April 20th, 2009

Mr. Patrick Leung
School of Engineering Science
Simon Fraser University
Burnaby, British Columbia
V5A 1S6

Re: ENSC 440/305 Pet Care System Post Mortem
Dear Mr. Leung:

Please find attached the document, *Pet Care System Post Mortem*; this document outlines the process in which we realized our project for ENSC 440/305.

The goal of Pioneer Solutions was to design a system that would allow a pet owner to take care of his/her pet away from home via a webpage. The system involved multiple components that assured the pet's health for an extended duration.

This post mortem document concludes the documentation of the project by highlighting several topics. The highlighted topics include: how the project was conducted, an evaluation of the prototype, future plans for the project, comparison of estimated and actual project measures, such as budget and schedule, and finally a review of the project by each team member.

If you have any questions or concerns regarding our post mortem document, please feel free to contact me by phone at (604) 313-2981 or by e-mail at kwinkelm@pioneersolutions.ca.

Sincerely,

Kyron

Kyron Winkelmeyer
Project Manager
Pioneer Solutions

Enclosure: *Pet Care System Post Mortem*

Pioneer Solutions

Pet Care System

Post Mortem

Version 1.1

20th April, 2009

Submitted to:

Patrick Leung (CEO and CFO)

Steve Whitmore (CIO and VP Human Resources)

Jason Lee (Senior Design Engineer)

Jamie Westell (Senior Design Engineer)

Project Team:

David Chin
Alan Lau
Ricky Chau
Rusty Clarkson
Kyron Winkelmeyer

Table of Contents

1. Introduction

An engineering student's career at Simon Fraser University there is not much room for innovation; however, in the Capstone Project, innovation is expected.

In the spring 2009 offering of the Capstone Project, David Chin, Kyron Winkelmeyer, Alan Lau, Ricky Chau, and Rusty Clarkson united to form Pioneer Solutions. Pioneer Solutions' mission statement didn't revolve around delivering projects that utilized the latest and greatest technologies; instead, the common goal of the team members was to provide a technology that would help people make their busy lives a little easier.

The Pet Care System (PCS) was one of many ideas proposed by the members of Pioneer Solutions; however, due to its consistency with the team's mission statement, this idea eventually became the goal of the semester. 13 weeks later, the project has successfully been completed following the demo, and many lessons have been learned. This document presents these lessons and shares the experiences of the team members.

2. PCS Prototype

The current prototype of the PCS creates a bi-directional communication interface with the user(s) via the internet in ensuring the well being of the pet residing in the users' residence. The well being is ensured by the food dispenser, water dispenser, gate, and camera. These components are considered subcomponents of the PCS and are controlled by the development board. The development board's actions are controlled by a webpage. The operations of the PCS are based on an automated state or a manual state; the state/mode of the PCS is selected by the user via the webpage. Figure 1 illustrates the overall system.

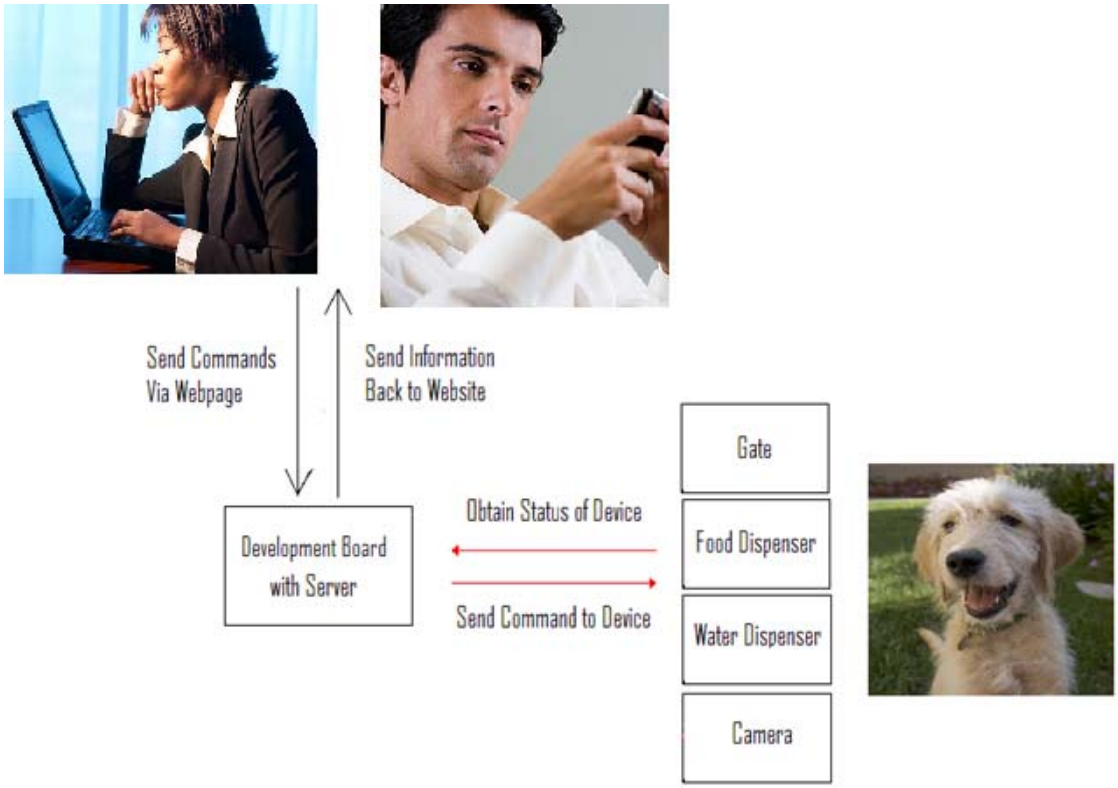

Figure 1: Overview of Pet Care System [1] [2] [3]

The automated mode of the PCS is the scenario whereby the subcomponents of the system are controlled on a user defined basis. The user will log on to the webpage and select the time of the day at which the subcomponents will be activated. Following the confirmation of the schedule, as well as the selection of the automated mode, the PCS will activate the subcomponents of the system at the times

defined by the user as long as there are no major malfunctions with the respective subcomponent. The activation of the subcomponent is dependent on the internet connection speed/latency as well as the mechanical movement of the subcomponent.

The manual mode of the PCS will be the scenario whereby the subcomponents of the system are controlled by the user whenever he/she decides to activate them. The user will log on to the webpage and will click a button and activate the respective sub component. Following confirmation of the request, the PCS will activate the desired sub component of the system as long as there are no major malfunctions with the respective sub component. The activation of the subcomponent is dependent on the internet connection speed/latency as well as the mechanical movement of the subcomponent.

The two modes have the same bidirectional communication scheme. Figure 2 illustrates the forward communication scheme. As illustrated, the webpage communicates with the server, which is embedded on the UC Dragon FS2410 development board.

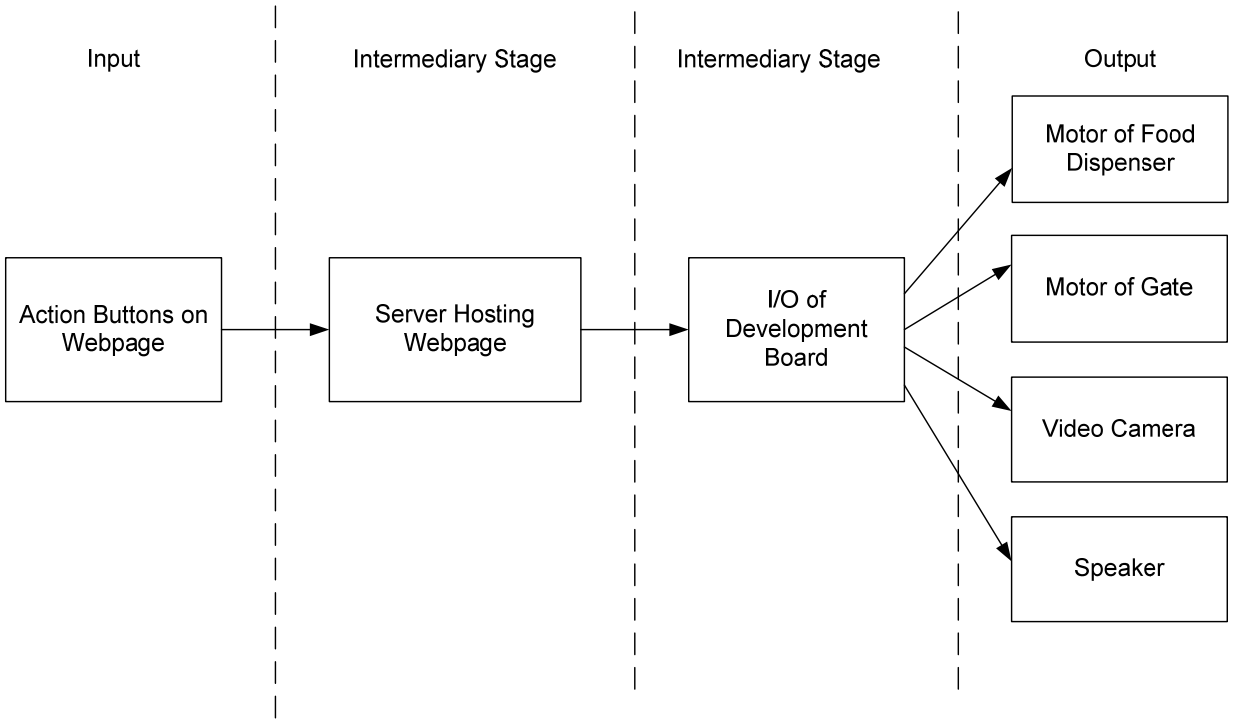

Figure 2: Forward Communication Scheme

A program written on the Linux platform communicates with the I/O pins of the development board. The commands sent by the development board to its I/O pins are derived from the webpage.

The output of the PCS is in the form of four different subcomponents: a food dispenser, camera, speaker, and gate. Both the gate and the food dispenser are enclosed in a wood structure and their mechanical operation is controlled by a motor. The gate's mechanical operation includes the toggling of a lock to release the gate's motion, allowing the pet in and out. The dispenser's mechanical operation includes the opening of a compartment of the enclosure to release dry food and the closing of the compartment to prohibit anymore food from being released. The video camera, which captures real time streaming video of the pet, is controlled by the user, as in it can be turned on and off. The speaker is included on the development board and its operation is characterized by the driver included with the board.

It should be noted that the water dispenser is not controlled by the development board or the webpage; however, water is circulated to the pet continuously via a fountain like method.

Figure 3 illustrates the backward communication scheme between the user and the subcomponents of the PCS. The subcomponents will have various inputs regarding their welfare as well as other information. This information is sent to the development board via the input pins. The development board reads this information and updates the webpage via the webpage server that is hosted on the development board. Following the updating of the webpage, the user(s) will have up to date knowledge on the PCS.

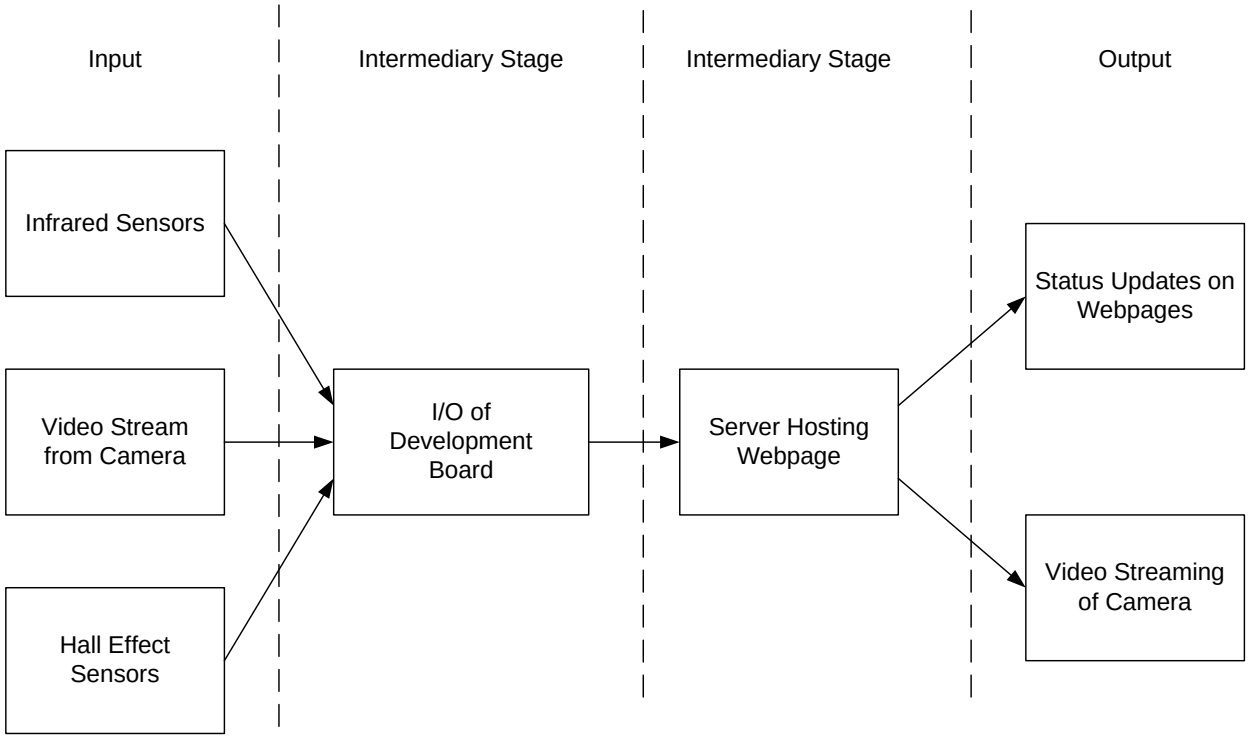

Figure 3: Backward Communication Scheme

The input components of the backward communication scheme are the infrared sensors, the Hall Effect sensors, and the real-time video stream of the camera. The real-time video stream is obtained from the camera and sent through the development board and uploaded to the server hosting the webpage. This video data is then viewable by the user by logging on to the webpage. The infrared sensors are used on the gate to determine the position of the pet with respect to being inside or outside the house. This information is relayed to the user through the development board and uploaded to the webpage; thus, the user has up to date knowledge on the whereabouts of the pet. The second set of sensors is the Hall Effect sensors which are used on the water dispenser, food dispenser, and the gate. The Hall Effect sensors are used on the gate to determine the position of the gate; this information is sent to the development board. The Hall Effect sensors are used on the food dispenser to determine if the compartment has been closed or not; if the food dispenser cannot close fully, it will try 3 times to readjust the dispenser to the closed position. The Hall Effect sensors are used on the water dispenser to determine if the level of water is at a critical level.

All warning messages about the malfunction of a subcomponent are uploaded to the server and this information is visible on the webpage. The malfunction and the nature of the malfunction are also sent by email to the user.

The PCS prototype created was functional and delivered the essential results to verify that the project was a success. The tests were done on both automated and manual mode.

3. PCS Deviations from Specifications

The Pet Care System delivered was a success, as stated in the aforementioned sections; however, the prototype that was implemented deviated slightly from both the functional and design specifications released earlier. Some deviations were due to time constraints, others from finding a better way to implement the functionality of the system.

Time Induced Deviations

The only significant deviation was the audio functionality. Initially, it was thought possible to implement the function in which the user could record a command onto the development board either through a microphone or by downloading an audio file. In addition, the user would be able to control the playing of this audio via the webpage. Unfortunately, Pioneer Solutions was unable to deliver this functionality as stated in the functional and design specifications. The only remnant of this functionality is that the user could play a downloaded audio file by controlling the development board directly; this would not be much use to the user if he/she was outside of the residence. Thus, the functionality of commanding an audio file to be played via the webpage was not fulfilled.

There was a second minor deviation with respect to the camera being able to turn on its base; this functionality was a modifiable requirement and was low on the priority list. Due to the audio functionality not working, this camera functionality was decided to be abandoned and all remaining time spent on debugging the audio issues.

Improvement Induced Deviations

The most significant deviation from the functional and design specifications was the implementation of the water dispenser. Instead of building our own water dispenser, Pioneer Solutions opted to buy a water fountain dispenser from a local pet store and modify the parts. The fountain only required filling the water tank with water and plugging the device into an outlet. From there the water dispenser circulates and dispenses the water automatically. This device eliminated the explicit command from the development board to dispense water. A picture of the water dispenser is seen in Figure 4.

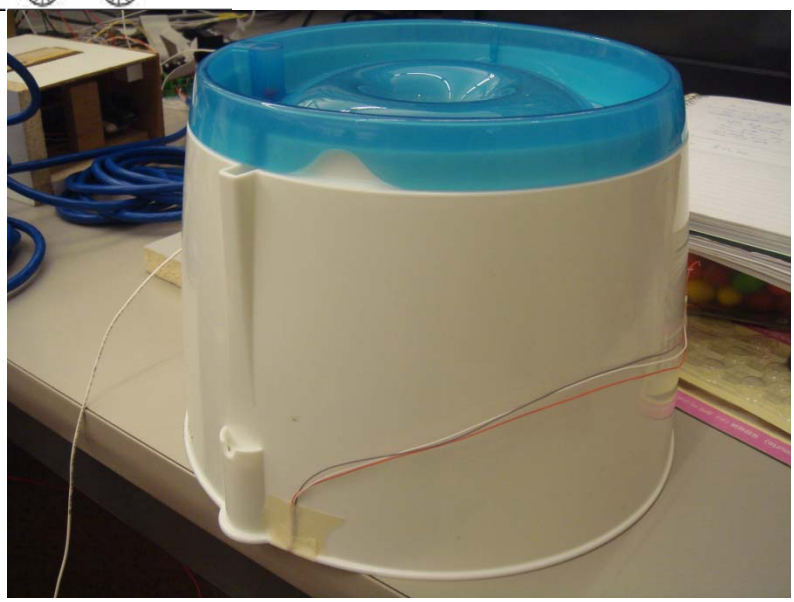

Figure 4: Procured Water Dispenser/Fountain

The second deviation that was implemented as an improvement on the design specifications was the use of Hall Effect sensors. These sensors were both cheap and effective in performing actions once reserved for other devices. The Hall Effect sensors replaced the reed switch used in the food dispenser by placing one on the flap that opens to let the food out; by placing the sensor on the flap, a logic high or low can be toggled to monitor the position of the flap. If the flap gets stuck for any reason, an algorithm embedded in the development board will recognize that the flap is not closed by the sensor and will try to close the flap a maximum of three times. If this attempt from the board fails, then any further attempts will be discontinued and an error message will be sent to the user. In addition to the use of the Hall Effect sensors with the food dispenser, they were also used with the water dispenser to monitor the water level; this was a change from the initial idea to use infrared sensors to monitor the water level.

4. Future Plans/Improvements for PCS

The prototype implemented was successful in realizing the functionality originally proposed; however, this is not to say that improvements and modifications could not be made in the implementation of a final product with more time allotted.

The following subsections propose improvements and modifications for the PCS.

Webpage and Development Board

The development board used was very difficult to program; thus, improvements involving this component of the PCS would be greatly beneficial. The proposed improvement would be abandoning the use of the development board altogether and using a modern desktop or portable computer. The I/O pins of the development board could be replaced by a USB to Serial interface that could be plugged in to the computer. An installation disk would be included to install the PCS on the home computer. Obviously Pioneer Solutions would not expect the user to buy a computer to solely operate the PCS; therefore, two models of the PCS could be created, one with the USB to Serial interface, and one with the traditional development board as seen in the prototype developed.

The webpage that was developed was created with traditional HTML and JavaScript. This option was chosen due to its simplicity; however, as contemporary society begins to use mobile devices more frequently, a webpage that would be more compatible with mobile devices should be developed. This webpage would still be created with HTML and JavaScript as the web browsers on mobile devices don't necessarily operate under circumstances that different from regular web browsers. Limited controls (no mouse), smaller screen size, and less memory/bandwidth are just a few of the ways mobile devices are restricted when it comes to viewing and using websites. Hence, the HTML/JavaScript currently used in the web pages would need to be slightly updated to reflect these limitations.

There are two significant pieces of the website that would need to be solved for mobile devices: processing a command and video streaming. Currently video streaming requires the operating system that is running the web browser to have Java support implemented. However, while this is available on regular operating systems, it isn't available on any mobile operating systems yet. The current mobile operating systems have very limited abilities on watching live streaming video, so coming up with a new method to stream which is compatible on a mobile operating system could be a very complex task.

The command processing is only currently available through ActiveX on Internet Explorer. It I believed, but not tested, that the commands would successfully work on a mobile operating system that runs a mobile-based version of Internet Explorer. Also, if support for XMLHttpRequest's were added, browsers

such as Firefox, Safari, Opera and more would most likely be able to process our commands. Hopefully this success would transfer over to the similar mobile web browsers.

Food Dispenser

The food dispenser performed the functionality as expected; however, improvements to the physical structure are still desired. Currently the enclosure is made out of wood; Pioneer Solutions would like to see a plastic or hard metal enclosure. A change of enclosure is desired due to the non robust nature of the current enclosure, as well as its unsightly appearance. The material that would be used would still need to be damage resistant from the pet's actions.

A second improvement that would need to be realized if this system would want to serve the "wet food" market would be a compartment capable of dispensing wet food. A design considered by Pioneer Solutions but not implemented due to time constraints was the use of a trap door apparatus that would dispense wet food. This design could be easily implemented for the final product.

Water Dispenser

The water dispenser performed its function as specified; however, improvements remain. The current implementation of the functionality of the water dispenser limits the amount of water that can be dispensed over a given duration; in other words, the total amount of water that can be dispensed is limited to the size of the water tank. This constraint does not lend itself well to owners that would go on lengthy trips or excursions outside of the residence. The only proposed change to the water dispenser would be connecting it to the residence's water pipe so that an unlimited supply of water would be available. Unfortunately, a satisfactory design of this implementation escaped the team members of Pioneer Solutions; therefore, going forward a design to implement this functionality would be desired.

Gate

The implementation of the gate was successful; however, there are several improvements that could be made in order to make the PCS more useful to the user.

The first improvement Pioneer Solutions would undertake would involve a more rigorous case study of the possible scenarios in which the pet would interact with the gate. Although the team covered most of the scenarios that can be detected via the two optical sensors, this study would not be sufficient in a real life household. In order to monitor the movement of the gate, a more applicable sensor, such as a degree sensor that measures the angle between the hinge and the gate, should be used instead of the two optical sensors.

The second improvement for the gate would be implementing a security mechanism that would monitor the status of the gate if an intruder gained access to the residence. This functionality could be implemented with many designs.

The last significant improvement for the gate would be implementing a communication scheme between the gate's locking mechanism and the smoke detector. The current prototype has no functionality to prevent the pet from being locked in the house if a fire would occur. This functionality would afford a greater piece of mind to the user when leaving the residence.

Camera

The web camera provided real time streaming video to the website. Possible improvements to this peripheral of the PCS would be a camera with higher resolution as well as the use of a rotating base which could be controlled by the user via the webpage.

5. Project Budget

The project was completed on budget. Although some items were added to the original estimate, the total expenses incurred were still less than the estimated total. Tables 1 and 2 highlight the estimated and the actual budget respectively.

Item	Price ($)
Hall effect sensor x 4	25
Optical switch x 2	10
6 pin on/off switch	5
24V DC adapter	30
2.5mm 6 ft DC power cable	5
PCB terminal connector	10
9V regulator	5
Motor driver	10
Hinges x 2	5
Motor mount	5
Photo sensor x 2	20
Total	130

Table 1: Estimated Project Budget

Item	Price ($)
Hall effect sensor x 4	11.8
Optical switch x 2	9
6 pin on/off switch	2
24V DC adapter	33.1
2.5mm 6 ft DC power cable	2.3
PCB terminal connector	9.8
9V regulator 7809	1.25
Motor driver IC L298	6.5
WD40	4.42
Hinges x 2	2.95
Motor mount	1.25
Superglue	6.71
Photo sensor x 2	33.6
Total	124.68

Table 2: Actual Project Expenses Incurred

The primary reason for the difference in the budget and the expenses incurred were due to the fact that the estimated budget was given room for error in the form of a 15% addition to the budgeted total. The actual expenses included items not included in the budget, such as superglue and WD-40, because the team thought they would be available in the machine shop; evidently these materials were not available.

Pioneer Solutions was adamant about avoiding costs as no financing of the project was obtained. Several tactics were employed to minimize the costs incurred, these included: using motors from old printers, using scrap wood from building supply centers, and using scrap parts.

It should be noted that since the development board was already in the possession of Pioneer Solutions, no expenses were charged to the procurement of a development board; this advantage led to a significant avoidance in cost.

6. Project Schedule

The project was demoed on time; however, the successful implementation of the project was not completed until after the presentation, due to technical difficulties realized during the demoing. Thus the schedule failure was the biggest failure, if not the only failure, realized by Pioneer Solutions. A comparison of the estimated schedule versus the actual schedule can be observed by comparing Figures 5 and 6.

ID	Task Name	Start	Finish	Duration
1	Project Start	1/26/2009	1/26/2009	0d
2	Design Overall System and Alternatives	1/26/2009	2/3/2009	7d
3	Build a Linux Platform on the Board	2/4/2009	2/17/2009	10d
4	Create a Working Program on the Board	2/18/2009	2/20/2009	3d
5	Establish a Server on the Board	2/18/2009	3/3/2009	10d
6	Enable Video Streaming through Internet	3/4/2009	3/12/2009	7d
7	Build Gate	2/4/2009	2/17/2009	10d
8	Build Food Dispenser	2/18/2009	2/24/2009	5d
9	Build Water Dispenser	2/25/2009	3/3/2009	5d
10	Create Program to Control Motors	3/4/2009	3/10/2009	5d
11	Create Main Software	3/13/2009	4/1/2009	14d
12	Debug and Test	4/2/2009	4/13/2009	8d
13	Project Finish	4/14/2009	4/14/2009	0d

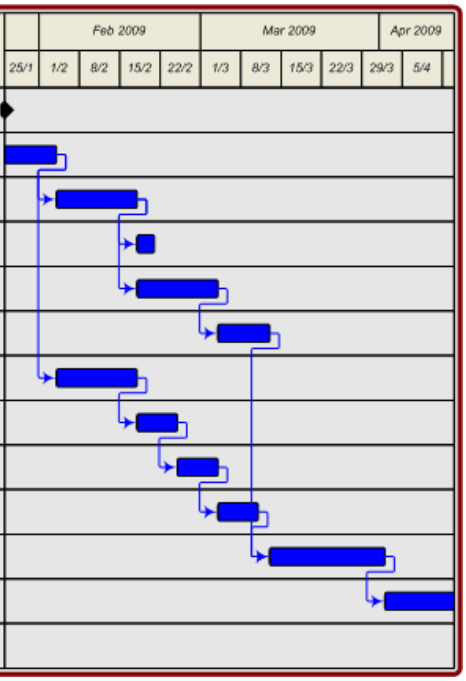

Figure 5: Estimated Project Schedule

ID	Task Name	Start	Finish	Duration
1	Project Start	1/26/2009	1/26/2009	0d
2	Design Overall System and Alternatives	1/26/2009	2/3/2009	7d
3	Build a Linux Platform on the Board	2/4/2009	2/23/2009	14d
4	Create a Working Program on the Board	2/24/2009	3/2/2009	5d
5	Establish a Server on the Board	2/24/2009	3/13/2009	14d
6	Enable Video Streaming through Internet	3/16/2009	3/18/2009	3d
7	Build Gate	2/4/2009	2/17/2009	10d
8	Build Food Dispenser	2/18/2009	2/26/2009	7d
9	Build Water DIspenser	2/27/2009	3/2/2009	2d
10	Create Program to Control Motors	3/3/2009	3/6/2009	4d
11	Create Main Software	3/19/2009	4/8/2009	15d
12	Debug and Test	4/9/2009	4/17/2009	7d
13	Project Finish	4/20/2009	4/20/2009	1d

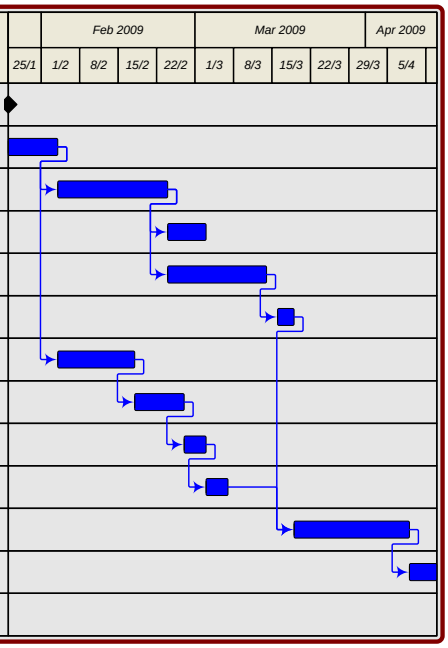

Figure 6: Actual Project Schedule

The primary reason for the deviation in schedule can be observed by comparing the dates of the estimated schedule and the actual schedule between tasks 3 and 5 inclusively. The tasks of building a Linux platform, creating a working program and establishing a server on the board, were the major bottleneck in the completion of the project. The team failed to schedule these tasks correctly due to underestimation of their complexity; this fact resulted in the entire schedule falling behind.

Conflicts in time management arose and ultimately led to the delaying of the completion of the project. These time management issues were elicited by the team members being encumbered by other commitments, such as work, other courses, and friends. Pioneer Solutions recognizes that the elimination of some of these commitments would have been necessary to complete the project on time.

It should be noted that the project began in late January due to Pioneer Solutions initial project being rejected.

7. Team Member Testimonials

Kyron Winkelmeyer

The Capstone Project has taught me several lessons; these lessons are not limited to an academic nature, but extend to the interpersonal realm as well.

In terms of academic skills, I have learned several new concepts and techniques. My primary responsibility was project documentation; in the course of the semester, I realized how to write several project documents. The writing of these documents expanded my knowledge from previous project management courses taken in earlier semester and now I feel much better equipped to enter an engineering firm and produce documents of a high caliber. In addition to writing project documents, I also was involved in the construction of the peripheral devices, such as the food dispenser and gate. The construction of the physical devices used mechanical material learned in previous courses but new information was also required to be ascertained from literature in order to build/integrate more complex components, such as motors.

In terms of interpersonal skills, I have learned to homogenize in a diverse group of personalities and perform to the best of my ability. This transition was not easy as I have traditionally done the majority of the work in group projects due to my distrust of other's abilities. This semester I succeeded in trusting others in their attempts to produce successful results; however, I believe I may have removed myself too far from the project at times, resulting in me losing touch with the project. For future projects I will have to try and improve on this skill.

Overall I believe the project was a huge success, although our mark may not reflect this fact. Our group consisted of five students with significant outside commitments and a delayed project start. In the face of this adversity, we still managed to produce a product that successfully performed the functional requirements stated in the documents written, albeit after the demo date. I am sure if the members of the group had known that the amount of work required for the course was not worth 4 credits, we would have eliminated some of our outside commitments.

Ricky Chau

From a technical perspective, I have gained so much fundamental knowledge on the underlying concepts of a linux based system such as cross platform compilation, kernel development, linux file system and linux driver development. These knowledge has better equipped me to work in the area of embedded system. And I feel more confident in developing a complete embedded system.

Other than software, I have also exposed to different mechanical design ideas and components such as motors and sensors which I never have chance to play around with in any case. Having the experience of mechanical consideration, it helps me broadening the scope of consideration when doing the design of system as a whole. Co-op experience with massive soldering and some prototype building had helped me shortening the design time and building time of several electrical circuitries and skills has further improved in this project.

Beside technical area, I have learned much more on the soft skills of dealing with people, working as a team and managing a project. In my point of view, not having a successful demo was definitely a big failure. The reason behind, I think, it's more about the team spirit.

I feel that the team spirit of our team is low, partly because of the decline of the first project idea, and partly because of irresponsive or lack of communication of few team members. Our communication channel is mostly email, however, this channel is not effective enough to separate tasks, set deadlines, seek support and solve problems. Unable to meet face to face, we have hard time drawing conclusion on some high level designs and making decision as a team, which ends up each of us is more like working individually.

Second reason of failure would be missing a strong leader in our group. We were missing a strong leader that can monitor everybody and push tasks to be finished according to their deadlines. Since we lack of communication, letting people work by their own responsibility doesn't work effectively since people tends to be lazy or procrastinate. I would have been the best choice to play such a leader role since I have the least amount of work load in the group, however, I wasn't responsive enough to the situation and take lead of the team. This is really a good lesson to learn how to work as a team and step out to lead the team at the right timing.

In terms of project management, I realized tasks should be broken down as detail as possible so that we can well plan ahead and separate work more evenly. Update from teammates and updating your teammates are always important to create feedback to the group and synchronize everybody. Backup plan is also important in case if anything fails. And one more important thing is strategy to demo. We would have delivered a better demo if we have given up the auto mode and secure the performance of the manual mode in the last few days of debugging period.

I have learned a tough lesson from this capstone project. I will definitely remember all these I have learned and will not let this kind of failure happens again in my life.

Alan Lau

I have learned that the correlation among the entire team plays a critical role in the outcome of the team's success. I realize that each member in the team must be constantly feeding other members of the team with progress updates and positive criticisms. If this is not done consistently, the entire progress of the team will be out of sync and as a result bottleneck the progress of the project. I also recognized that it may be difficult at times for team members to meet up together. Hence, emails, sms, phone calls, and voice mails became a vital communication tool throughout the project life cycle.

The technical skills I have acquired have definitely shaped me to become a computer engineer that is also hardware oriented. For example, I learned that most stepper motors provide a good precision and torque for a given input, whereas, DC motors may be faster but are often more difficult for precision control and have lower torque. DC motors also require a more complicated motor driver compare to stepper motors. Given the scope of our hardware requirements, I was able to quickly decide stepper motor worked the best. Next, I have learned to identify the characteristics of stepper motors when its data sheet was not available, such as motors found in fax machines and printers. I have also studied and built the kind of circuit that is required to interface between the stepper motor and micro controller. Perhaps the most challenging part was the marriage between electronics and physical components. Almost all the time physical parts are always slightly off with the electrical components and I would have to spend extra time trying to adjust and modify its physical structure. Throughout the project I have consistently spent time in the machine shop and hence I have sharpened my hands on skills tremendously. The most valuable experience I now acquired from working on the PCS is, how do you build a solution from scratch that will satisfy all hardware functional requirements.

Rusty Clarkson

From a technical perspective, I have accrued much knowledge on both the software and hardware side. For the first time, I understood how stepper motors work as well as had the opportunity to implement them into a working design. Also, I furthered my experience with microcontrollers, whether it be by delving into the board schematics to trace the location of specific pins or to determine how to properly work from the lowest level of the board. One of the biggest obstacles I was appreciative to experience was the opportunity to work in the C programming language, get past the point of frustration and actually have a working product. On the software side, while I've had previous experience with Linux, this was the first opportunity I've had to write a driver for the kernel. This was especially rewarding as it was written in, C, the new complex language I've had to learn.

From the start, I believe our team was very ready and planned to be one of the best groups this semester. We discussed the project far before the courses even began and we had good ideas. However, a key factor has been that our initially proposed idea got rejected. Our group was trying to be too ideal from a practical perspective. We all wanted to work on a project that, in the end, would be capable of helping the world in some way. However, the fact is that the combination of these courses are considerably marked from a technical point of view. Therefore, we would have possibly been better guided had we developed an item that was similar to ones that had been previously implemented.

Project management is probably the most important lesson learned for me. While our group seemed well organized in our capabilities and ideas, when it came down to executing and performing, I believe we were ignorant. Due to time constraints of members, our abilities to work on the project at the same time were overly limited. Thus, things like designs, plans, use cases, test cases, etc. were never discussed as fully as they should have been. Therefore, each member was working on their chosen parts, but not necessarily all situations were covered. This probably would have been avoided had someone been a bit more proactive in a leadership sense, but I know that no single one of us was sure about how to do all aspects of the project. This resulted in a lack of willingness to be in command. Knowing all of this now, I feel I will be much more likely to step up and take that responsibility in the future.

David Chin

I have learnt so much from this project, particularly in the realm of project management and timing. Prior to this course, if you ask me whether of not I process the skills to be a successful team leader, I would say “yes”. However, after the project, I will have to say “no” to that question. The lack of a team leader in our project was primary the reason that the project did not go through as planned.

Prior to the course, everyone on our team was a mere stranger to one another. We gathered up and form a group without knowing each other in detail. In a case like this, it is utterly important to have a person in the team to take on the leadership role and to make sure that everything is implemented and delivered before the deadlines.

Being a person with leadership ability, one should realize when a project is not progress well and should step in and take initiatives once the trend has been spotted. I would have to say that I do not possess that ability, and therefore, I am not yet suitable to take on a leadership role.

On the technical side, I have learnt how to program under an embedded development environment, and how to setup an OS on a development board. I also have to opportunity to put very topics that I learnt from the computer networking class into practice, and to learn the beauty behind various handshaking protocols. I also learnt that unlike a software environment where the patterns are always the same, the mechanical system tends to behave differently due to external factors such as temperature variation, and one should also take those factors into consideration when designing a system.

Overall, I would say that the most important lesson that I learnt from the project is about myself, and the area that I can improve in order to make myself a better team player in the future.

8. References

1. Woman on Computer, [Online picture – cited April 12, 2009], Available: www.myfrontline.info/woman-laptop-horiz.jpg

2. Man Using Cell Phone, [Online picture – cited April 12, 2009], Available: http://wwwdelivery.superstock.com/WI/223/1804/PreviewComp/SuperStock_1804R-12045.jpg

3. Happy Dog, [Online picture – cited April 12, 2009], Available: www.carolynbremer.com/wordpress/images/HappyDog.jpg