Trash Talk

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***Abstract* — Waste Management is an essential part of any strong developed society. Although there are numerous ways of handling and maintaining trash, this design strives to increase the sustainability and efficiency of trash management. The concept of our design would allow a network of trashcans to be self-sufficient and be able to wirelessly communicate with each other on the status of their trash level. All of the trashcans would send data and location information to a control system to allow waste management workers to visually see the status of each of the trashcans.**

I. Introduction

Proper trash management can depict the cleanliness and level of comfort patrons can expect to have in their environment. Big cities and big theme parks such as New York City, Chicago, and Disneyworld respectively pay a lot of money on workers and equipment to keep a handle on trash. The way of doing so now in Theme Parks is simply having a person or more designated to a certain zone of the park and aimlessly walking around in that zone repeatedly waiting until the trashcans are close to full.

Emptying of trashcans in big city parks such as New York and Chicago are pretty similar to the Theme park method. In these big popular cities, trash maintenance is implemented with a relatively better system, yet there is still an adequate amount of room for improvement. Park and Recreation services in these cities routinely send workers out to empty trashcans throughout the Parks on a timed schedule constantly whether they're full or not.

This method of trash handling causes the unnecessary use of extra manpower, by having various different workers deployed to locations to visually determine whether or not trashcans need to be emptied. This method also wastes a large amount of gas from the garbage trucks which make a run around the city to pick up trash from the park locations no matter if it is a lot or not. A better method of trash handling would be Eco friendly by reducing the unnecessary driving of the gas garbage trucks as well as labor effective by reducing the amount of unneeded workers. Ultimately, the improved method of managing trash in these big cities would be very beneficial to the city's budget by cutting cost.

Trash Talk strives to make trash management more sustainable and efficient. Trash Talk will implement a wirelessly connected network of trashcans that will send the trash levels and location of each trashcan to a control system. The control system will display the trashcan information in an easy-to-use way to the user. The user then can use the information to make the necessary procedures to a more efficient way of trash management.

II. System Concept

TrashTalk's overall system will consist of five subsystems. The five subsystems are the trash sensor detection system, the GPS location system, the user interface data collection system, the wireless communication system, and the self-sustaining power system.

The microcontroller will receive data from the sensors and the GPS module. It will then combine the data into one packet and send the package through the wireless communication network. The control system will receive data from each trashcan and proceed to organize and store the updated information into the database. When the user accesses the user interface, the user will see the latest updated information of each trashcan.

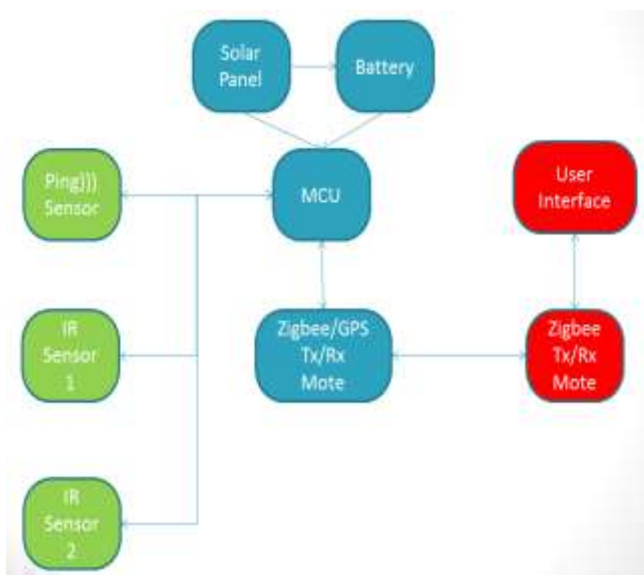

Fig. 1. A block diagram of an overall Trash Talk system.

II. SYSTEM SPECIFICATIONS

The trashcan system is responsible to gather information about the trashcan. The information gathered will determine the status of the trashcan. The trashcan will use sustainable energy. Rechargeable batteries will be used to power the trashcan system. Solar panels will be used to recharge the batteries. The sensors will return data to determine if the trashcan is full or not. Wireless communication will be used to share data collected from the sensors. The user interface is responsible to display the information of the trashcans. Information will include the location, the status, and the time last updated of each trashcan. It will also give the user additional information so that they will know what different entities represent on the map. The user interface will give the user the option to edit the system. The following table shows all of the specifications for both the trashcan system and the user interface system.

Project Specifications	
Hardware specifications	**User interface specifications**
• The system shall use rechargable batteries as the main source of power.	• The system shall be accessed via a website.
• The system shall use solar panels to recharge batteries.	• The system shall display three main components: a map, a map legend, and a status list.
• The system shall will have two sensors to detect trash levels.	• The system shall provide the ability to zoom in and out on the map.
• The system will have three sensors to detect trash levels.	• The system shall provide the user the option to log into the system for more options.
• The system shall use a GPS module to provide the coordinates of the trash cans.	• The system shall list each trashcan along with its identifer number, status, and the last time it was updated.
	• The system shall show the status of each trashcan by color dots representing different statuses.

Table. 1. Table of Trash Talk system specifications.

III. TRASHCANS

The type of trash can that would be the most beneficial to use is a square, plastic trash can for mounting everything but due to a limited budget, steel round trash cans were used that were donated from the Land and Natural Resources (LNR) department at UCF. One of the aspects of this project that we want everyone to understand is that the Trash Talk system is scalable. It can be used on small, indoor trashcans or up to the large 70 gallon trash cans and maybe even more. The planar sensors wires are mated with a female connector that goes into a male connector that comes from the main board. This will allow workers to disconnect the sensors from the lid prior to removal and alleviate the risk of damaging the system. The lid of the trash can for the prototype has not been weather proofed due to limited time and resources. The PING))) sensor is currently located in an enclosure, centered on the lid of the trash can. The planar sensors are mounted on the actual barrel, or rigid can liner, that is located inside of the trash can.

II. SENSORS

The main idea of this design is to provide a system that can detect when the trash can is full with a small focus on being able to identify the level of fullness. The plan is to achieve this by using a system of sensors. There will be a depth measuring sensor and two planar sensors. The depth measuring sensor will placed in the lid and the two planar sensors will be placed at the 100% and 50% levels on the rigid can liner. The type of sensor chosen for the depth measuring sensor is the Parallax Ping))) Ultrasonic sensor and the type of sensor chosen for planar sensor is the Sharp GP2Y0A02YK0F Infrared Sensor.

A. Ultrasonic Sensor

As stated earlier the ping ultrasonic sensor is the choice for the depth measuring sensor. Using an ultrasonic sensor is a better option for the depth sensor because it is not affected by UV rays if placed in an exposed trash can. The sensor was a good choice for this project because it is low-cost and easy method of distance measurement. This sensor is a feasible replacement for infrared sensors and is good for either stationary or moving objects. It uses an ultrasonic pulse as the transmitter and calculates the distance by measuring how long it takes for the pulse to return. One especially notable benefit is that it is easy to interface this sensor with microcontrollers. Some other notable features of this sensor are that it has simple pulse in/pulse out communication, indicator for in progress measurement and a 3-pin header for easy connection. It also has a variable width pulse which would possibly reduce the amount of sensors required for each level of the planar sensors. The PING sensor has a fairly wide field of view of about 20 degrees of visibility on each side.

B. Infrared Sensor

The idea to use an infrared sensor was originally an alternate to the ultrasound for a depth measuring sensor. Since the range of all of the infrared sensors was significantly less than that of the ultrasonic sensors, we decided to use the infrared sensors as the planar sensors. They have the capability of accurately detecting the absence or presence of objects though the analog sensors lack the accuracy to detect exactly how far an object is from it. The digital sensor is by far the most appropriate sensor for this type of application. However, we chose the analog sensors. The reason we chose these sensors instead of the digital is we did not want to overload the digital inputs for the microcontroller and the analog sensors also gave us the opportunity to apply some principles that we learned throughout engineering. Since the output is analog and we chose not to incorporate an analog to digital converter, we had to figure out a way to linearize the output. We used Matlab to input the data and linearize the output.

III. Power Supply System

Each trashcan structure will use a power supply subsystem consisting of a Solar Panel, a PCB (Printed Circuit Board), and AA batteries. The solar panel will be 12 volts and will supply 1 watt of power to the PCB, which will in turn regulate the current and voltage supplied to the batteries, as to avoid damage or overcharging. The main purpose of the solar panel and regulating PCB board is solely to continuously recharge the AA batteries for maximum extended life capability. The design will use 6 AA rechargeable batteries connected in series supplying 9V and 14400mAh. The batteries will directly power the MCU (Microcontroller Unit), which needs an input of 5 volts. The MCU's onboard regulators then supply the necessary volts to the trashcan system components. Figure 2 shows the general setup of the Power subsystem with the output from the batteries leading to the MCU.

A. Battery Selection

The battery selection was a straightforward task in which the appropriate battery would only be selected if its capabilities met necessary standards. The battery must be able to last for a long period of time without easily losing its terminal voltage. It must not contain a poisonous or toxic component that can harm people and the surrounding environment. It must be able to maintain a steady voltage drop while it is depleting. The battery must also have a reasonable amount of rechargeable cycles to insure that the Power subsystem would last for an adequate amount of time before any human interaction. Lastly, the battery should be easily disposable and recyclable. The two batteries that came close to meeting all these preliminary requirements were the Lithium Ion (Li-ion) battery and the Nickel metal Hydride (Ni-MH) battery.

Nickel-Metal Hydride rechargeable batteries are steady voltage batteries, which supply a consistent voltage of 1.2V without a load. With a load the battery drops to about 1.1 volts. The batteries also provide between 800-2700 mAh. The steady voltage rate supplied by the battery allows for consistent system operation with little decline in performance. The NiMH battery has a rechargeable cycle life capability of between 150-500 times before the batteries become unusable. The battery discharges by itself at an average rate of 1% a day. On a monthly scale that self-discharge rate is roughly 35% give or take. The self-discharge rate is the rate in which the battery discharges when not in use. The battery is also capable of performing well in both cold and hot weather and is easily recyclable. NiMH batteries contain no toxic or dangerous elements that would be harmful to humans, animals, or the environment. The NiMH batteries are also easily accessible and relatively cheap when compared to other battery options.

Lithium-ion rechargeable batteries provide an average terminal voltage of about 1.5V and provides between 1900-2900 mAh. The Lithium ion battery's best usage is for everyday electronics that are constantly being used; various electronics such as laptops, cameras, camcorders and etc. The Lithium-ion battery's rechargeable cycle life is between 500 and 1000 times. The battery has a very low self-discharge rate. It's self-discharge is so small compared to other batteries that it is not necessary to take into consideration. Although the self-discharge rate is low, the batteries overall capabilities diminish as time goes on. The Lithium-ion battery is notoriously known for easily losing its overall lifespan as time goes on. One main contributing factor to the short lifespan is long period of times in which the battery is not being used. Additionally, as time goes on and the battery is not constantly being used, the more the terminal voltage permanently decreases. The battery is most capable when constantly being utilized. Lastly, although the batteries are easily accessible, Li-ion batteries are among the more expensive battery options.

Between the top two batteries listed, NiMH batteries prevailed as being more suitable for usage in the power supply subsystem. Both batteries displayed the main capabilities deemed necessary for the project design, but the NiMH had fewer disadvantages, which were easy to overlook. The NiMH seemed more stable because although it had a large discharge rate compared to the Li-ion battery, it was consistent with its capabilities and did not easily diminish over time. The Li-ion batteries were too unpredictable. Also the Li-ion batteries are mainly used in everyday electronics, which require constant use. The project design would not constantly be used, which is bad for the Li-ion battery. Without constant use, its capabilities began to diminish drastically. After long periods of time with subtle usage, the Li-ion battery begins to lose its terminal voltage and in turn becomes ineffective. As for the NiMH batteries, although their self-discharge rate is extremely high compared to the Li-ion batteries, the batteries are able to maintain their standard capability even after long periods of time and do not lose its terminal voltage. The batteries are more predictable and controlled. As far as price and accessibility, the NiMH batteries were just as accessible as the Li-ion batteries for a lower price. All of these compiled facts lead to the selection of the NiMH battery over the Li-ion battery.

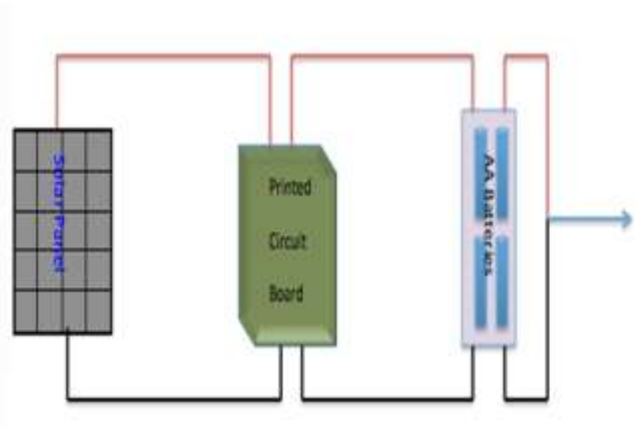

Fig. 2 A block diagram of the power supply system.

B. Printed Circuit Board

The automatic charger printed circuited board has become a component that would greatly benefit the projects overall design. The circuit board is essential because it would extend the power systems overall lifespan by continuously monitoring the status of the batteries and then taking the necessary actions thereafter. The automatic battery charger circuit would be able to determine if the batteries onboard need to be charged or if they should be left alone. More specifically, the automatic charger circuit will continuously check if the batteries are within a certain voltage range. If the batteries terminal voltage were above the set voltage range the circuit would then stop the supply of current being distributed to them. If the batteries terminal voltage were below the set voltage range, the circuit would then at that point allow the input current from the solar panel to supply them. The design idea for the circuit came from extensive research. The selection of the board design was between two favored researched designs.

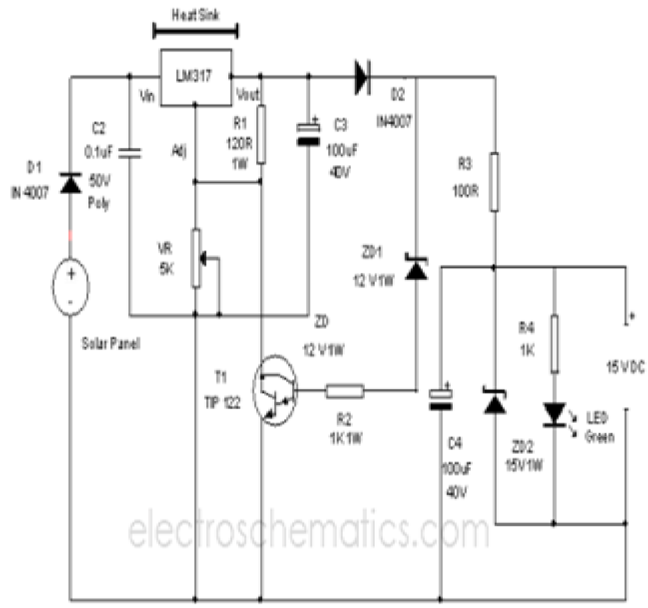

Fig. 3 Inverter battery charger.

The first circuit design, which sparked an interest with the group, was an inverter battery charger, which utilized input current from a solar panel. The design was courtesy of Electroschematics.com posted by P. Marian. Figure 3 displays the inverter battery charger with the ability to stop charging when the ideal terminal voltage is obtained. The schematic displayed shows a circuit capable of supplying a steady 16 volt supply with variable current ranging between 250mA to 300mA. A smaller voltage supply can be implemented into the design. The current can ultimately be altered and controlled by switching the resistor values of R1 and R3. When the solar panel is charged, the current then passes through diode D1 that become forward bias. In the forward bias mode, the current is then inputted into the regulator. The regulator can be adjusted to supply a specified amount of current. The current output from the regulator then passes through diode D2 and resistor R3. That same current then passes from diode R3 and enters zener diode ZD2 that conducts and then allows the current to begin charging the battery. In the case of the power subsystem design, the current would charge the batteries that would be connected in series.

The second circuit design, which sparked an interest with the project designers, was a design found that also utilized a solar panel. The design was courtesy of Electroschematics.com posted by P. Marian. Figure 4 displays the solar panel automatic charger with current regulation and automatic cutoff. The schematic displayed as is with the component values listed is capable of charging a 6 Volt 4600mAh battery by using a 12 Volt solar panel and a variable voltage regulator to easily adjust the output voltage and current. The variable voltage regulator being used is an IC LM 317. The high voltage being supplied from the solar panel ensures that the system will continuously charge the batteries with a sufficient amount of voltage and current. The voltage regulator is strategically placed between the adjust pin and ground to supply the output voltage to the battery. Resistor R3 restricts the charge current going to the battery while diode D2 prevents current from discharging from the battery once charged. Additionally transistor T1 and zener diode ZD act as a cutoff switch when the batteries reach maximum terminal voltage. As said also, the uniqueness of this design is its capability to cutoff automatically when the battery is fully charged. Also the design is unique because the user has the ability to adjust the current to the desired level suitable for specific batteries. This option allows the automatic charger to be nearly universal for all batteries since different batteries require different amounts of current to adequately charge.

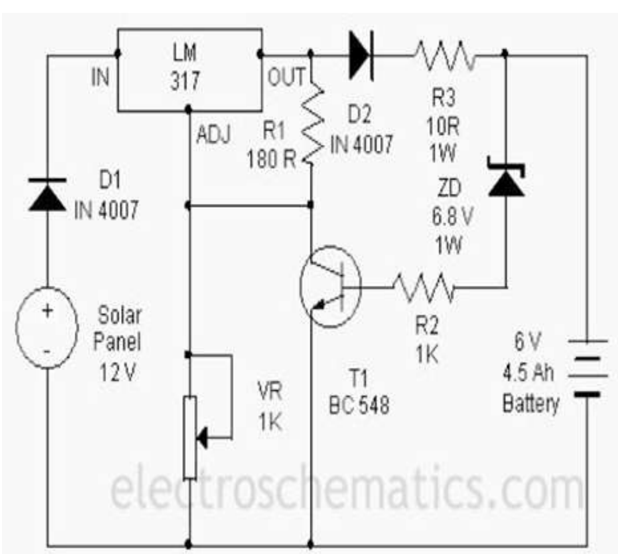

Fig. 4. Solar panel charger.

Between both designs, circuit design number two was a better selection to complement the overall power supply subsystem. Circuit design number two was simplistic and did the same thing as circuit design number one, with fewer components. Using fewer components ultimately correlates to being more cost effective. Both circuits regulate the inputted voltage and supply the necessary current to charge the batteries.

III. GPS

The GPS chosen for the design was a parallax 648. The power requirements for the GPS are 3.3-5V, the Parallax GPS has a built in rechargeable battery for memory and RTC (Real Time Clock) backup and is capable of 20 parallel satellite tracking channels. This feature is very useful for updating the location of the trash node with great accuracy in a mobile application of Trash Talk. The data from the GPS is used to overlay the location of the trashcan on a map. The low power consumption of the Parallax GPS makes it an ideal choice for the design; this feature allows it to maintain its self-sustainable, self-sufficient feature. A few other GPS devices were looked at, but none brought the cost benefit along with reliability factor that the Parallax 648 brought with it.

III. Wireless Communication

Each trashcan will have a wireless module which allows the sensor and GPS data to be sent wirelessly to the control system. Compared to a wired network, it will eliminate the chaos of having wires running all over the monitored area.

The network will be implemented by a self-healing, self-organizing network. The range of the network is variable. The multi-hop routing protocol handles multi-protocol logic. It has the ability to allocate ID's and retransmit packages if they get lost. It avoids package collision by listening on the channel before sending and including wait states if the channel is busy. This makes the system very reliable, in that, the package will continue to be resent until it is acknowledged by another node within the network.

All trashcan data will be sent to the control system. No matter how far the trashcan network range is, the data will be sent to the control system as long as one trashcan in the network is in range with the control system. This is possible when each trashcan node is within range of at least one other trashcan node.

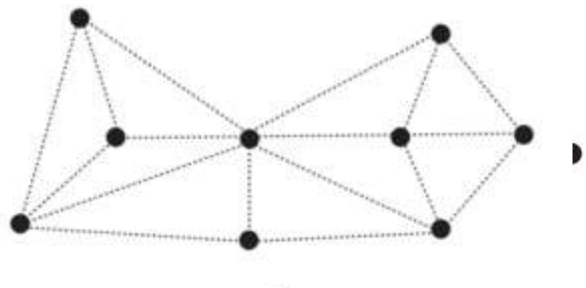

Fig. 6. A visual of a mesh network.

The network will utilize the DigiMesh protocol. It is a high level communication protocol that uses small, low power digital radios to transmit data. DigiMesh utilizes intermediate or closer nodes in order to communicate to the ones further away from the system. The DigiMesh protocol allows the system to be self-sustainable, self-reliant and very little power to operate in the transmission mode. There is only one type of node for the DigiMesh network. This gives the network more flexibility to expand the network. All the nodes can route data and is interchangeable. If one node is unable to connect within the communication network, the network will still be stable as long as all each node is within range to communicate with another node.

DigiMesh has a data transmission rate of 250 Kbits/s; this specification of the system is best suited for intermittent or periodic data transmission from a sensor or other input device. At a predetermined time set by the system administrator or system operator, the trash level will be checked and this information passed on the main wireless module where the data is processed which intern is used to update the webpage with the trashcans overlaid on the map of the area where the trashcans are located.

The wireless network will be implemented by XBee DigiMesh 2.4 OEM RF Modules. Each XBee module will be given a unique ID number to represent a trashcan and all trashcans in one monitored area will be set on the same network.

III. Microcontroller

For the microcontroller we used an Atmega328 for this project, it is a high performance, low power 8-bit microcontroller. We were also considering using TI's MSP430 line of low power microcontrollers as the microcontroller of choice for this design. There were a few drawbacks with the MSP430 that steered us away from the MSP430 and more toward the Atmega. One of them being that the microcontroller had to be programmed in MSP430 assembly language, which the design team had very little experience with, and not as easy to configure as the C-based language of the Atmega line of processors. We went with the Atmega 328p instead because there were a lot more resources available to help us in configuring the setup and manipulating libraries to fit the need of the design. We considered 16-bit and 32-bit microcontrollers because those would be able compute a lot faster than the 8-bit, but those would also drain a lot power from the batteries unnecessarily putting added strain on the power system recharging the batteries and ultimately the system as a whole. The 8-bit microcontroller was ideal for our design in that it does not require a lot of power and would reduce the number of recharges the batteries go through over a certain time period. These features made the Atmega an excellent choice for the microcontroller in our design. The microcontroller is essentially the brain of each trash node. It gathers the data from each of the sensors within its network, then packets the data and passes it on to the next node through the XBee wireless communicator. The ability of the Atmega328p to be powered by 5V rechargeable batteries allows the system to be truly self-sustaining, self-reliable network that utilizes renewable energy provided by the solar panel.

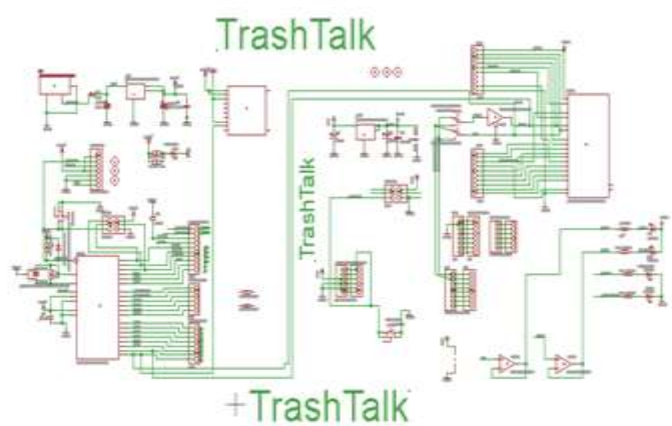

Fig. 7. Design of Trash Talk printed circuit board.

Other boards that were considered for the design to achieve the desired results included TI Launchpad developmental board, which uses the MSP430. Xilinx FPGA boards which utilize Vertex microcontroller were also considered as viable choices for the design of Trash Talk. Manipulating the Arduino design made the most practical sense because we were already using one to do initial testing and prototyping. The Arduino also brought flexibility and the ability to expand the design further as two additional benefits that were taken into consideration when choosing a board design to reference for Trash Talk's PCB design.

A. Design

The Trash Talk PCB was designed based off the Arduino Uno design. The Arduino Uno was modified by eliminating the second microcontroller and the USB half of the Uno; this change made the unit no longer capable of communicating via USB, instead a wireless communication module was added instead. Both parts were integrated into one board. A GPS unit for updating the position of the wireless node was added to the design as well. These changes make the PCB design very unique Trash Talk.

VI. USER INTERFACE

The user interface for the user should be user-friendly, simple, and easy to read. Also, there should be enough information for the user to know exactly what is being presented to them and do not need special or extensive training on the user controls. The user interface will be implemented on as a website.

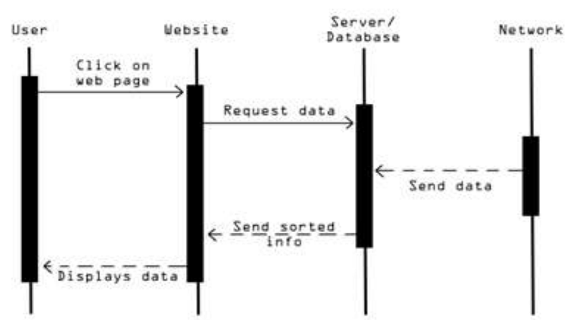

Fig. 8. Sequence diagram of the process between the control system and the user interface (website).

A. Control System

The process behind the user interface will analyze and sort the received data from the wireless networks and then display the desired information to the user. The data that is received by the wireless module connected to the control system will be directly read from the serial port. That data will then be sorted so that it can be saved into the database without difficulties. The website could be used by multiple users, the home display does not require log in credentials.

B. Home Page

The home page display will be made up of four components: a map, a status table, the map legend, and links to other pages.

The map is the main focus on the display, because it will show exactly where each trashcan is located. It is where the user will look to quickly and efficiently locate each trashcan. If the location of the trashcan is changed, it would be easier to see where the new location is rather than to just describe it. The user will be able to zoom in and out on the map displayed.

Markers will be added to the map to represent the trashcans that will be monitored. Markers will be added by longitude and latitude on the map. The longitude and latitude is received through the wireless network from the GPS module. Google Maps offers a detailed map of the desired location, which includes sidewalks. To be able to efficiently display outside trashcans on the map, it will be ideal to show where they are located relative to the sidewalks.

Customized markers will be used on the map to display the status of each of the trashcans. There will be three different colored markers to represent the trashcans on the map shown. The red colored marker represents that the trashcan is full. The green colored marker represents that the trashcan is 50% full or less. The yellow colored marker represents that the trashcan needs maintenance. Maintenance can include corrupt data that was received and no response from the node, but is not limited to these events. A map legend will be displayed next to the map on the website. The purpose of the legend is to reinsure that the user knows what each colored marker on the map represents.

C. Login Credentials

If user clicks on the "Home" page link and the user is already on the page, the page would just refresh. When the user clicks on "Login", the user will be taken to another page. The user will be asked to enter a username and password to access the administrative page. The user will only be asked to log in once during a web session. A web session is closed out when the user closes the web browser.

Once the user is logged in, the links on the top of the page will change. The user will have the permissions allow the user to add or remove a trashcan. When the user wants to add a trashcan, the user will click the "Add Trashcan" button. A popup will appear asking the user to enter an ID number for that trashcan. The trashcan will appear on the map once the wireless network updates the location of the trashcan. Removing a trashcan has the same procedures as adding a trashcan. The removal of the trashcan on the map will be reflected immediately.

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THE ENGINEERS

Errol Bozel will graduate from the University of Central Florida with a Bachelor of Science in Electrical Engineering in May 2013. Errol plans to earn a few years industry experience before embarking on graduate studies.

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Paula Nguyen will be graduating the University of Central Florida in May of 2013 with her Bachelors of Science in Computer Engineering. She is currently working as a Software Engineer intern for Cubic Defense Simulations. Paula's career goals are to grow into a position with higher responsibilities and to oversee the design and implementation processes for projects.

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