8888 University Drive
Burnaby, BC V5A 1S6
(778) 862-2242
ensc-440-weiibo@sfu.ca
www.weiibo.com

April 12, 2008

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

Re: ENSC 440, Post-Mortem for the Wireless Parked Car Finding System (uFind)

Dear Mr. Leung:

The attached document contains the post-mortem for uFind. It outlines a summary of the design and development process, the team and individual achievements and experience towards the successful completion of the project.

The goal of the project was to design and implement a prototype model of a device that would assist drivers locate their parked cars conveniently in parking areas without causing disturbance to the public.

Weiibo Inc. is a company formed by Karl Simard, Hooman Jarollahi, Dennis Xu and Diwaker Malla. We are 3rd or 4th year engineering students who put dedication, enthusiasm and organization towards the completion of the project. Should you have any questions or comments about this document, please do not hesitate to contact us via phone at (778) 862-2242 or e-mail at hjarolla@sfu.ca.

Regards,

Hooman Jarollahi
CEO, Weiibo Inc.

Enclosure: Post-Mortem for the Wireless Parked Car Finding System

Post-Mortem for the Wireless Parked Car Finding System (uFind)

Project Team: Diwaker Malla
Karl Simard
Hooman Jarollahi
Dennis Xu

Contact Person: Hooman Jarollahi
hjarolla@sfu.ca

Submitted to: Patrick Leung – ENSC 440
Steve Whitmore – ENSC 305
School of Engineering Science
Simon Fraser University

Issued Date: *April 12*, 2008

Revision: 1.0

Table of Contents

List of Figures

List of Tables

Acronyms

ADC	Analog to Digital Converter
DAC	Digital to Analog Converter
FSD	Functional Specifications Document
FSM	Finite State Machine
LADJ	Level Adjust
LCD	Liquid Crystal Display
LOS	Line of Sight
PWM	Pulse Width Modulation
RF	Radio Frequency
RSSI	Received Signal Strength Indicator
SUV	Sport Utility Vehicle
TFLF	Time of Flight Loop Frequency
TOF	Time of Flight
TPA	Transmission Power Adjustment
UUT	Unit Under Test

Glossary

TOFLF Method: A method used to calculate proximity between two objects developed by Weiibo Inc. It uses the accumulation of the TOF delays to transmit and receive a message signal by sending the message many times in a fixed period of time and counting the number of received or transmitted messages which would vary with distance.

TPA Method: A method used to calculate proximity between two objects developed by Weiibo Inc. It uses the adjustment of transmission power to calculate the reception range and hence the distance approximation of the receiver.

uFind User: Any person who meets all of the following characteristics:

- At least 10 years old or with supervisions by someone older
- Without impairments in visions and hearing for complete usage of the device

1. Introduction

Weiibo Inc. was formed by Hooman Jarollahi, Diwaker Malla, Karl Simard and Dennis Xu in early December of 2007. Initially, we researched and investigated the need for a product that did not exist in the market and that would fit the scope of the course. After a lot of analysis of ideas by Weiibo Inc. members, we chose to solve the frequent problem of having to find one's parked vehicle at large and busy parking lots. After the idea was approved by the course instructor, we set to accomplish a proof of concept prototype of the uFind, a wireless parked car finding system. This document outlines the functionality, accomplishments, results and analysis of uFind along with what we have learned from developing the uFind.

2. Background and Motivation

"We forget all too soon the things we thought we could never forget." – Joan Didion [2]
Forgetting where one is parked can be an exhausting and frustrating experience. This becomes even more frustrating at times when the situation is rainy, snowy, foggy, and so on. In desperate times, you are probably even tempted to press the panic button to get an idea where you are parked. However, these high-pitched alarm sounds (honks) from cars can prove to be very annoying and frustrating for other people at the parking lot. In addition, these keyless entry systems and car alarm systems come with another drawback when they need to be used as a car finding device: they have a fairly short range.

We have thus attempted to solve this problem with the uFind, a device that quietly and conveniently conveys proximity and direction between the user and car.

3. Overall System Description

The functional specifications of the device along with corresponding design specifications are fully explained in their corresponding documents. The major features of the device are:

- Assist the user to find the direction towards the car
- Display the proximity between the user and the car by indicating relative distance
- Provide other functionalities such as remotely turning on car lights, lock/unlock the doors, turning on car engine as requested by the user for further convenience.

- Store/Display the parking lot information entered by user for further assistance.

In order to design and implement the first feature, the direction, a directional Yagi antenna was used to receive a signal stronger at the right direction. For the second feature, the proximity detection, a method was designed which we called Transmission Power Adjustment (TPA) as well as an alternative design solution called Time of Flight Loop Frequency (TFLF). The basis of TPA method is that the proximity between the user and the car can be detected by dividing the distance into sub-regions and adjust the transmission power level on the boarders to detect the acknowledgement back from the car as a sense for the threshold as shown in Figure 3.1.

An LCD was used as a user interface unit to display the directionality indicator combined with the proximity. Some other menus such as display of date and time, password protection and other settings of the device are also implemented to complete the integrity of the user needs. A keypad is also integrated in the device as a user interface unit. It has menu navigation and selection keys and function activation keys to activate the car lights, the beeper, etc.

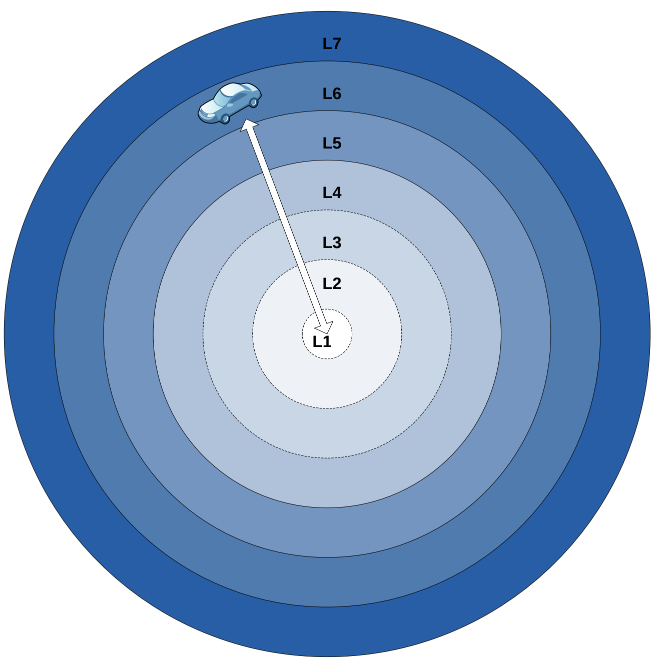

Figure 3.1: Sub-regions in the proximity between the car and the user

Figure 3.2 outlines the communication system between the car and user. Two pairs of communication modules of different frequencies coupled with decoder and encoder units were employed to make a communication possible and to avoid interference. These encoder/decoder units can produce 2^{24} different addresses to avoid interference in the usage of multiple copies of the device at the same parking lot. Two control units are involved: The handheld control unit and the squelching system in the car module.

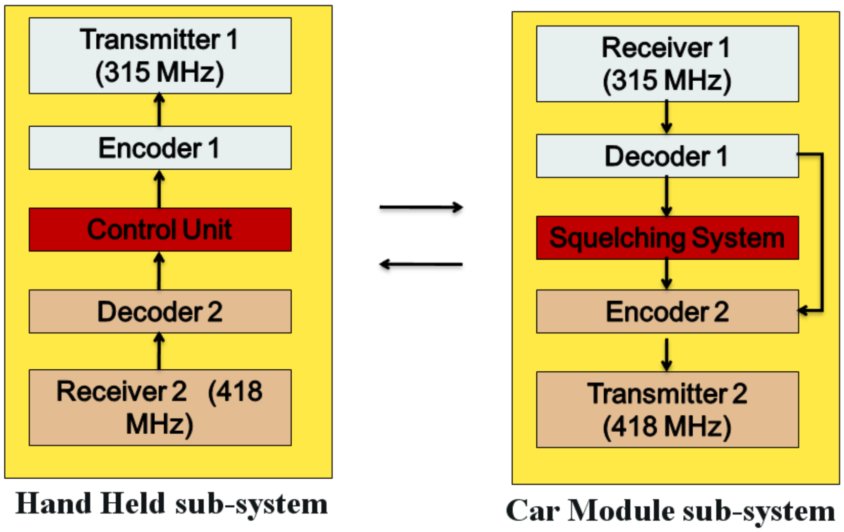

Figure 3.2: Block diagram representation of the communication system

Figure 3.4 and Figure 3.4 represent these two units. For more detailed explanation of the design, the design specification document can be referred.

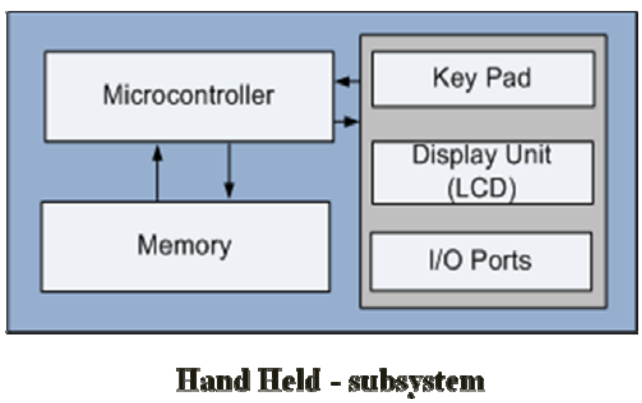

Figure 3.3: Block diagram representation of the control and user interface unit

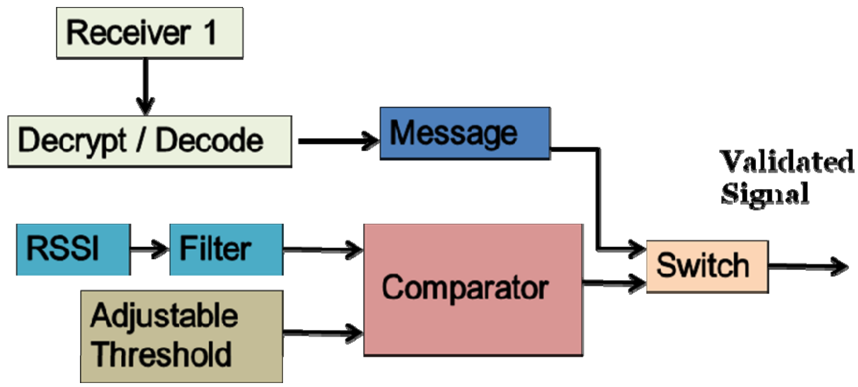

Figure 3.4: Squelching system in the car module

Figure 3.5 depicts the circuitry for the transmission power level adjustment which causes some small ripples in power level and a delay in the system.

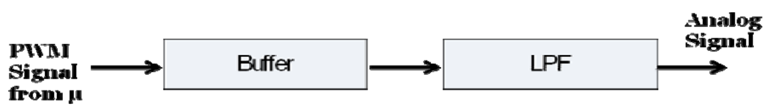

Figure 3.5: Block diagram representation of the digital power adjustment circuit

Figure 3.6 depicts the firmware modules including the search algorithm, communication control, DAC and LCD display related to proximity detection.

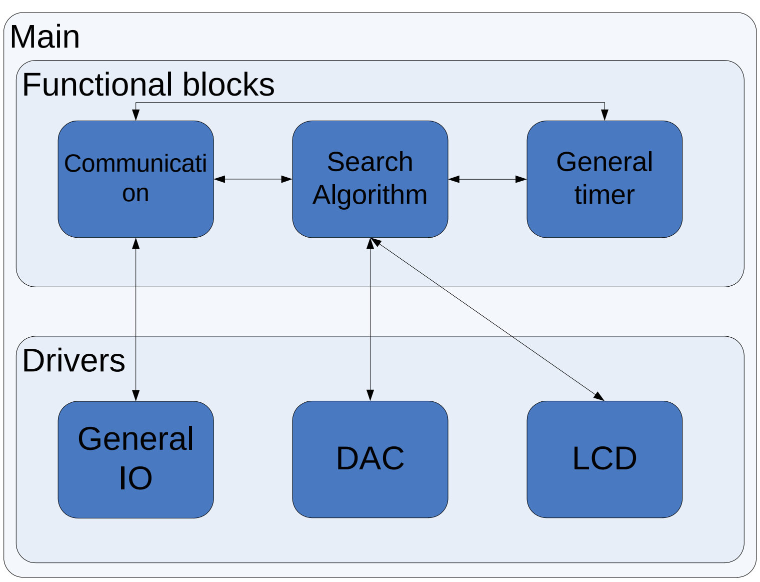

Figure 3.6: Firmware modules related to proximity detection

4. Performance Limitations and Constraints

Due to the properties of radio frequency (RF) signals, when TPA method is used to determine the proximity and direction, surrounding objects in the environment pose limitations and constraints. RF signals are absorbed and reflected by concrete, tree, metal (vehicles), and other surrounding objects that are present in the line of sight between the car and handheld module. Furthermore, the objects made of metals essentially introduce similar effects produced by conductive planes. The water in the air during rainy, foggy, and snowy situations also contributes to the absorption and reflection of the RF signals which further alter the performance of the uFind.

The squelching system will also reduce the range of proximity detection feature to around 80 meters though it does not affect other functionalities. The reason is that the other functions bypass the squelching system though not transmitted back to the handheld since not necessary and no tracking is needed for them.

5. Current Status of the Project

Figure 5.1 shows the integration of the whole system. The components are assembled in such a way that all of them are detachable using proper connectors and wiring for ease of debugging, modifying and future improvements. The device is not yet portable since a PCB design needs to be done and also the antenna's need to be replaced with compact ones such as fractal antennas.

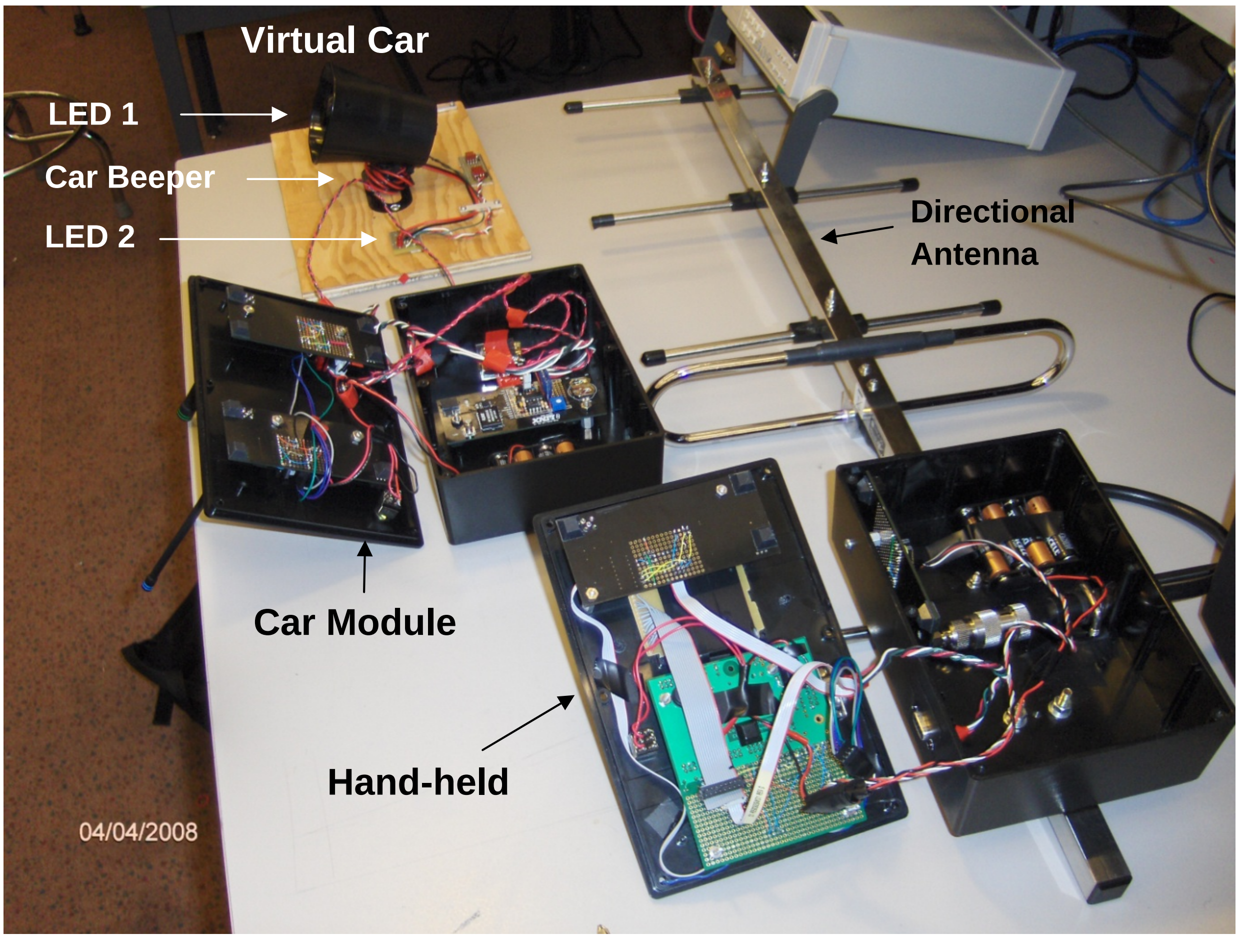

Figure 5.1: The prototype model of the entire system

Figure 5.2 depicts the user interface of the prototype model.

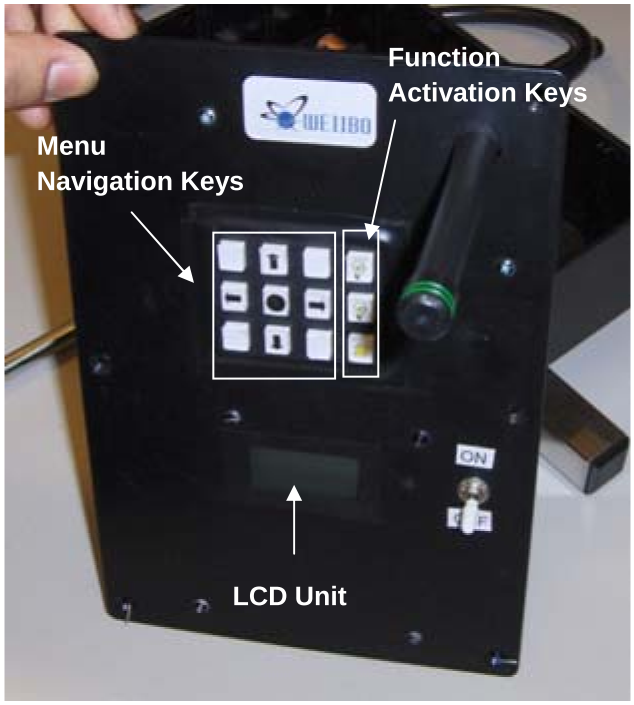

Figure 5.2: User interface

Figure 5.5 displays the performance of the device using different search algorithms in terms of firmware. Based on the experimental observations and considering the response time of the device, the 3 peak average method worked out to be the best algorithm though 30 point average was also satisfactory. However, more points are taken into account, the response time will be longer.

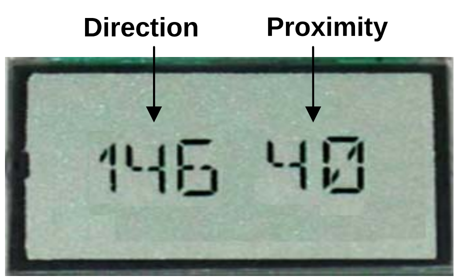

Figure 5.3: An example of implemented directionality and proximity indication

Figure 5.4 depicts the user menus implemented in the user interface.

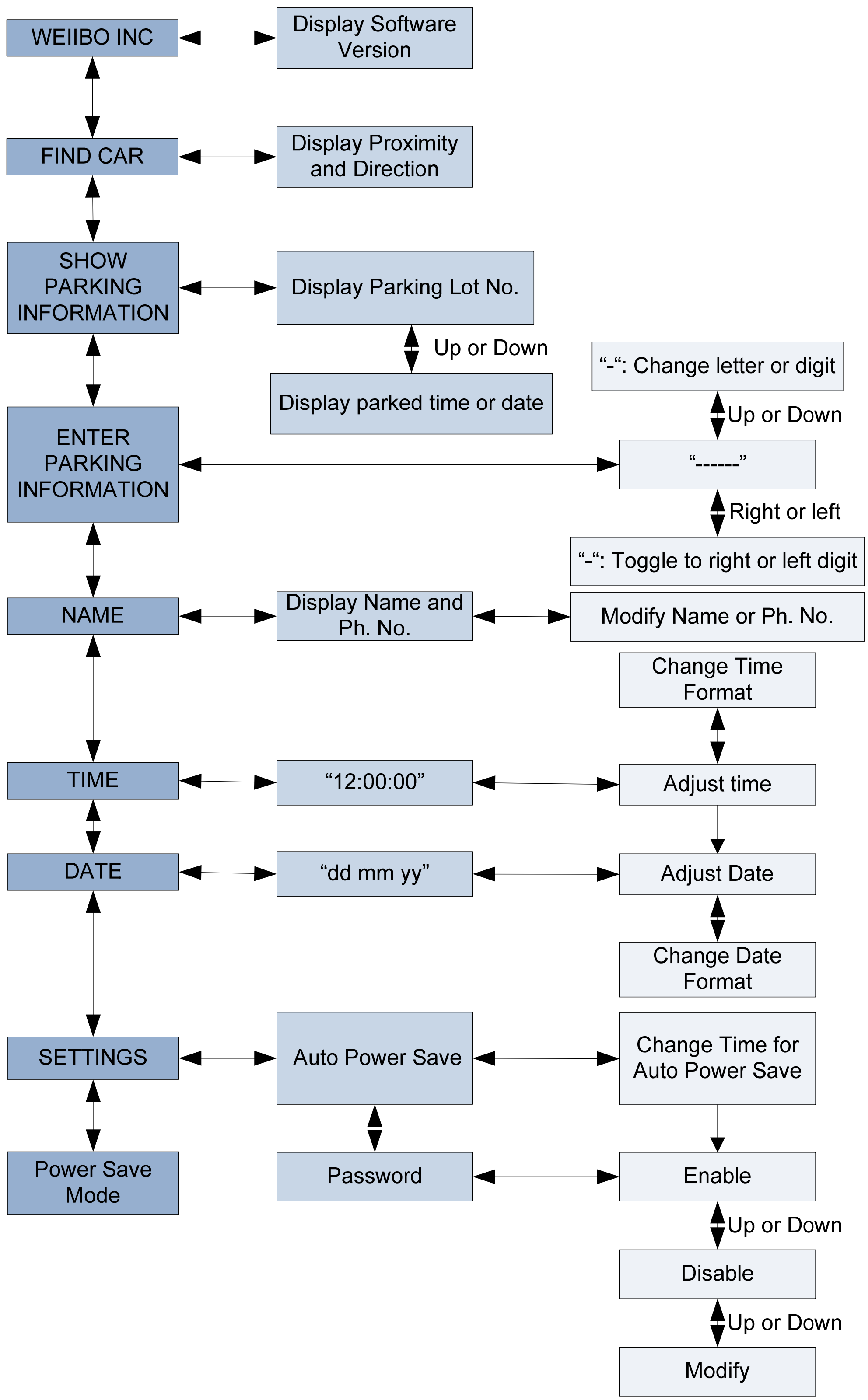

Figure 5.4: FSM for the Display Menu

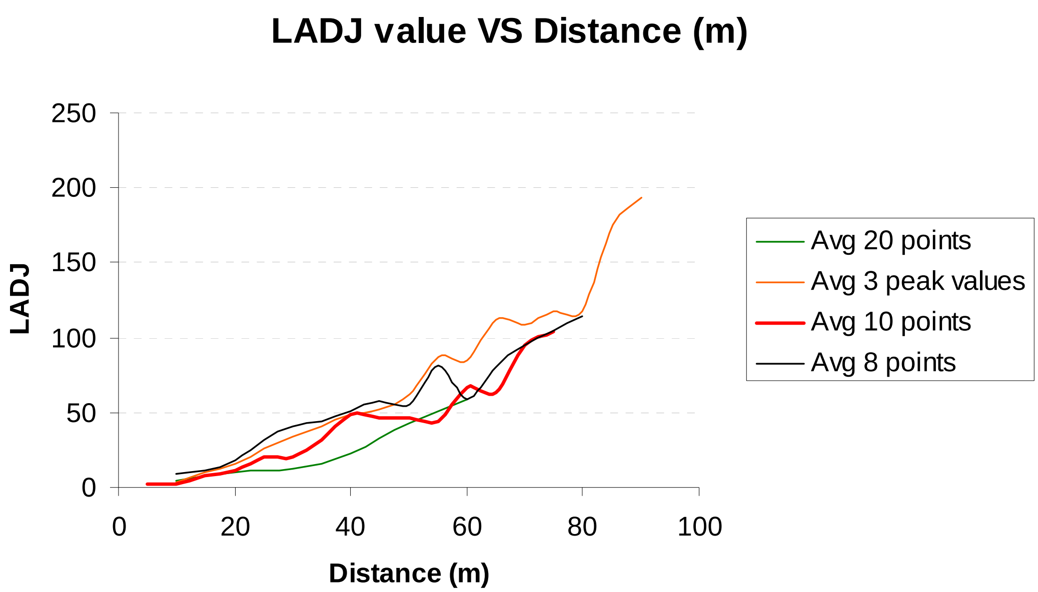

Figure 5.5: The calculated distance vs. transmission power level for different calculation algorithms

6. Functional Deviations

According to the functional specifications document [1], most of the specified functionalities for the prototype model (**Rxx-I** and **Rxx-II**) match what we have implemented except:

"[R14-I]: The operation range between the hand-held and the car module shall be between 1 to 80 meters." The proximity detection range is compliant to what was mentioned. However, for other functionalities such as turning on the car lights, a longer range of around 1 Km is implemented.

"[**R40-II]:** The proximity detection on the hand held shall be displayed within 5 seconds." The device displays the proximity much faster than 5 seconds within 50 meters and a bit longer than 5 seconds after that.

7. Design Deviations

Since the design specification document [3]corresponds to the functional specification document [1], and the deviations in the functional specification are minor and more towards improvement of the design, only minor design deviations were accounted. These are mostly related to firmware algorithms and adding a keypad to the user interface.

8. Future Improvements and Plans

With the level of success we have achieved with the project to date, we aspire to take the uFind to the market with the following improvements. To attain the dimensions as specified in the functional specifications for a marketable prototype, we will implement all the circuitry in a Printed Circuit Board (PCB) and make use of a fractal antenna instead of a "Yagi" directional antenna. Furthermore, we plan on improving the display unit and user interface with the use of a color LCD and a user-friendly keypad. For enhancing the detection of direction, we will also implement multiple directional antennas. Last but not least, we plan on developing a communication protocol that will replace the decoder and encoder chips, supplied with the communication module, to speed up the response of the device.

To raise funds required for making a marketable prototype and eventually launch the uFind in the market, we plan on featuring the uFind at events such as the SFU Open House, business plan competitions, etc. We have recently launched a website, www.weiibo.com, that will help us to address questions and find potential investors of the uFind.

9. Budget and Timeline

9.1 Budget

Table **9.1** outlines the estimated cost at the planning stage of the project and the actual cost incurred to demo date. The actual cost to demo date is slightly higher than the estimated cost primarily because of having to purchase a directional antenna for finding the direction of the car and an extra communication module.

Weiibo Inc. members looked into ways of implementing a directional antenna by building it in the lab, however, to achieve the required accuracy and to keep up with projected timelines, all the members decided that a “Yagi” directional antenna be purchased instead of building one in a lab. This resulted in a slightly higher cost than the estimated cost which was split equally among the members. Given the $640 award by Engineering Science Endowment Fund (ESSEF), going overboard on the expenditures amounted to only 70 extra dollars for each member. Overall, with contingencies taken into account, the completion of the project can be considered to have met the estimated budget estimation.

Table 9.1: Budget Planning, Estimated and Actual Cost

Part Description	Estimated Cost ($)	Actual Cost ($)
Communication Module	380	489.96
Control Module	120	112.84
User Interface (W/ Enclosure)	120	76.00
Antenna (Instead Of Internet Domain)	30	126.87
Miscellaneous	140	90.06
Total	**790**	**895.73**

9.2 Timeline

Figure 9.1 presents the Gantt chart with the estimated and actual timelines in green and blue respectively. By starting the research and planning of the project a couple of months prior to the start of spring 2008 semester, we ensured that the timelines would be met as laid out on the estimated timelines on the Gantt chart. Aside from using the allowable extra three days to fine-tune the design specification, we have achieved all the milestones earlier than what had been planned.

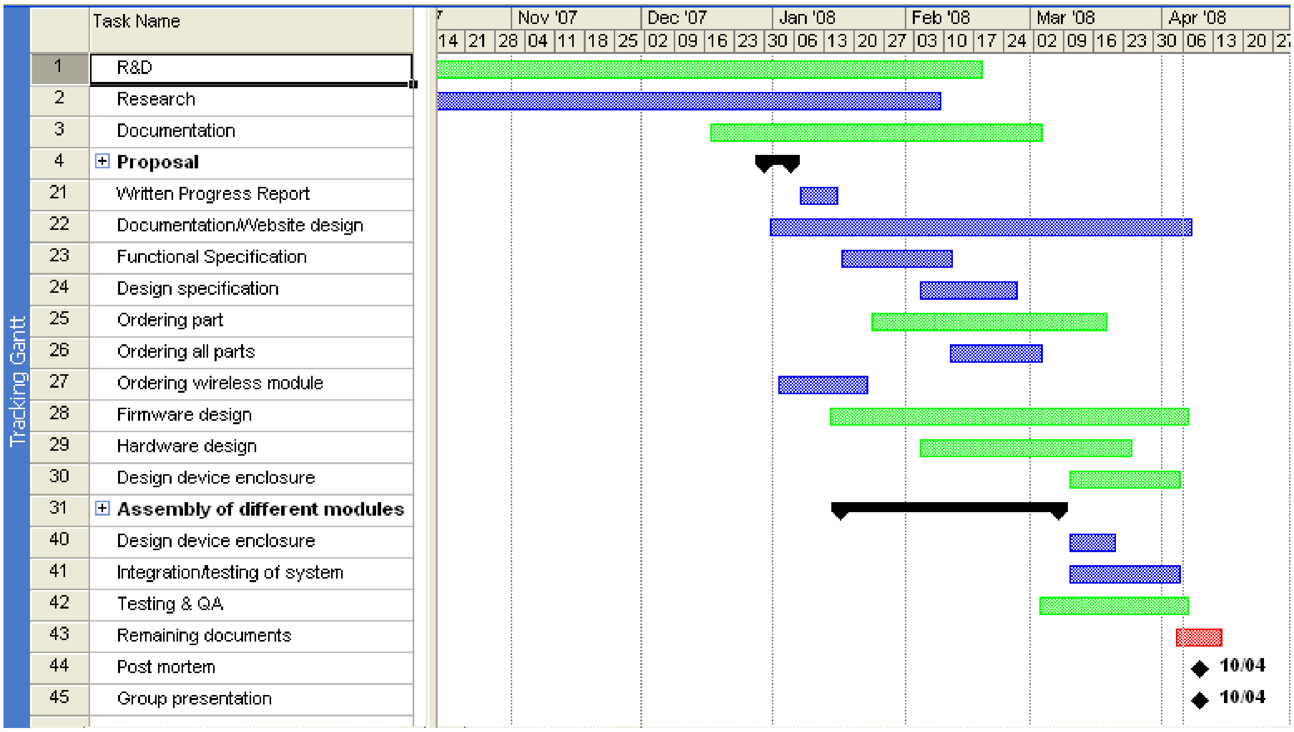

Figure 9.1: Gantt chart with Timeline and Schedule, Estimated (Blue) and Actual (Green)

10.Interpersonal and Technical Experience

Hooman Jarollahi

Some of the times during this course, being involved so much, I almost forgot that what I was working on was a course to be graded as usual. Instead, I considered it as an opportunity to develop a real product which would help people have a more convenient life even if it was by a small portion. It needed to be useful and safe to use. I felt a responsibility not just to myself but towards the whole group. My grade at the end wasn't as important as the feeling of satisfaction it would give me to develop a successful project and do it the right way. I worked with wonderful people in my team who were not only very dedicated to and skillful in the project, but were open-minded in terms of respecting each other's ideas, being good listeners, being patient and understanding at different occasions especially when extremely odd technical problems occurred. When the idea of designing a remote car finding system initiated, everyone started to appreciate and acknowledge its usefulness and originality. However, when we started to design the system, nobody knew how it would be possible to design. Everyone had a guess on the design which was by no means guaranteed. Many believed that it would be impossible to do in such a short time and with reasonable expenses. We encountered problems that nobody knew how to solve such as calculating the proximity. After doing research and being involved for sleepless days and nights, we started developing ideas and solutions. After numerous analysis, testing and design changes, we could finally solve problems keeping alternative designs in our pockets. More testing and calibrations were needed to improve the performance. It would have been impossible to finish this project without the dedication and patience from each person in the team and an excellent organization and planning on the internal/external deadlines both on the technical aspect and documentations. Technical communication can be very challenging when you have lots of goals to accomplish and a very short time. Organizing 4 people's schedules and finding their strengths was not always easy.

In terms of technical experience, I was involved in the development cycle of a new engineering product at different stages such as R&D to implementation, testing and assembly. A short period of time as well as challenges in problem solving ideas and not making too many mistakes would add to the level of stress and sometimes becoming hopeless.

In this project, I had an opportunity to design a wireless communication system, learn about directional antennas, design some of the firmware algorithms, and learn more about pre-designed digital and analog circuits and chips in the market and their applications. I also designed an alternative method to calculate proximity which I called Time of Flight Loop Frequency method (TFLF) but due to the time constraints, this method wasn't as developed as the TPA method though conceptually proven with preliminary testing.

Improving my collaborative documentation skills was also incredibly important. I also experienced how joyful it was to celebrate the success of a goal as a team while working towards the same goals. Each person was working on specific tasks while helping others out too. Finally, I would like to thank everyone who contributed towards our project completion especially Patrick Leung and Steve Whitmore.

Karl Simard

Working on this project is the most interesting and rewarding experience I have had since I joined the school of engineering science at SFU. It is in fact true that ensc440/305 is a lot of work but since we are working towards creating a useful prototype, the time spent is well worth it. One part of this project that I liked most is the fact that we get so much hand on experience, not only do we get hands on experience in designing our product, but we also get to learn how to order parts, put the parts together, test the parts, build modules, incorporate the modules together, and the list goes on forever.

From a technical standpoint, I enjoyed choosing the hardware I would work with, put it together and make something useful out of it. It was nice to be able to apply all the knowledge I acquired in the past and also surprising as to how much knowledge is required to build something that seems rather simple. Keep in mind that this project required a lot more knowledge than what we learned in previous courses, there was a lot of knowledge we needed to pick up as we went along. When I worked through other courses in the past, rarely did I need to go through an entire datasheet, most times the information is fed to us by the instructor and we take it for granted, well this way of life took a turn for the worst while working on this project. It is interesting that pretty much everyday, I needed to look at the datasheet for some information or another, this course taught me a lot about relying on my teammates or myself to get the information needed. There are a lot of little details that are taught in engineering classes and you think they are “little” details until you begin to build your own circuit. At that point, “little” details are what make the difference between you microcontroller blowing up or your microcontroller working just the way you want it to, ultimately is makes a difference between your product being functional or not.

From a group dynamics perspective, this project was an excellent experience. What I thought was exceptional is that I got to join a group of people that I did not know at all prior to beginning the project. I believe that our team performed really well throughout the term. Everyone put in the efforts necessary and everyone had a say in the project. Without everyone’s cooperation this project would not have succeeded. From this project I learned that team dynamics and team communication is vital to a team success. Everyone must have a say in what goes on and everybody must be good listeners such that everyone in the team moves in the same direction.

Every week we held meeting to ensure everyone in the team was aware of the progress done and I believe that this played a large part of our team communication.
Finally, after all the work is done, I can now look back at what we accomplished and can honestly say that this is the best experience I have had so far, as an engineering student. All the elements of what we have studied for since first year were present in the project, whether technical skills or soft skills were involved, I believe all of us needed to use them at one point or another.

Dennis Xu

Working on the project was an exceptionally worthwhile experience in my undergraduate studies. I am really happy to have worked with four extremely hard-working, dedicated, and intelligent individuals. I have gained valuable experience in the design and implementation of a new idea.

First of all, I learned a lot from choosing the project topic. We started to form a group in the beginning of July 2007 and we did a lot of research on what kind of product we were going to working on. We brainstormed and analyzed the ideas and then decided to choose a product which would be most suitable for the purpose of this course. We discussed the ideas with professors in that field to make sure our project topic is feasible. Through doing research and consulting with professors, I learned more about the knowledge of directional antenna and RF communication systems.

Secondly, I learned a great deal about time management and group meetings. Time management is a very important factor for doing an engineering group project. As a group, we need to consider how to manage the 13 weeks to do each part of the project; as an individual, everyone needs to manage his time for each course he was taking. As for me, I spent most the day time working on this project and working on other two courses at nights and weekends. Group meetings are the best way for us to share our ideas and experiences. We met at least once a week in a formal way and took minute minutes to bring everyone on the same track. We worked in the lab almost every day in order to solve various problems. Regarding team dynamics, the most important aspect I learned is to be patient and to understand and respect each other.

Finally, as we started earlier and worked very hard in the first two months, we finished our main milestones in the middle of March. Therefore, we had sufficient time to test our prototype and to improve its performance a lot. I am sure the experience and knowledge I gained through this project will be a valuable asset in my future career.

Diwaker Malla

On the technical side, ENSC 440/305 is the most hands-on course that I have taken to date. The course allows the group to set what it wants to accomplish as opposed to other courses that narrow projects down with limitations and restrictions. A group isn't restricted to accomplishing a proposed project, however, it is up to the group to decide what it wants to accomplish given that the instructor approves of the achievability and ensures that proposed project meets the scope of the course. As much as group dynamics plays a vital role in accomplishing the project technically, the same level of group dynamics is involved in the decision making process that involves deciding what needs to be accomplished for the project.

Everyone was involved and motivated from the start of the project to the completion of the project. We all started by garnering potential projects in the initial meetings and analyzing to see if the proposed ideas by the fellow group mates were achievable in a four month period and if the ideas would be approved by the instructor given the scope of the course. At the time, I personally thought that we were over-thinking details and the scope of the project. However, reflecting on how the project may have turned out if the details hadn't been analyzed to that depth, I am glad that we had over-thought some aspects of the design of the project. This could perhaps be compared to the design and implementation of computer software where developing algorithm is given a significant amount of time before implementing the algorithm. With this experience, I learned that paying attention to the details and organization of the design before it is implemented is an important path towards successfully completing the goals that are set for the project.

With the technical onset of the project, the group was divided into teams where we each agreed to work on a given portion. Some of the considerations that were made to streamline the progress of the project may seem to have been overly planned, but detailing and looking at contingencies paid out on the long run.

Although the group was divided into teams, everyone was involved in the project to a degree where one got a very good idea how the assigned tasks were being implemented. I started off by designing the user interface where I also encountered a lot of limitations on the side of the microcontroller we were using. Overall, trying to see if one could get around the limitations and learning to program a new microcontroller kit, I have learned a lot about firmware programming. By working with the wireless modules and using the modules to accomplish various tasks, I have also learned valuable soldering and circuitry skills at the prototyping level. Although neatly assembling a prototype may not seem as important as getting across the proof of concept, I have learned that assembly and good organization will lead to significant reduction in debugging time and overall, decrease the chances of mistakes that could be encountered in the last minute.

11. Achievements and Team Dynamics

Although the group was divided into teams to accomplish portions of the project successfully, each member was involved in almost every aspect of the product development cycle. With the extensive use of the microcontroller kit and wireless communication modules to accomplish the goal of the project, we gained valuable knowledge and experience with firmware and wireless communication designs respectively. We were all involved with documentation where each member wrote a specific portion that fell under his expertise and proofread others' parts to ensure coherence in the document. In the end, one of the members was responsible for a final proofreading and formatting. In this aspect, we all gained a comprehensive experience in writing documents for developing a product from its conceptualization to its prototype stage. The modules, circuitry and the microcontroller kit were put together in a prototyping board, assembled in an enclosure, and tested. We were all involved with the final assembly where we learned prototyping, soldering, and assembling skills. In the end, to ensure that the uFind performed and met the standard we had specified in the design and functional specifications, we tested uFind and made changes as was dictated by the test results. This part of the product development cycle was also a valuable experience where we all learned to analyze the firmware and hardware designs that had been implemented. Most importantly, with technical and implementation decisions to be made at various stages of the development cycle, we learned that team work was vital where each of us learned to listen, contribute, and concur to make decisions as a team.

12. Conclusion

Losing one's vehicle in large and crowded parking lots and the use of lock/unlock or panic buttons to locate them are frustrating to the driver and others. In an attempt to locate our cars, we have probably used both these means. However, these activities have repercussions that affect all of us: people ignore car alarms and car alarms, meant to convey that the driver is in panic or the car has been broken into, don't get the attention of the people.

The uFind conveys proximity and direction of the vehicle without any disturbance. There are various improvements that the uFind could use to perfect the system: portability with the use of a fractal antenna and circuitry on a PCB to resemble conventional FOB key sizes and response speed with the use of a communication protocol.

Weiibo Inc. members have been successful at following and meeting their schedules, matching the estimated budget with the total cost, and deviating very little in the implementation of functionalities and designs as specified in the functional and design specifications respectively. By starting the project several months prior to the start of the semester and organizing all the aspects of the project efficiently, we have successfully presented the uFind on April 7, 2008.

The project would not have been possible without the tremendous support and help from Patrick Leung, Steve Whitmore, Brad Oldham, and Jason Lee: our sincere appreciation and thanks. We would also like to thank the Engineering Science Student Society (ESSS) for providing us with the funding and all the staff and faculty of the School of Engineering Science, SFU, who helped us with their expert advice on our project.

References

[1] Weiibo Inc. Technical Staff, "Functional Specifications for the Wireless Parked Car Finding System (UFind)," Weiibo Inc. Burnaby, BC, Canada, 2008

[2] Giga Quotes Staff, "Forgetfulness Quotes & Quotations Compiled by GIGA," GIGA Quotes, para.7, April 9, 2008 [Online]. Available: http://www.giga-usa.com/quotes/topics/forgetfulness_t001.htm [Accessed April 11, 2008].

[3] Weiibo Inc. Technical Staff, "Design Specifications for the Wireless Parked Car Finding System (UFind)," Weiibo Inc. Burnaby, BC, Canada, 2008

[4] Weiibo Inc. Technical Staff, "Proposal for a Wireless Parked Car Finding System," Weiibo Inc. Burnaby, BC, Canada, 2008