for the plant. In an essence the only function it has is a watering system that is based on a timer.

Figure 5: Veg Plot Irrigation [5].

The Tower Garden is a small home garden aeroponics based system, as seen in figure 3, it has soilless seed pods called rockwool and has a nutrient solution and water reservoir at the base of the system. The system waters the plants in 15 minute intervals. The Tower Garden does not have any other features therefore it is not able to calculate the environment's humidity and temperature, amount of light, or even provide light. The Intelligent Food Growing System has the capability to do all of these functions, it can read the temperature and humidity of the plant's environment, monitor the amount of light the plant is receiving, water based upon the plants needs not just in time increments, and even notify the user if the water tank level is low. Knowing all of these factors allows the user to adjust the system to better help the plant. This can help the plan because it will have the correct water consumption needed, varying at different climates.

Figure 6: The Tower Garden [6].

There are also systems that have been created to solve the problem of convenience and organic living but do not tackle the recognition of being an "intelligent" system. Other systems that have been created, do not know what has been planted or what the plant needs. Every plant or vegetable cannot be treated the same when it's growing. Each plant has a different amount of water that needs to be supplied to it or a different amount of sunlight it needs throughout the day. What makes our system unique is that it will be able to know what is being planted and adjust its entire caring system to help the plant get the most nutrition, water, and sunlight it needs to be healthy. We plan to tackle every aspect that other systems lack so our system can be as unique and successful as possible.

What makes our system "intelligent" is the interdependability of systems upon each other and the number of sensors we have to allow our system to be automated. A feature we find unique is the way our lighting system interacts with the light sensor. If the placement of the plant, meaning the system structure, is in a location that has a lot of sunlight, depending upon the amount, the light will dim or turn off.

Another perk of our system is that it is heavily self-maintained, there is little to no user interaction. The system has the ability to understand what the plant needs and will be able to provide for it on its own. This only shows another reason why the Intelligent Food Growing System is unique and more efficient.

B. Resources Needed To Complete The Project

The resources that will be needed to complete the Intelligent Food Growing System will be, to begin with; our own teammates knowledge. Our teammates will be the most important resources because as computer and electrical engineers, we have knowledge on hardware and software. The other source we will be using is the Senior Design lab. If the lab is not available, a teammates home will be the next best thing. Another major source that we will need is anything on agriculture. Since we are not proficient on knowing everything about plants, we will educate ourselves on what will make a plant healthy and grown to its maximum potential. The school library will be a great source to learn more about agriculture; as well as online research.

C. Design Idea Summarization

1) Features

The Intelligent Food Growing System has many features all of which are based upon the requirements for plant growth and user interaction. There are four main fundamental features a watering system, lighting system, sensor system, and a user interface system. The watering system consists of a water pump for direct watering, a tank level indicator, and water flow sensor, which will measure the quantity and flow rate of water.

The lighting system is comprised of a primary light, which will dim based upon the amount of light the sensor system detects around the environment of the plant. The sensor system consists of a temperature, humidity, soil moisture, and light sensor. The feedback from the sensor will allow the watering and lighting systems to adjust to proper settings. The user interface portion of the design consists of an LCD user interface and web application. The LCD is used to display data that is gathered from the different systems. The web application is used to display and record all the data from the sensors in a nice clean and easy to read environment.

2) Hardware

The hardware needed for our design will be as followed: an Intel Edison, Grove Base Shield, an LED grow light panel, a pump, two relays for the light and pump, a light sensor, a ping sensor for the tank level, temperature and humidity sensor, a soil moisture sensor, a wooden framed structure with a removable wooden box, plastic tubing for the watering system, and an LCD display. All of the listed hardware components were used during the first semester with the exception of the microcontroller and shield. The Intel Edison and Grove Base Shield (figure 7b) replaced the Arduino UNO and Open Garden Shield. The main change that was implemented in the second semester was that the majority of the components were replaced in order to function correctly with the Intel Edison.

The Intel Edison is a microcontroller board based with a dual core Intel Atom processor [4]. It has many input/output pins, which allows the use of other accessories, analog inputs, a 500 Mhz processor, a USB connection, a power jack, an ICSP header and a reset button. Other specifications include 1 GB DDR3 RAM, 4 GB eMMC flash, 40 multiplexed GPIO interfaces Bluetooth 4.0, Wi-Fi Yocto Project, Brillo Arduino compatible. Our original plan was to use all of our hardware components from the Arduino on the

Intel Edison but we quickly realized that that was not going to completely work. For some of the components we managed to manipulate code in order to get it to be compatible with the Edison but some of the components needed to be replaced all together.

The Open Garden Shield was used because it had designated pins for the temperature and humidity and soil moisture sensor, this allowed for keeping track of the plant's needs. It also had a photo sensor directly on the shield, it detected and monitored the amount of light that is present around the plant and that will help us determine if the plant needs more light. It will also help with determining of the watering system should be used. A temperature sensor will keep track of the temperature of the environment of the product. This can help figure out if the system needs to be placed in another location, if the plant needs more water to compensate for the amount of heat/temperature. A humidity sensor will detect humidity in the surrounding environment. Humidity can affect the way a plant grows depending on the type of plant. In order to see what all the sensors were sensing we had an LCD display to show all of our findings. To store that data we used a data-logger, which was attached to the Arduino and displayed in an Excel spreadsheet.

Figure 7a: Intel Edison that will be used in our product [7].

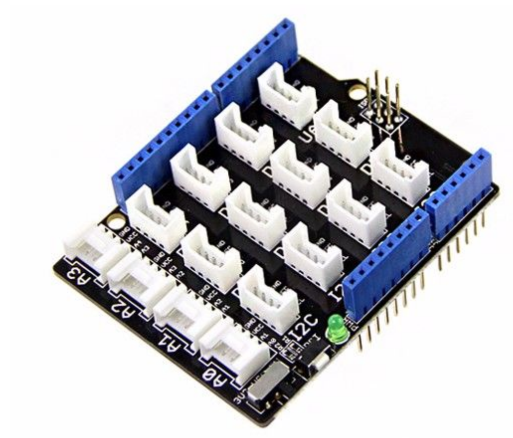

Figure 7b: Grove Base Shield [7].

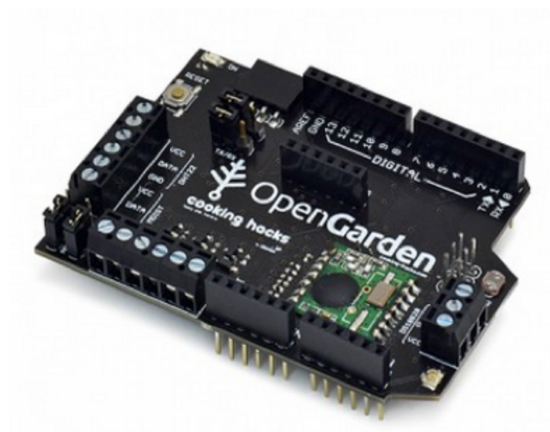

Figure 8: Open Garden shield we will be using for our product [8].

In order to use all of the listed technological hardware we will need a place to house our crop, a wooden frame and water resistant coating on the removable box will do the job. To water the plant and keep the humidity balanced we used plastic tubing and a pump to transfer the water to the plant. Along with the pump have a flow sensor to determine the amount of water needed for the plant, which will vary for every type of plant. Since our product will first be designed to be indoors we will need lights to help the plant grow. A relay will also be incorporated; relays are used when a circuit has a low-powered signal it can turn on or off a much larger electric current. To help power the system we will need three relays, one being for the pump and for the lighting.

3) Software

The Intel Edison is capable of using C/C++ language and has it's own IDE that is shares with Edison, which will be used to code our system. The Edison can also be programed with other IDE's with many different languages. During the first semester the Arduino library was used along with the open source Open Garden Libraries. That particular library had the compatible with the different functions needed to use for the sensors as mentioned. The software used for the Intel Edison was very similar to the Arduino but we basically had to reimplement our old code into a new one in order to accommodate all of the components.

IV. FUNDING

The funding for the Intelligent Food Growing System consisted of outside and internal funding from team members. Starting with the outside funding for the project, there was not many outside funding other than team members pre-owning components used in the project, and being sponsored by team mates family members with the garden structure materials. Some of the components that were pre-owned by members were the light sensor, water pump and Arduino Uno. Most of the components that were used in the watering system were pre-owned by team member Zack Douglas-Allen. This was very beneficial for our IFGS project because we were able to save some money on parts and spend the remaining budget on other components. Another outside funding for our project was from Ezequiel cousin named Geovanni Renero. His cousin was able to sponsor/provide our team with the wood and materials to built the garden structure. Our team was also able to work with him and get some feedback on the construction of the structure since he is a professional in this field.

The internal team member funding for our Intelligent Food Growing System was average and understandable when it came to costs of our items. The funding came from each team member by splitting all the costs evenly throughout the four team members. Below is a table that shows all the components for our project and their price. The parenthesis next to the price of the item explains if the item was pre-owned by one of our team members, if the team members funded them or if they were sponsored by outside funders. As you can see from the table, the most expensive part of our project was the Intel Edison microcontroller. The overall total that was put into the project was $315.40. The funding for the project was reasonable and the budget estimation was close to the final total cost.

Item:	**Price:**
Intel Edison	$92 (team funding)
GroveShield	$60 (team funding)
LED Grow Light Panel	$45 (team funding)
Soil Moisture Sensor	$4.90 (team funding)
Temp/Humidity Sensor	$8.50 (team funding)
Ping Sensor	$5 (team owned)
Light Sensor	N/A (team owned)
Water Pump	N/A (team owned)
Flow Sensor	$10 (team funding)
Garden Frame/Struc.	N/A (sponsored)
LCD Display	$30 (team funding)

Arduino Uno	N/A (team owned)
Water Tank	~$40 (team funding)
Garden Soil	$10 (team funding)
Irrigation Tubing	$10 (team funding)
	Total: $315.40

V. PROJECT MILESTONE (Jonathan)

A. Sensor system

The sensor system was the first part of the project that was started. It was crucial to finish this test in the beginning of the project because all other systems were dependent on the sensors for data logging and visualisations.

B. Growing structure and Lighting System

The growing structure came in after the skeletal makeup of the system was developed. We needed somewhere to store the electronics and a place for a plant to grow.

C. Watering System

The watering system was complete shortly after the construction of the growing structure. The watering system algorithm was a major milestone to keeping this project meet up to its standards of keeping a plant alive without experience.

D. Data Logging

With the data being collected from our growing system we developed a data logging system that stores data onto an excel file for analysis. This milestone meet our standard for making an educational product.

E. Data Visualisation and Web Application

Data visualizations were used to show the user the plants environment from a smartphone app. This hit our milestone of having an Internet of Things device.

VI. WORK BREAKDOWN STRUCTURE

A. Watering System

Team member Zack is responsible for the entire watering system, which consists of the tank level, water flow and soil watering systems. The Intel Edison is the microcontroller which controls all the functions of the watering system. Zack developed and implemented code for each sensor in the watering system, which are outlined in the design documentation section, to manage each function. Each sensor will provide an output to control hardware or provide data. Zack integrated the hardware components, such as water pump, into the entire watering system.

B. Lighting System

The lighting system and all of its components was managed by Ezequiel Morales. The lighting system consisted of a LED grow light panel, mosfet circuit, and a photosensor. The construction of the mosfet circuit was done by Zack. Zack is the electrical engineer in the team and had more knowledge and skills when it came to modifying electrical components. For the LED grow light, there was not many hours spent trying to built the light since it was bought already assembled. The place where there was a lot of hours spent was actually finding the right LED light that had dimmable abilities. A total of around four hours was spent researching and testing the right LED light that would get the job done right. Once we obtained the right LED that would work with our system, then another four hours were spent programming and coding the light. When it came to the photosensor circuit for the light to be dimmed at a certain value, a total of two hours were spent building it and testing it. Once everything was done, a total of about 10 hours was spent in the lighting system for the growing system.

C. Sensor System

The sensor system contains three sensors and was managed by Eloisa Esparza, the sensor include a temperature and humidity, light, and soil moisture sensor. This component took a lot of time to be fully functional. We tried two other sensors before purchasing this one, the DHT22 and DHT11 both did not work due to different clock speeds on the Arduino compared to the Intel Edison. This component took around 24 hours between researching, testing, and debugging. The light sensor took some trial and error but eventually we came to building our own circuit and put it onto a pcb. This component took roughly 6 hours. The next and most important sensor, the soil moisture sensor was by far the easiest to implement and only required testing to determine a range of moisture in the soil and for accuracy. The amount of time it took to implement this sensor was mostly done during the integration testing, which was roughly 35 hours.

D. User Interface

The user interface consisted of a LCD screen and TFT screen. This system was managed by Jonathan Molina. The user interface will show data from the sensors. The TFT screen had problems connecting to the Intel Edison because of hardware incompatibilities. We tried software libraries to create a work around to fix the issues which could not be fixed.

E. Web Application

The web application was managed by Jonathan Molina. We used the Blynk app to house all of our data. This web application as a service produced great code to streamline data to the web and onto a smartphone.

F. Garden Structure

The garden structure for the Intelligent Food Growing System was managed by Ezequiel Morales. The early prototype design for the structure was contributed by every member of the team. At the early stage of design, the team spent about three hours to come up with the correct specifications to support all the features in the system. Once the design was set, the beginning of constructruction started. A total of six hours was spent on the building of the garden structure. The physical construction of the garden was built with the help of Geovanni Renero, which is Ezequiel's cousin.

At the start of the second semester, new modifications were to be done to the structure of the project to be able to fit the new grow light. The design took about an hour to come up with. The physical modification of the new structure took about four hours to get done. There have been slight modifications as the semester went on which accumulates to another two hours. The final hours spent working on the garden structure were 16 hours

VII. RISK ASSESSMENT / MITIGATION

Risk is often viewed as something dangerous to the well-being of a person. The intelligent food growing system did not view risk in only this way.

Risk was also view as a dangerous to project success, and defined as probability times impact. Through the last two months we calculated the risk each system had to the safe of users and project success, which was used in implementing solutions to counteract the risk. Our system was susceptible to long term risk from for water damaging the wooded garden structure and causing a total failure of the device. The solution to this risk was creating a removable garden box that was coated in a water proof material, which significantly lowered the risk. The sensor system was also high on the risk matrix as shown in the figure below because it was directly integrated into other system, which caused for higher impact. If the sensor output information was incorrect multiple system would fail.

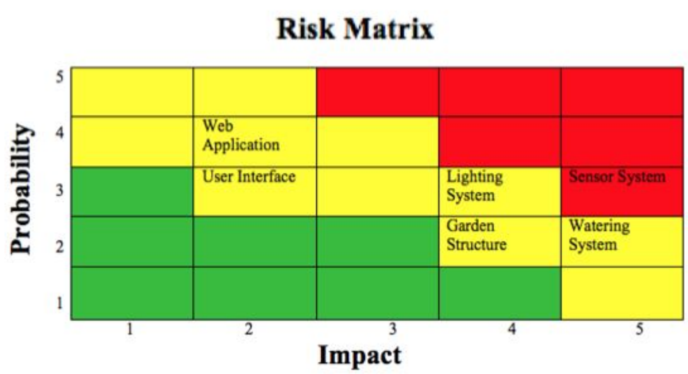

Figure 9:Risk Matrix [9].

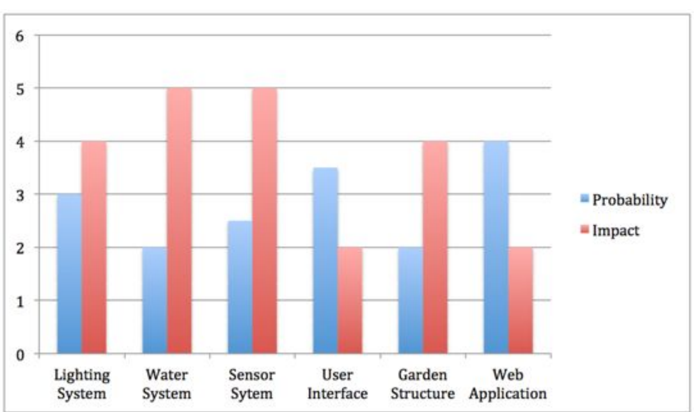

Figure 10: Risk Assessment Chart [10].

VIII. DESIGN DOCUMENTATION (team)

The design overview for the Intelligent Food Growing System can be broken down into six major components. These components consist of the microcontroller, user interface, watering system, sensor system, lighting system and web application. In the first semester of the project, an Arduino Uno was being used but then at the start of the second semester it was switched to the Intel Edison. The microcontroller was switched to the Edison because of the wifi capabilities and greater memory space. The breakout board was also implemented with the Edison due to its compatibility with the Arduino's IDE. The Edison was in charge of running the entire system and all its features.

The watering system is comprised of a tank level, water flow, and soil watering systems. These three systems come together to provide optimal water efficiency to each and every plant housed in the intelligent food growing system. The tank level system delivers the tank quantity in gallons, with the help of a ping sensor and a few calculations. The flow system measures the water flow rate and total water consumption with a flow sensor. The soil watering system using sensor information to water the soil at the optimal time with the use of a water pump.

The sensor system consists of three sensors the first being the temperature and humidity sensor which utilizes a TH02 sensor that can meet measurement needs of general purposes (figure 11). It provides reliable readings when environment humidity condition in between 0-80% RH, and temperature condition in between 0-70°C. It uses I2C instead of analog. The temperature and humidity sensor does not interact with any of the other systems but is still important to know because this can help the user be notified if the system is in an environment that is too humid or not humid enough, same goes for the temperature of the environment. The next sensor is the light sensor, it consists of just a photocell with a resistor. At first we bought a specific light sensor but we could not get it to work so we resorted to a photocell and soldered it onto a pcb. The photocell reads a lumen value ranging from 0 to 1024. The last and most interdependent sensor is the soil moisture sensor (figure 12). The threshold that the soil moisture sensor uses is 0~300 is dry soil, 300~700 is moist/ humid soil, and 700~950 is wet soil.

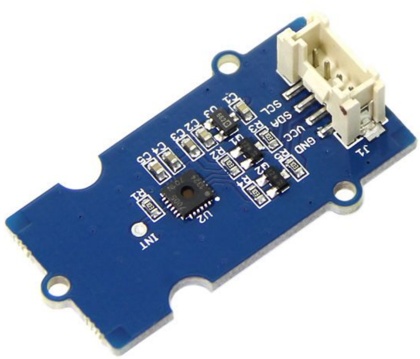

Figure 11: Temperature and Humidity Sensor [11]

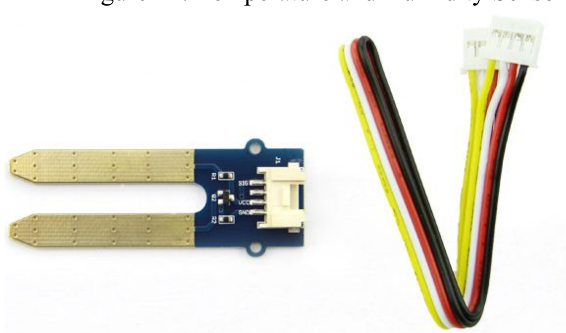

Figure 12: Soil Moisture Sensor [12]

The lighting system consists of a LED grow light panel, mosfet circuit and a photoresistor. The mosfet circuit's purpose is to create a pulse width modulation and be able to dim the light panel. The photosensors reading is what will determine if there is enough light on the plant or if there is not enough and it needs more. There is a total of four different range values for dimming. These values go from 0% which turns off the light, 1-33% turns the light on at that percentage, 34-66% and finally 67- 100% will turn the grow light to full power. The LED grow light consists of red and blue leds. The red LEDs are responsible for making plants flower and are essential to a plant's early life of seeding and growing. The blue LEDs are essential for the plant to have strong, healthy leaves at the later stage in life.

Finally, the Blynk app was the last major component in our IFGS project. The purpose of the app was to get readings from majority of the sensors on your phone. The Blynk app has displaying the temperature, humidity, tank level, soil moisture and the light intensity. The temperature and humidity are very straight forward when it comes to reading the values. From the screenshot below, you can see the temperature was at 77.3 F and the humidity was at 34.0.

Figure 13: IFGS Blynk App [13]

There is also gauges to display the other values of the IFGS. The tank level is measured in gallons, while the soil moisture and light sensor are measured by percentages. What the number means in the moisture reading is the percentage of moist soil that is surrounding the plant. The light sensor indicated the intensity of light the plant is receiving.

IX. DEPLOYABLE PROTOTYPE STATUS

The Intelligent Food Growing System is fully deployable to our standards. Our initial design for the watering system was accomplished. The system has a pump and a tank level sensor both of which function how we intended them to. The water level is recorded and outputs an accurate reading to the user. The pump works with the soil moisture sensor and the two are functional to our expectations. The lighting system dims just as we set out to do at the beginning of semester two. It has a mosfet which allows it to dim. The dimming is based on the light sensor and dims accordingly; if there is too much light around the plant the light will dim or turn off. As mentioned the soil moisture and light sensor work hand in hand with our other feature sets. Our biggest problem sensor, the temperature and humidity reads accurately and is fully functional. The web application too meets our initial goal of functionality. It is clean and easy to use. The only change we set out to make to our garden structure was to accommodate the light panel that we added to reach a greater area for the plants' health. The only two functions we were not able to implement on the Intel Edison was the flow sensor and the LCD screen.

X. DEPLOYABLE PROTOTYPE MARKETABILITY FORECAST

The Intelligent Food Growing System is very close to achieving a marketable prototype level that can be manufactured. The IFGS still needs a few improvements and revision when it comes to hardware and software. Starting with the hardware side of the project, the issues that need to be addressed and refined before releasing it onto manufacturing is the wiring. In our project, the wiring has the right amount of safety features to pass safety regulations, but it can be improved. At the moment, the IFGS has a separate electronic box that is attached to the front of the structure. This electronic box contains all the components that are dangerous if wet. This includes the Intel Edison, power strip, LCD displays and wire connections. Although the electronic box is of good size, all of the electronic components were not able to fit in it.

This brings up another issue of having the water pump relay and flow sensor right under the detachable soil box. Having electronic component that can get wet due to overwatering (which our system won't allow), can cause a major hazard. When researching the market for similar products to ours, we found that a feature that our system lacks is being enclosed. In comparison with the Niwa One[4], which is an enclosed growing system, our system is not enclosed which makes some of the heat from our grow light get lost and never reach the plant. Other than those hardware components, the Intelligent Food Growing System prototype is ready for market.

When it comes to software, there aren't many components that need to be refined to be ready for manufacturing. Most of the software for our components are working properly and are displaying correct readings. The only thing that the Intelligent Food Growing System can improve on and be refined is in the code for the project. At the moment, the code for the project is taking a slightly longer time to upload and run. It is understandable that the system will be running slightly slow due to all the components and feature in the system, but it would be great if the program could run a bit faster and smoother. If these software adjustments were to be done, then the Intelligent Food Growing System deployable prototype would be ready for manufacturing.

XI. CONCLUSION

The intelligent food growing system has developed into a deployable prototype. Our team has worked through many engineering challenges to develop a system that will allow an individual to grow organic produce from their home. We grew and learned the knowledge necessary for successful projects through many assignments. The project timeline structured our pace and the market review guided our business plan. The team used all the knowledge learned to stay true to our societal problem, and develop a functional deployable prototype.

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[13] Morales, E., 2017. *Soil and Plant.*

[14] Morales, E., 2017. *Intel Edison with Grove Shield.*

[15] Morales, E., 2017. *Power Cords.*

[16] Morales, E., 2017. *Water Tank Filled With Water.*

[17]"Grove - Temperature&Humidity Sensor (High-Accuracy & Mini) - Sensor - Seeed Studio", Seeedstudio.com, 2017. [Online]. Available: https://www.seeedstudio.com/Grove-Temperature%2

6Humidity-Sensor-(High-Accuracy-%26-Mini)-p-1921.html. [Accessed: 25- Mar- 2017].
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APPENDIX A. USER MANUAL

(Pg # for appendix start with "Appendix A-1")

The first step to operate the Intelligent Food Growing System is to add soil and seed to the detachable soil box.

Figure 14: Soil and Plant [13]

The following step is to take the Intel Edison microcontroller and connect the Grove Shield that contains all the sensors connected to it, and plug it into the Edisons breakout expansion board.

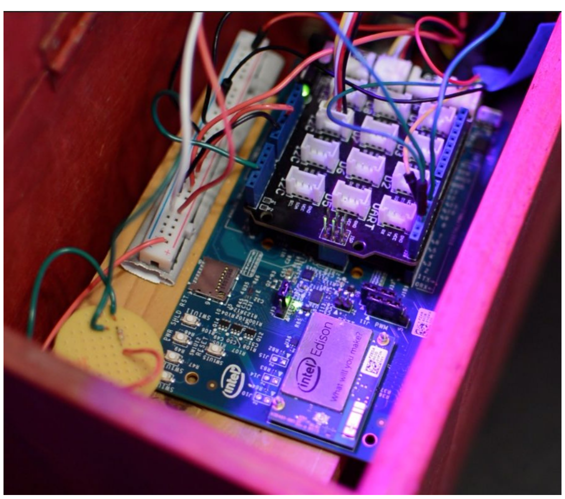


Figure 10: Intel Edison with Grove Shield [14]

The next step is to power up the Edison board with a 5V power cord. The cord is then connected into a power strip that is to be connected to a wall outlet. The water pump cord and light cord are to be connected to the same power strip that the Edison is connected to.

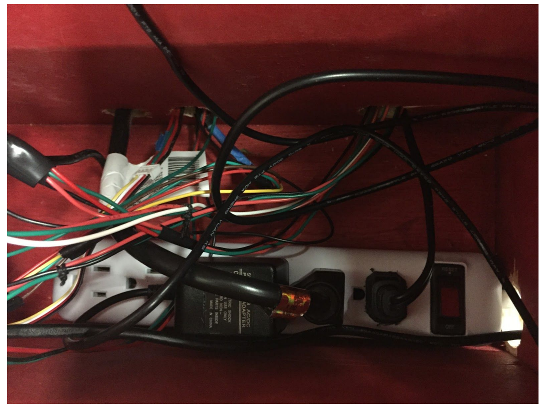


Figure 15: Power Cords [15]

Next, you want to add 2.5 gallons of water into the the water tank while being careful not to get water on the ping sensor.

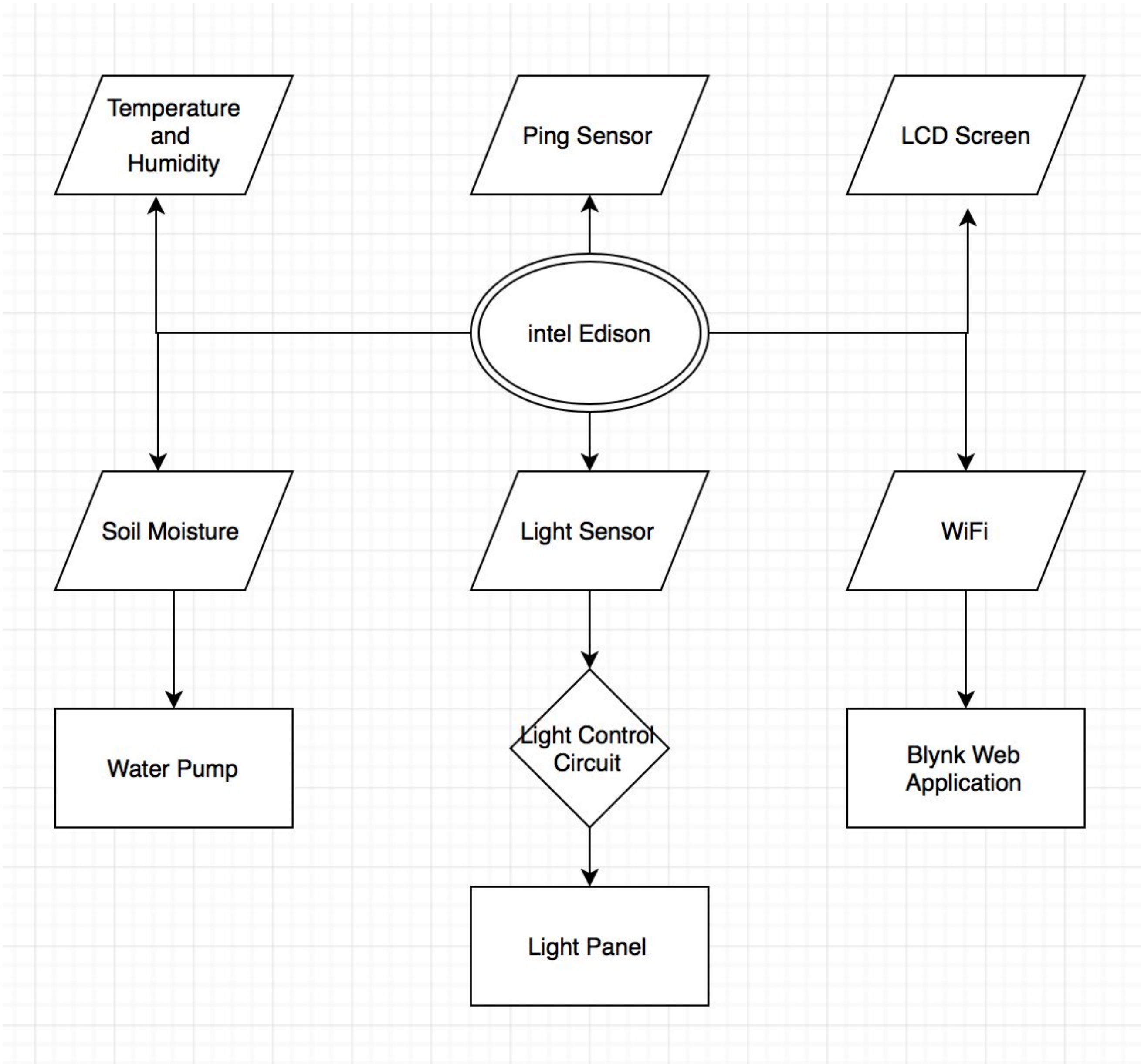
Figure 16: Water Tank Filled With Water[16]

Lastly, log into the Blynk App and select the Intelligent Food Growing System project. Once you have the Edison connected to the wifi, you are set to run the IFGS project in the Blynk app to see all the values for the sensors.

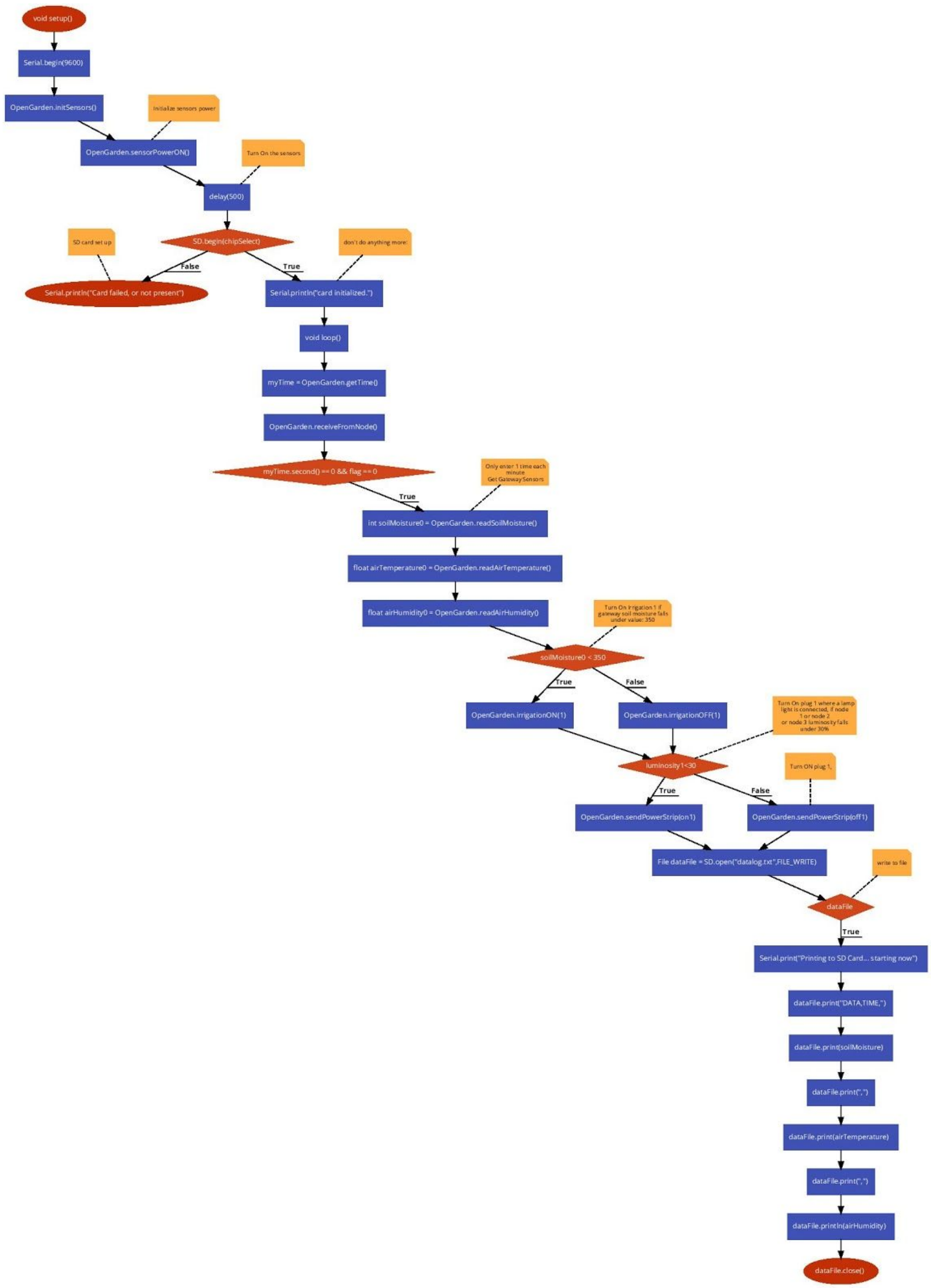
Figure 17: IFGS Blynk App [12]

The final step is to sit back, relax, and see your new Intelligent Food Growing System do all the work of growing your own crops.

APPENDIX B. HARDWARE



APPENDIX C. SOFTWARE



APPENDIX D. RESUMES (team)

- Remove address, emails, phone number from resume
- Page numbers for this appendix start with “Appendix D-1”

www.latinosteam.com/
www.linkedin.com/in/jbmolina93

Jonathan Byron Molina

jbmolina93@gmail.com
Cell: (925) 207- 6233

OBJECTIVE: My experience in software development and technical leadership skills, combined with my eagerness to learn and use new technologies, and my desire for constant improvement can help the organization in terms of both efficiency and profitability.

SUMMARY: User Interface Design / Testing, Debugging and Documentation / User Training and Support / Business logic and Database Design / Full lifecycle Software Development / Online Marketing Collateral/ Client Relations

EDUCATION

In progress: B.S. Computer Engineering, California State University, Sacramento
Expected graduation: May 2017

HONORS AND AWARDS

Star Member, Society of Hispanic Professional Engineers (SHPE) – Fall 2012 - Spring 2015
Minorities in Engineering (NACME) Scholarship, CSUS – 2011 - 2012
Louis Stokes Alliance for Minority Participation (LSAMP) program, 2011 – Present

SKILLS

- **Operating Systems:** UNIX/LINUX, Win 10, Win 8, Win 7
- **Hardware:** SSD Servers
- **Programming languages:** Python, Java, C ++, C, PHP, MySQL, XML, HTML, CSS
- **Software:** Django Web Framework, Eclipse IDE, Visual Studio, Photoshop, MS Office
- **Tools**: Diligent Analog Discovery, Oscilloscope, Function Generator, DMM, Spartan 3E board, Microchip PICKit 3, Parallax Propeller, Raspberry Pi, Wireshark.

PROJECTS

- **Server/Client Chat, *Socket Programming*:** Prepared a server socket to send HTTP header line into socket and sent the content of the requested file to the client.
- **Robotic Hand, Socket *Programming*:** Designed a host and client server using the Intel Edison to communicate wirelessly between the wireless glove and the robotic arm using C++.
- **Automated Launch Pad, *microcontroller*:** Designed a launch pad for the Competitive Robotics Club with the goal to increase student interest and participation in our annual Engineering Expo held at Sacramento State.
- **Customer Login, GUI *Programming*:** Using Java programming language designed a GUI to keep track of customer information by writing to a file and reading the file to display the customer's information on the screen.

WORK EXPERIENCE

Director of IT, Latino STEM Association INC, Sacrament, CA. Summer 2015- Summer 2016
Duties: http://www.latinostem.net/.Responsible for the design, development, and maintenance of web site content for a non-profit organization. Implemented a mobile app to increase the participation from Students. Organized the "Water Challenge" and "Energy audit" workshops for the first Latino STEM Conference at UC Davis.

Vice Regional Representative, Society of Hispanic Professional Engineers Sacramento, CA. Summer 2014-Spring 2015
Duties: Collaborated with five SHPE region one presidents of the central valley for maximum cooperation through the school year.

Outreach Director, Society of Hispanic Professional Engineers, Sacramento, CA. Summer 2013- Spring 2014
Duties: Inspired SHPE members to help spread STEM education to underprivileged youth.
Lead weekly meetings to increase participation in the Outreach Committee.

ACTIVITIES AND ACCOMPLISHMENTS

- **Noche De Ciencias,** Language Academy, Sacramento, CA, Spring 2014 & Charles E. Mack elementary, CA, Fall 2014
  Organized and implemented individual science experiments for 100 students from kindergarten through eighth grade with a budget of $300.
  Collaborated with other clubs and managed a total of 50 college students in presenting science workshops.
- **Intel Ultimate Engineering Experience,** CSUS, Sacramento, CA, Summer 2013
  Developed a game using Java Script, HTML, and CSS that promoted healthy eating habits.
  Tested quad copter to stabilize its movements during flight.
- **Vex Championship,** Orlando, FL, May 2011
  Designed and constructed a robot to perform a competition's required tasks in a team of eight students.
  Raised $8,000 in fund raising events to cover trip costs.

Ezequiel Morales

- **Objective:** To obtain an career/internship in a computer engineering environment

- **Education:** CSU Sacramento, Bachelor of Science; Computer Engineering (Fall 2017)
- **Related Courses:**

Advance Logic Design	Program Concepts and Methodology I & II	Data Structure & Algorithm
Circuit Analysis	Computer Hardware Design	Adv. Computer Organization
Computer Interfacing	MicroComp & Assembly Lng.	Operating System Pragmatics
Signals and Systems	Network Analysis	Machine Vision
Electronics I	Discrete Structures	CMOS & VLSI
Operating System Principles	System Programming in Unix	Computer Network & Internet

Skills and Knowledge:

Bilingual: Fluent speaking/writing in English and Spanish **System:** Windows, x86 Assembly **Programming Language:** Python, C, C++, Linux, Java, HTML, CSS, VHDL, Assembly, Verilog **Software:** JGrasp, Multisim, PSPICE, Basic Matlab. **Hardware:** Oscilloscope, Digital Multimeter, Function Generator. **Other Knowledge:** Ability to anticipate, manage, and troubleshoot problems effectively and efficiently. Great communication skills within teams, Organization and Time oriented skills, Teamwork skills.

Experience/ Work History:

The Coding School: (Spring 2016 - Current)
Working in a team of two, I am teaching students at a Michael J. Castori Elementary School for a span of 6 weeks. The tasks are to teach students how to create their own website. Teaching HTML was the first task for the students to understand, then once they felt comfortable, we started to teach them about CSS and how to give style to their websites.

Intelligent Food Growing System (IFGS): (Spring 2016 - Current)
Working in a team of four, we are developing a growing system that will allow you to grow food without the stress and time consumption of a normal garden. A Intel Edison is being used as the microcontroller to run the lighting, soil, temperature and water sensors. The IFGS adjusts its functions to accommodate any plant you want to grow. A user interface will allows the user to see the progress of the plant. Finally a web application will be create to adjust the components of the system from any place the owner is at.

Operation Innovate (WSUD): (Summer 2016)
I was assigned to be a summer instructor at Westmore Oaks Elementary School. Being one of four instructors, we had to create a weekly curriculum on what to teach the children each week. I was able to teach children about Python, Web Developing, HTML & CSS, Raspberry Pi, and Arduino Uno over the course of five weeks.

Solar Tracker with LCD Display: (Fall 2014)
As a member of a team of two, a solar tracker was to be built with a LCD to display the temperature and light intensity of the solar tracker. The parts we learned to use and implement in the project were servos, Arduinos and photo sensors. An Arduino was programmed with photo sensors to track the sun while displaying the temperature and sun sensitivity on a LCD display. The coding behind the project was written in C and was programmed into the Arduino.

Awards and Accomplishments:

- CSU Sacramento
  - Fall 2012 Deans Honor Roll
  - SHPE Fundraiser & Historian
  - MEP Engr & Computer Science Program
  - Society of Hispanic Professional Engineers
  - School of Engineering and Science Fair Judge

Eloisa Esparza

Education:
California State University, Sacramento
Computer Engineering
Class Level: Senior
Expected Graduation: May, 2017

Qualifications, Skills, and Courses:
- Ability to execute advanced communication skills in both technical and business disciplines
- Programming Languages: Java, C/C++, Verilog, VHDL, basic HTML/CSS and JavaScript
- Applications: Xilinx, NI Multisim, PSpice, jGRASP, Cadence Virtuoso
- Courses in Progress: Senior Design, Computer Network & Internet, Operating System Pragmatic

Experience:
- IntelliBricks, Instructor, September 2016 – Present
  - Rocklin & Antelope Creek Elementary School, Rocklin, California, Fall 2016
    - Teaching kindergarten through third graders about engineering through hands on workshops using Legos
  - Inspire Charter School, Rocklin, California, Spring 2017
    - Teaching 9 to 14 year olds about robotics using Lego Mindstorms
    - Teaching 1st – 4th graders about engineering and programming using Legos
  - Adventure Christian School, Rocklin, California, Spring 2017
    - Teaching 4th – 6th graders about electronics using an Arduino and programming in JavaScript
- The Coding School, Instructor
  - Michael J Castori Elementary School, Sacramento, California, September 2016 – Present
    - Teaching 4th-6th grade students how to code using HTML and CSS
- Envision, Advisor for National Youth Leadership Forum: Engineering & Technology
  - UC Berkley Clark Kerr Campus, Berkeley, California, June – July 2016
    - Taught high school scholars about engineering, technology, and professional development
    - Facilitated 3D Modeling (SketchUp), Video Game Development (Unity), Robotics (Vex), Electronics, Helicopter Workshops (Arduino), and Simulations
    - Lead an Introduction to Electronics seminar
- IUEE, Intel Ultimate Engineering Experience, Internship
  - Double Tree Hotel, Sacramento, California, July – August 2012
    - Developing and building a game application
    - Designing and constructing a prototype of a consumer product
    - Programming and assembling a quadcopter using an Arduino Uno

Community Service:
- Expanding Your Horizons Student Mentor – Single Day Workshop, CSU Sacramento, California
  - October 2015 & 2016
    - Empowered 6th-8th grade girls in water resources and DNA
    - Mentored 6th-8th grade girls in an introduction to robotics and chemistry
- GATE Student Teacher, Harmon Johnson Elementary, February 2014 - May 2014
  - Taught 3rd-6th graders weekly lessons about structural/civil engineering through hands on learning

Extracurricular Activities:
- Society of Hispanic Professional Engineers (SHPE)
- MESA Engineering Program (MEP)

Zachariah Douglas-Allen

OBJECTIVE

Obtain a position as a hardware engineer; this role will allow me to fully utilize my educational background while making use of my communication, organizational, and problem solving skills.

SUMMARY

Ten years of effective leadership skills
Enthusiastic, personable, professional in appearance and manner
Self-motivated individual with a passion for learning

EDUCATION

Bachelor of Science, Electrical Engineering 2014-Present
(Projected completion Spring 2017)
Sacramento State University, Sacramento, CA

Transfer Requirements, Electrical Engineering 2012-2014
Modesto Junior College, Modesto, CA

PROFESSIONAL EXPERIENCE

AppleCare Advisor **2015-2016**
Apple, Inc., Sacramento, CA

- Provided customers with exceptional technical support.
- Ensured that each customer interaction was expedited satisfactorily and in a timely manner.
- Demonstrated outstanding product knowledge

Aircraft Electrical Specialist **2006-2012**
United States Air Force

- Performed electrical maintenance, inspection, repairs, and troubleshooting.
- Executed effective problem solving and decision making skills necessary for success.
- Supervised group operations and led training organizations to ensure personal effectiveness.
- Established leadership and management skills as a shift leader