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April 8, 2004

Lucky One
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RE: ENSC 440 Project Lord of the Seeds Post Mortem

Dear Mr. One,

The attached document, Post Mortem of Lord of the Seeds (LOTS), overviews the current status, budget, timeline, and, future improvements of our project. This document also includes personal comments on the project by each of our team

Poseidon Microsystems was formed by 5 engineering students of Simon Fraser University in January 2004: Abdul-Haseeb Ma, Yvonne Lai, Carson Leung, Stella Li and Takaya Ueda.

Please feel free to contact us if you have any questions, comments or concerns. We can be reached by email at poseidon-microsys@sfu.ca or by cell phone at 604-726-5989.

Sincerely,

Abdul Haseeb Ma

Abdul Haseeb Ma
CEO and President
Poseidon Microsystems

Enclosure: Post Mortem for the Lord of the Seeds

Poseidon

Microsystems

Post Mortem for Lord of the Seeds

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Submitted to:

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School of Engineering Science
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Glossary

AC	Alternating Current
ACK	Acknowledge Packet
A/D	Analog to digital conversion
EC	Electro-Conductivity: ion concentration in liquid; measured in μSiemens/cm^3
FSK	Frequency Shifting Key
GUI	Graphical User Interface
ISM	Industrial, Scientific and Medical equipment
LED	Light Emitting Diode
LOTS	Lord of the Seeds: our product, plant monitoring system for hydroponics
NAK	Not Acknowledge Packet
NRZ	No Return Zero
pH	potential of Hydrogen
RF	Radio Frequency
RS232	Serial communication connection
SIMO	Slave In Master Out
SOMI	Slave Out Master In
SPI	Serial Peripheral Interface
TC	Temperature Compensation
TDMA	Time Division Multiple Access
TI	Texas Instruments

1 Introduction

Lord of the Seeds is an automated hydroponics control system for home growers and hobbyists. The system will enhance plant growth by monitoring and controlling the temperature, pH and nutrient level of the solution. The information of air temperature and humidity data are collected through sensing devices and logged into our GUI software for a convenient history resource.

The overall system configuration is shown below in

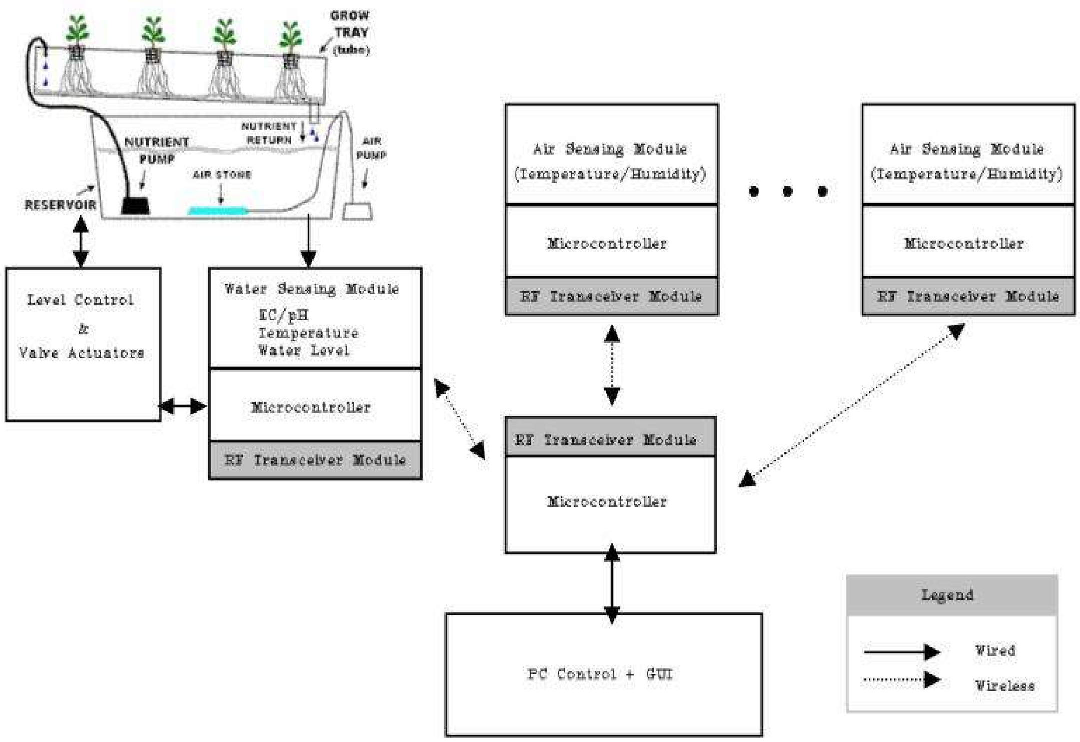


Figure 1: System Overview

Over the past 13 weeks, our team has been working hard to create the hydroponics control system. We faced many difficulties and long hours to make this project work. At the end, we have succeeded in creating a product that we are satisfied with.

2 Current Status of the Product

Currently, the product is in its prototype stage. There is plenty of room for improvements, but we were able incorporate most of the functionalities outlined in the *Functional Specification* document. The following sections will outline the current status of the individual parts of the product.

2.1 RF System

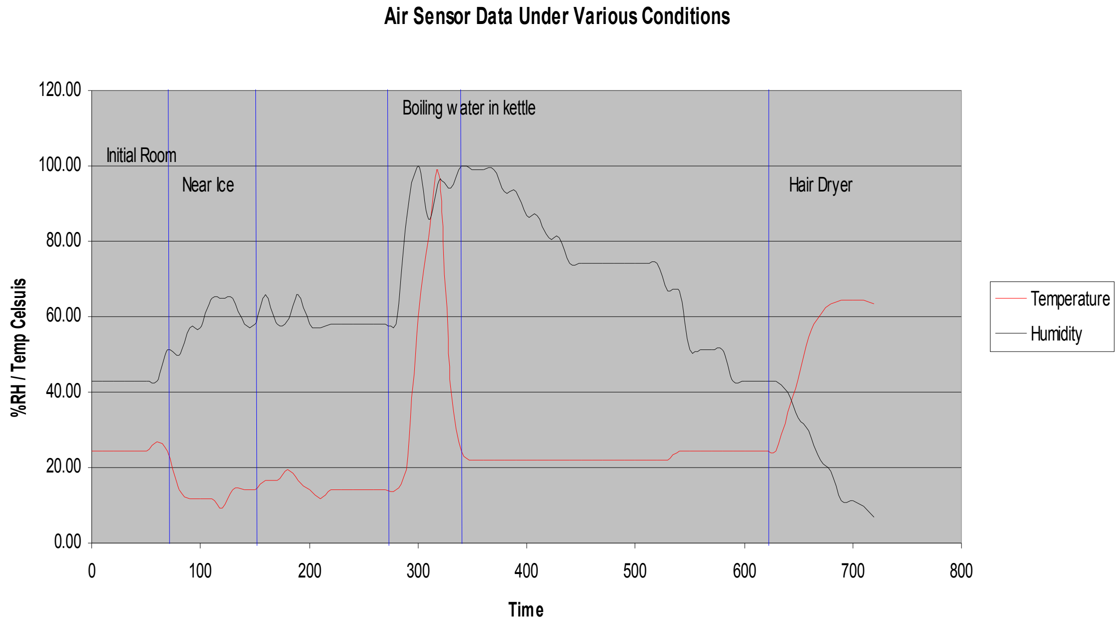
The RF system is complete according to the specification of the *Function Specification* document. Verification testing have shown maximum operating range between two RF modules to be approximately 17.7m after the internal PCB antenna has been replaced with an external quarter wave antenna. This range is verified when two modules are operating within line of sight and with full battery power. Physical interference and radio interference can reduce operating range dramatically. According to the RF chip TRF6901 specification, theoretical maximum data transfer rate is 38400bps. Actual implementation, however, has shown that maximum data rate is approximately 5250bps. The major source of this data rate discrepency is the amount of code overhead needed to operate the RF chip from the MSP430 microcontroller.

2.2 Liquid Measurements

At the completion of the LOTS project the liquid module was in working order though accuracy can be improved. The liquid module consists of the pH, conductivity, and water temperature sensors. Signal amplification was required which entailed a development of driver circuitry. After the amplification stage, analog to digital conversion was required. Currently, our pH meter has an accuracy of roughly 0.5 pH at 0.1 resolution. Meanwhile, the conductivity meter's accuracy is unknown due limited resources. The temperature meter's accuracy must be improved upon for future considerations with a value of 5 degree Celsius.

2.3 Air Measurements

Two air sensor modules are developed in this project. Both modules functioned to specifications. Particularly, the temperature sensor is verified to function within 0-40 °C with an accuracy of ± °1C and the humidity sensor functions from 0% to 100% RH. Experiments are performed to verify its accuracy and range. Various conditions are impacted on these sensors and log files from the PC are saved and the following graph is obtained.



The time scale is every 10 seconds. The performance of these sensors worked to our satisfaction. Measurement takes no longer than 62ms and acknowledgement of a command takes no longer than 380ms. Overall, these sensors worked very well for our project.

2.4 GUI

Currently, the GUI has all the features listed in the proposed functional specification, although some of the features that were proposed for certain menus, such as the menu selection option in the Options menu, were moved to another menu. Extra features, such as specifying the water reservoir level and the pH and concentration of the solutions we dispense into the reservoir with our control system, were added in hindsight when we realized that those values will change for each user.

Menu selection of GUI is located at the top of the display window, along with the date, time, com port and data log file location.

The GUI requests data from the central module every 30 seconds and controls the pH and or EC every 5 cycles. The GUI waits for the 30 second interval, then requests data from the central module. After the received data is processed, the GUI checks if pH control is requested and required. If so, then the GUI will calculated the time required for the valves to open and sends the valve address and time to the central unit. The GUI will check if the EC control is requested and required. If so, the GUI will once again calculate the time required for the EC solution valve to be open and send the EC valve address along with the time to the central module. After the EC control step is done, the GUI waits until the next 30 second interval before executing the code again.

All received data is processed and all invalid data is zeroed. This unfortunately causes the GUI to display invalid data which disrupts the graphing feature of the GUI. A function was written in hopes to hold the previous data value if the incoming data is invalid, but the function was not working to specifications at the time of the presentation.

The numerical displays of the GUI are calibrated to increment by the accuracy levels given by the sensors, mostly to one decimal place. However, the graphs provide a higher accuracy (2 decimal places) than our specification.

At the beginning of every execution of the program, the options menu updates the respective values. However, if the option menu is not the menu displayed during that time, the values are not updated.

2.5 pH and EC Control

The pH and EC are controlled by the solenoid valve connected through a relay to the liquid module as shown in the figure below.

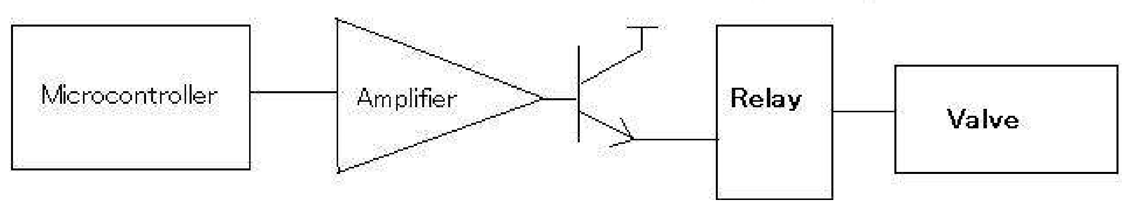


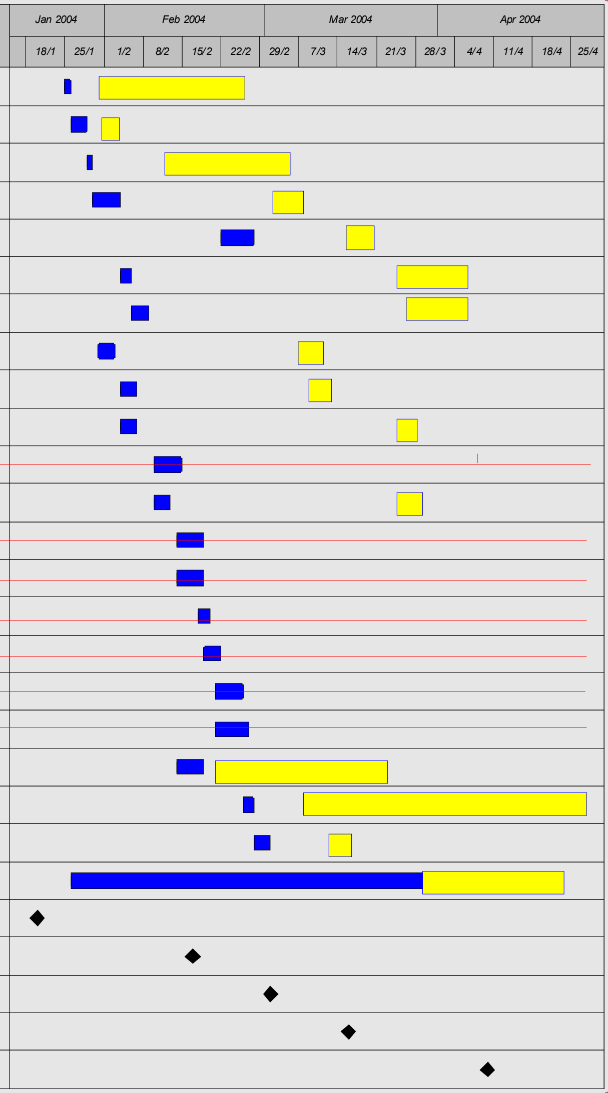
Figure 2: Valve Configuration

In our current version, the PC sends a command to open the valves for certain interval. The pH and EC control systems work in terms of dispensing the solutions when they are prompted by the PC through wireless communication. However through experiments, we found that the pH and EC control do not result in correct pH and EC values. One of the reasons is that the concentration of the dispensed liquid directly affects the accuracy. Highly concentrated solution will result in shorter dispense time but at the same time it will increase the margin for errors. Another problem was that the control calculation highly depends on the dispense rate of the valves. We found out that the dispense rate fluctuates a lot; thus resulting in inaccurate control of the EC and pH levels.

3 Timeline

The timeline of our project is shown on the Gantt Chart below. Our actual schedule compared to the planned timeline is delayed and tasks took longer than we thought it would be. Furthermore, certain planned tasks are cancelled since we have come up with more convenient solutions. For example, instead of building our own RF circuit, we purchased evaluation kits.

ID	Task Name	Start	Finish
1	P1-Shopping	25/01/2004	25/01/2004
2	P2-Build Plant System	26/01/2004	28/01/2004
3	P3-Build Nutrient/pH System	29/01/2004	29/01/2004
4	S1-System Communication Layout	30/01/2004	03/02/2004
5	H-Air Sensors	22/02/2004	27/02/2004
6	H1-pH to Microcontroller Interface	04/02/2004	05/02/2004
7	H2-EC to Microcontroller Interface	06/02/2004	08/02/2004
8	RF1- RF Communication Protocol	31/01/2004	02/02/2004
9	RF2-RF to Microcontroller Interface (Plant)	04/02/2004	06/02/2004
10	H3- RF Module to Microcontroller Interface (PC side)	04/02/2004	06/02/2004
~~11~~	~~RF3- RF Circuit Building~~	~~10/02/2004~~	~~14/02/2004~~
12	H4-PC to Microcontroller Interface	10/02/2004	12/02/2004
~~13~~	~~HI1- PC side PCB Layout~~	~~14/02/2004~~	~~18/02/2004~~
~~14~~	~~HI2-Plant side PCB Layout~~	~~14/02/2004~~	~~18/02/2004~~
~~15~~	~~HI3-PCB Verification~~	~~18/02/2004~~	~~19/02/2004~~
~~16~~	~~HI4-PCB Assembly~~	~~19/02/2004~~	~~21/02/2004~~
~~17~~	~~HI5-PC side PCB Testing~~	~~21/02/2004~~	~~25/02/2004~~
~~18~~	~~HI6- Plant side PCB Testing~~	~~21/02/2004~~	~~26/02/2004~~
19	RF4- Receiver Driver Programming	14/02/2004	18/02/2004
20	H5- Microcontroller Valve Control	26/02/2004	27/02/2004
21	H6- Power Regulator	28/02/2004	01/03/2004
22	S1-Interface Program	26/01/2004	30/03/2004
23	***Proposal***	20/01/2004	20/01/2004
24	***Functional Specification***	17/02/2004	17/02/2004
25	***Design Specification***	02/03/2004	02/03/2004
26	***Oral Progress Report***	16/03/2004	16/03/2004
27	***Group Presentatin& Post Mortem***	10/04/2004	10/04/2004



As can be seen, the time intended for each task took a much greater amount of time to complete. Also, component shopping time and delivery exceeded what was expected and hence pushed all development back. For next time, it is advisable to get all shopping done as early as possible, leaving time for integration and testing.

4 Budget

The table below compares our actual expenditure and proposed budget for our project.
(All units are in Canadian dollars)

Resource/Parts	Initial Estimated Cost (January 21)	Final Cost (April 7)
pH Sensor	75	Combined cost of: 395
EC Sensor	75	
Microcontroller Modules (2)	450	Combined cost of: 515
RF Modules (2)	350	
Hydroponic System	100	40
Nutrient/pH control system	100	233
Air humidity and temperature sensors	(not included)	70
SUBTOTAL	**1150**	**1253**
20% Contingency Fund	230	(n/a)
TOTAL	**1380**	**1253**

Although the amount and the type of resources we have purchased were not identical to what we have initially estimated, the total cost remains close to what we have expected.

5 Future Plans

The following sections outlines the possible future improvements that we can make to the LOTS system.

5.1 RF System

While the RF system has complied to the *Functional Specification*, further improvement can be achieved by increaing RF transmission power to improve interference resistance. Also, higher data transfer rate can be achieved by increasing the speed of the MSP430 microcontroller. Currently, the microcontroller runs at a clock speed of 1MHz, but the microcontroller can potentially go up to an operating clock speed of 20MHz.

5.2 Liquid Measurements

Further testing of the probes are warranted and greater accuracy for all sensors are required. Control of the LOTS system will prove to be more painless with accurate, precise and fast monitoring instruments.

5.3 Air Measurements

In the future, a more durable and enclosed casing is needed for the air modules to protect them from environmental and physical damages.

5.4 GUI

Future plans for the GUI include data holding for invalid data, graph precision that matches the specified sensor precision and instantaneous options menu values update.

Changing the current tab display to pop-up windows is also desired so one can see multiple menus at a time.

Another feature that could be streamlined is the data acquisition and pH/EC control feature. This feature was shown during the demo as the wait loop was removed from the program. However, whether the RF modules can handle that frequency of data requests was not known. The inability to handle that frequency of data may have caused the modules to reply with invalid data.

5.5 pH and EC Control

One of great problems with the current pH and EC control is that the dispense rate is not accurate. However, according to our TA, Nakul Verma, the control circuitry can be improved significantly to enhance the accuracy of the valves. This option will enable us to improve the LOTS system without significantly altering the entire system.

Another option is to add a mixer or a mechanical device to agitate the reservoir. By doing so we can control the pH and EC by simply monitoring the pH and EC level changes as the solutions are dispensed.

6 Personal Comments

6.1 Abdul Haseeb Ma

Besides working on the RF system, I am also responsible for integration of the project. My major contribution involve programming the microcontroller to suit the needs of my team members, as well as help troubleshoot various programming problems that have arised. Although programming is my strong point, yet I have encountered many challenging problems during the progress of the project. I have learned from my mistakes and have learned from my team members' mistakes. If I am to work on a project of this scope again, however, I would like to work on more hardware- and circuit building-oriented work and improve my skills in tha area.

Overall I am satisfied with the project, although if we have given it an earlier start then we can produce a better and complete product. Too much time has been spent on the planning phase, and also for the few weeks when we have our own respective midterms, no practical work has been done. If our team have identified the goal as well as the full scope of the project earlier, then the project experience will be more enjoyable.

Team dynamics worked out quite well too. Many warnings have been given to us before the course started saying that we might end up “hating” our team members. However, we worked as a whole from beginning to end and have not encountered any team problems. We were quite supportive of each other and have always maintained a light and enjoyable working atmosphere.

6.2 Yvonne Lai

My feelings from working on this term project with my team members are a memorable and enjoyable experience. Everyone in my group worked hard and no arguments occurred even in the toughest times. Each member participated actively in various aspects of the project and is rarely late for team meetings. A strong advantage of our group is that each individual has their own expertise. When a problem occurs, everyone is very willing to pull resources together to solve the problem. Throughout this term, I learned a lot about my group members and realized the importance of having true team spirit.

Our hydroponics system is a very involved project with many components to integrate. I learned a great deal about time and budget management for a large-scale project. From working on this project, I did a lot of self-learning: on sensors, driver circuits, control and the techniques of hydroponics. I was primarily responsible for the air sensor modules. During the course of the project, I helped out on various aspects of the project when team members needed help, bought parts, performed researches and contacted outside resources. I tried to keep everybody together, organized parts and to keep my group focused.

Overall, I found the project to be a rewarding experience. I am happy to have worked and overcame so many challenges with these four talented individuals. I have no regrets on choosing this project and forming this team.

6.3 Carson Leung

In short my contributions are mainly directed to the completion of the liquid module for liquid pH, EC and temperature monitoring. I had the chance to work with three different kinds of sensors; ordering them, testing them, throwing them across the room and finally, calibrating them. I was also in charge of building the driver circuitry for these sensors with help from various other group members and Nakul. Also, I did the logo that you see on top of every page of this document.

The project taught me a few lessons. From the ordering process to soldering on the driver circuit on the perf board, I found that is was a valuable experience overall. I was warned that integration would be the toughest part of the project, and it truly was. Leaving things undone and trusting something to work when you haven't had actual test data going into the final week of school and be the bottleneck of the group doesn't mean you will fail the course; No, it just means that you won't be sleeping for the rest of the week.

6.4 Stella Li

For this project, I was responsible for making the GUI since I had the most experience using LabVIEW. The downside of writing a GUI is that no testing can really be done until the hardware works since the GUI interfaces the user to the hardware. This resulted in long periods in the lab where I just sat and waited for the hardware to work so that I could check if the GUI worked. Thus, the intricacies of the GUI operation were not known until the hardware was integrated into the system. Because we did not foresee the hardware problems we would encounter, most of the GUI debugging occurred during the last few days and nights before the project was due.

Even though I was responsible for the GUI, my previous experience in hardware, manufacturing and troubleshooting were quite beneficial. I was known as the soldering guru of the group since most of the soldering was either done by me or fixed by me. All the little tips and parts I picked up during my years at BCIT and on co-op proved to be quite useful in our time of need. And the long standing fact that integration will take the most amount of time still holds true.

Regardless of all the sleepless nights spent at the lab, this project was memorable. The time spent with my group members doing work, not doing work, doing bubble tea runs, playing GBA, etc., will be times I will remember. I still wish our total schedule was pushed back a few weeks so that the GUI would have been in better shape, but we can't change the past. It was still fun.

6.5 Takaya Ueda

For the LOTS system, I was responsible for making the pH and EC control system using liquid valves. I spent significant amount of time trying to find the parts that I can use without spending a fortune. Other than finding viable parts, the most difficulty I had was making my circuit conform with the other parts of the system so it can be integrated. Even though circuit for the valve control was simple, but I found out that it is far from perfect. After the demonstration, I was advised by Nakul that the circuit can be improved significantly to increase the accuracy of the control logic.

When I look back to the 13 weeks of this project, even though there where long endless nights work, I think this was an enjoyable experience. At the end, I am satisfied with the result of the project.

7 Conclusion

Although the Lord of the Seeds project came to a close without achieving all of the proposed specification, we at Poseidon Microsystems are mostly satisfied with the end result. Several possible improvements have been taken note of towards the end of the project, and we are confident that we can tackle such a challenge again.

Time is any project's greatest enemy, and there is no exception to Lord of the Seeds. Most of the team members feel that if we could have concentrate on the project without interference from other courses, then we can definitely produce a superior product.

