ENSC 305W/440W Grading Rubric for Post-Mortem

Criteria	Details	Marks
Introduction/Background	Introduces basic purpose of the project. Includes clear background and motivation for the project.	5 **/05%**
Body of the Document	Provides a high-level description of main functions and project modules. Outlines materials, costs, and schedule (both estimated and actual).	14 **/15%**
Problems/Challenges	Outlines major technical challenges encountered. Explains how these were resolved. Details any major changes in scope and design.	5 **/05%**
Group Dynamics	Includes a discussion of how the team was organized, any problems that arose, and how they were resolved	5 **/05%**
Individual Learning/Work-load Distribution Chart	Includes a one-page, individually written reflection upon what was learned from the project, both technically and interpersonally (each team member writes a page about their learning experience). **The workload distribution chart outlines major technical, administrative, and support tasks and indicates who participated significantly in those tasks.**	25 **/25%**
Conclusion/References	Summarizes outcome and evaluates the project. Includes discussion of future plans, if any (or explains why project will be abandoned).	10 **/10%**
Meeting Agendas/Minutes	Includes an appendix that provides all the meeting agendas and minutes produced by the team over the course of the semester. (NB. Neatness does not count here.)	20 **/20%**
Presentation/Organization	Document looks like the work of a professional. Ideas follow in a logical manner. Layout and design is attractive.	5 **/05%**
Format Issues	Includes title page, table of contents, list of figures and tables, and references. Pages are numbered, figures and tables are introduced, headings are numbered, etc. References and citations are properly formatted.	5 **/05%**
Correctness/Style	Correct spelling, grammar, and punctuation. Style is clear, concise, and coherent.	4 **/05%**
Comments		98

Post Mortem Report for Wireless Electronic Price Tag System

AccuTag by Precision Wireless

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1 Introduction

The AccuTag System by Precision Wireless is an eco-friendly wireless display solution, which is also a feasible replacement for the traditional paper price tags. With efficiency and coordination at its foundation, the AccuTag system was developed to better enhance the supermarket experience for both the stores and their customers. In a world that incorporates competition in all aspects, product price changes are inevitable and can occur on a daily basis in order to keep company revenues high. This creates problems in terms of allocating time and resources for updating the prices on in-store shelves. Our system, consisting of a number of E-ink display price tags and a central transmitter, allows for these price tags to be updated almost instantaneously creating no complications for the stores and their consumers after initial installation.

The AccuTag central transmitter unit isinterfaced with a computer or a server from which it will obtain updated prices for individual items and broadcast the data to the AccuTag E-Ink price tags using radio frequency transmission. The AccuTag price tags come with a receiver which picks up the signal and updates the product name, information, barcode and price at the click of a button on the central computer. Much time and consideration has been taken into picking a screen with low power consumption, high visibility and long product life. A key feature of the E-Ink price tags is the ability to retain all information on the screen regardless of input power allowing for product information and prices to remain for a long period of time, changing only when a request is initiated. This offers a sustainable solution requiring minimal maintenance.

The function of the AccuTag system is substantial for supermarkets around the world. It is an essential upgrade from paper price tags and allows an abundance oftime, money and paper to be saved. Stores will no longer require extra personnel responsible for the updating of pricesresulting in no more mishaps for customers regarding correct prices.Overall it is a state of the art design that Precision Wireless takes utmost pride in and encourages all supermarkets to begin implementation of our wireless electronic price tag system.

2 System Overview

The AccuTag system by Precision Wireless will allow retailers and supermarkets to replace a portion or all of the price tags in their store with digital tags that can be updated automatically via a price catalogue. For optimal visibility and minimal power consumption the AccuTag price tags use E-Ink technology as well as single-chip ATmega256RFR2 RF Transceiver/microcontroller.

The operator of the system will need to connect their database to the AccuTag transmitter unit. The default host program that comes with the system will monitor their database for changes to prices and update the displays accordingly.

Maintenance will be absolutely minimal; the price-tags will need to be re-equipped with new batteries once they're drained and the transmitter may occasionally need some miscellaneous maintenance. Otherwise, once the system is configured correctly the store operators can essentially forget about having to change prices around the store.

Below is a block diagram of the overall system with its hardware and software components.

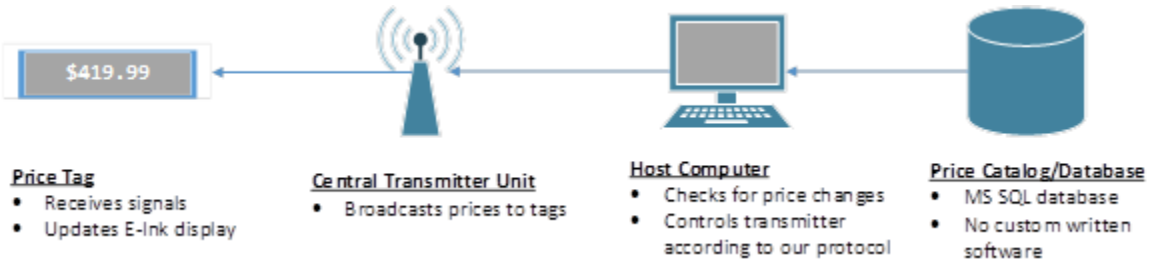

Figure 1 - Block Diagram of AccuTag System

2.1 Hardware Overview

In terms hardware components, we implemented and designed a full production standard PCB board for the AccuTag E-Ink display which was intended for manufacturing purposes.

Other hardware related components were related to proper product selection in ensuring that our functionality as outlined in the functional specification document was fulfilled.

2.2 Hardware Challenges

2.2.1 E-Ink Display

Unfortunately due to some unforeseen issues with the display some of the deadlines were needed to be postponed throughout the course of the project. The faulty Seeedstudio E-Ink Display Shield that was purchased delayed the prototype development. The integration of the database and user interface required trying out different display techniques to obtain the optimum results. Therefore, majority of the tasks were depending on how the information is displayed on the E-paper. Finally after choosing the Pervasive Displays EPD great portion of the tasks had to be modified and even a few tasks including the creation of the character bitmaps had to be added. We were also very optimistic when predicting the final date of the project as we were expecting the first week of December to be our deadline. Fortunately with considerable efforts from all the team members we were able to make up for the lost time and finish the project by the deadline. Although we missed on a few details that were promised on the proposal document, overall we are confident that the prototype can be ready for manufacturing after performing a few minor changes.

2.2.2 Printed Circuit Board Design

In hardware design there were few problems that we faced. The first major problem was the unavailability of many hardware parts in the Eagle library for which we decided to use alternative components that were the closest in terms of functional and operational specifications. Furthermore, we faced many challenges in routing the rat's nest prototype while we were placing the components in the PCB board file. The Eagle software was not very smart in terms of creating 0 degrees and 45 degrees traces. Also, it could not fully route our circuit due to the complexity associated with it. This was the most crucial part of our hardware design, since none of us had experience of manually tracing the circuit components. Along with this, we were completely unacquainted with so many of PCB design rules. There were so many of these that one could have easily ignore them while completely relying on the software itself. For instance the minor aspects of the design such as drill hole sizing, via sizing, minimum trace width, via placements and the number of layers etc, were all very important decisions. We were very fortunate to have these issues discussed with Lucky One (course instructor) and Fred Heap (lab technician) in advance, both of whom had practical PCB design experience. This way, we had final PCB design reviewed by Fred, which assured us of the accuracy and accomplishment of our goal.

2.3 Software Overview

The project consisted primarily of firmware in which there were several task divisions: Host computer integration with central transmitter unit, receiver and E-Ink integration, E-Ink driver initialization and E-Ink screen display. All software was done through the use of Atmel Studio 6 in C programming language.

Figure 1 above is a high level view of all the software components of the AccuTag system and brief description of what each one is responsible for.

Price Catalog/Database - the software here is not written by the Precision Wireless team. It is simply a Microsoft SQL server that's been setup with the proper table schema and is accessible by the host computer.

Host Computer – this component's role is to check for updated prices in the database then use some APIs to relay this information to the transmitter. This and the transmitter communicate according to a simple protocol discussed later.

Central Transmitter Unit – the program on this device waits for new messages from the host computer then broadcasts a new price update accordingly.

Price Tag – these units await new packets from the transmitter. If the packet is meant for them they parse the packet and use it to update the e-ink display.

Complete implementation of each component was necessary in order to have the final complete AccuTag system. The host computer required proper connection with the central transmitter unit through the COM port. The central transmitter then had to be implemented to send the proper signal to the receiver on the E-Ink price tag. The E-Ink driver and controller then had to be powered on and initialized before decoding the receivers signal and calling the appropriate functions to update the E-Ink display. All software teams created their programs to implement flawless integration which thus ensured a working final product.

2.4 Software Challenges

Challenges faced by for software development was the initial startup. None of the Precision Wireless team members had worked with Atmel's development studio or libraries before. Several days were spent at the start exploring the framework of an example project provided by Atmel before we found out how to structure our program on top of the framework.

2.4.1 Host and Central Transmitter

The next challenge faced was figuring out how to communicate with the transmitter through computer-hosted software. At first we thought we would have to resort to low-level USB functions but this did not turn out to be fruitful because there wasn't any documentation or sample code to use as a reference. We instead decided to "piggy-back" on the serial COM connection that was already available to us. Messages from the transmitter to the computer were done through printf.

We found out that the C library provided by Atmel requires you to jump through some hoops before scanf (used to send messages from the computer to the transmitter) worked properly. A few more days were spent exploring other options before we discovered a function for receiving a single byte on the COM port. We used this function to create some of our own IO methods and from there it was smooth sailings.

2.4.2 E-Ink Display

As explained in the design specification, there was a six step process in order to properly configure the E-Ink display to power on and write data from the memory onto the E-Ink display. As none of these steps were implemented for the Atmega256RFR2 Xplained Pro board, this proved to be the greatest challenge in our project. Specific steps explained in the data sheets for the Pervasive Displays E-Ink had to be followed with utmost precision in order to ensure that the E-Ink would even power on. SPI commands and their timing control signals had to be configured to properly communicate between the microcontroller and the COG (Chip on Glass) driver. Since the maximum clock that the display could accept was 12MHz and the only clocks available on our microcontroller was 16MHz and 32MHz, we had to use clock division to obtain the perfect 12MHz signal that we required.

In terms of powering and initializing the COG driver, we were required to create a whole function from scratch for controlling the PWM (pulse width modulation). The same story goes for the SPI data transfer function as there was no existing examples in order to gain information or help. Just powering and displaying took the major bulk of our project time and resources, which took almost till the day of the demo to complete. We realized that choosing a microcontroller with little reference required a huge learning curve, however due to the functionality of the Atmega256RFR2 board, we now believe this was the best product for our project.

3 Cost and Materials

As previously reported in earlier documentation, Precision Wireless was granted funding from ESSS for an amount of $600.00. After realizing that our project might require further funding, we also applied for the Wighton funding which in the end we did not use. Luckily due to the refund on the initial Seeeduino E-Ink display, we were able to purchase the new Pervasive EPD display which deemed much cheaper and more reliable. The table below outlines the projected costs at the beginning of the semester and the final tabulations after our capstone project was complete.

Projected Costs		**Actual Costs**	
Dot Matrix Displays	$40	ATMEGA256RFR2-XPRO Eval kit (Rx side)	$51
E-ink display	$120	ATM256RFR2-EK Eval kit (T side)	$361
Tx/Rx Evaluation kit (with mcu$_s$)	$450	Seeedstudio -E	$74
Circuit Components	$50	Pervasive EP	$58
Miscellaneous	$150	Miscellaneo	ators) $48
Total projected costs	**= $810**		**sts = $592**
			SSEF = $600
			g surplus = $8

Table headings go above

Table 1 - Initial and Final Project Cost Breakdown

The Precision Wireless team would like to thank the ESSS for funding this project and for committing their time and resources to listen to our project proposal along with providing us with the necessary amount to complete our project. We would also like to thank Dr. Andrew Rawicz for allowing us the opportunity to use the Wighton funding in the case that we were short on funds. Even though we were right on budget, this project would not be possible without the knowledge that the professors of SFU were ready to provide us with any accommodations necessary for completing this capstone project.

4 Scheduling

Gantt chart would be better.

Milestone	Projected Milestone Date	Realized Milestone Date
Project Planning/Proposal	Sep 26th	Sep 26th
Design	Nov 4th	Nov 7th
Prototype Development including Transmission Coding,Display programing	Nov 20th	Nov 25th
Database and user interface	Nov 20th	Nov 22nd
Integration and Assembly Test	Nov 25th	Nov 28th
Project Closure	Nov 29th	Nov 29th

Table 2 - Projected and Realized Milestones

In order to obtain the deadlines we had set for ourselves, we planned optimistically a set of milestones at the beginning of the semester for a smooth process throughout the course of the project. However, due to the dependencies on parts arriving and problems that occurred during the way in terms of the Seeeduino E-Ink display, there were major changes that were required to be made in our milestones in order to ensure the proper completion of the AccuTag system. As observed in the table above, even with the drawbacks that we faced, the project still progressed almost as planned and we were able to fully complete our project on the expected date.

5 Group Dynamics

The Precision Wireless team was split into individual tasks each correlating to specific skill sets. In terms of hardware of the E-Ink, Tauseef was the main PCB design lead. In terms of E-Ink firmware and implementation, Joemini, Mayhar, and Steven worked on the software for initialization and displaying of the E-Ink display. David was the lead software developer for the host computer and central transmitter.

Our group was adaptive and fully dynamic in the sense that areas that required extra assistance would have additional help from one or more individuals in order to fully satisfy the specific task. As our project required that every step of the way be error free, integration was done on a whole throughout the project procedure with exchange of ideas and design in order to ease the final integration at the end of the semester.

There were no problems with group dynamics throughout the semester as the team worked well and proficiently together. All members were hard working and were willing to help in other sectors when time was available. Meetings were conducted twice a week at the beginning of the semester and were later reduced to once a week in order to keep all processes running streamlined and in parallel. Overall the project would not have succeeded if it was not for the dedication and perseverance of the Precision Wireless team on a whole.

6 Individual Learning

6.1 Mahyar Mehran

During this semester I had the opportunity to be a part of the AccuTag capstone project. It was a unique and interesting experience to develop a prototype in 70 days. I had the chance to experience and witness various design considerations and challenges that a team of developers have to face before the product enters the manufacturing stage. This project has provided me with hands on knowledge and an insight into how a prototype evolves through various stages of development before it can be mass-produced and marketed in a competitive industry.

I worked on various tasks including hardware design, implementation and testing. After project selection, our team started brainstorming about the functional specifications that are suitable for the prototype. Based on the specifications that we decided upon and my prior experiences, I was given the tasks of utilizing the most suitable technologies for transmission and processing. Furthermore I was involved in various stages of hardware and firmware integration. I started the work on the AccuTag display unit by integrating the Atmel RF development board with the E-ink shield. I was then responsible for initialization various tools and libraries for the

development of prototype firmware including the GPIO and Chip on Glass (COG) drivers set up. Since we were also required to produce a hardware design and PCB layout of the final prototype, I had the chance to work with Altium Design software to develop high level block diagrams and schematics of the final prototype. Finally, I used SketchUp to design a 3D model of the AccuTag cover which was then printed using the Makerbot 3D printer at the micro instrumentation Lab at SFU.

The team dynamics within our team during the semester was quite good. However, we had put a lot of planning and research into our project before the start of the semester, we ran into some unexpected issues along the way. Fortunately we were able to overcome those milestones and finish the project on time and within budget. I had the pleasure of working with great team members that performed their tasks carefully and in the best way possible. I learnt to take advantage of the useful feedbacks that I have received on my work to improve on the quality of the final work. I also learnt to practice patience and foresight in performing my duties and tasks so that necessary changes can be made easily and in a timely manner. I am confident that the skills that I have acquired over the course of this project will make me a better engineer in the future and a better team player for my colleagues and co workers.

6.2 Joemini Poudel

Capstone Project was billed as the holy grail of engineering undergraduate projects and in no ways did it disappoint. Even though the engineering skills applied in this project were quite new and had a steep learning curve, the skills that I have exclusively acquired through the course of this semester have been managing group dynamics, resourcefulness, scheduling as well as time constraint decision making. In some ways, capstone project feels like a crescendo in my undergraduate degree where the cumulative experiences of my coop, courses as well as resourcefulness have been tested in an arduous manner.

My role within the course of this project has evolved and has adapted depending upon the needs of the project. Firstly, when individual roles were assigned at the beginning of the term, I was assigned to program the receiver of the AccuTag system. I had begun researching on the AVR MAC layer and with David had decided on a packet protocol to receive, parse and send control signals to the E-paper display. However after the first two months, the e-paper display that we had previously decided upon for our system had to be replaced because of hardware issues. Since, the new e-paper display arrived a week later and since work on the new e-paper display had not progressed to the extent our group required I had to step in as I had quite a bit of experience with firmware. Hence, I was assigned the task to drive the e-paper display in the first week of November and in the next three weeks I was engaged in driving the e-paper display. In terms of the challenges faced to program the e-paper display, the novelty of the technology proved quite a stumbling block. Since, the technology was novel the resources as

well as information online was very limited. Furthermore, since I had bit of experience with programming regular LCDs, I had assumed the e-paper display would be quite similar. However, this was not the case as the e-paper display in terms of its initialization as well as its display pattern was completely different to regular LCDs. Thus, I had to approach the problem in a step by step basis i.e. I had to make sure every module namely PWM, SPI, ADC modules were working perfectly before I integrated all three modules for display and initialization of the e-paper display. The major challenges that I faced while driving the e-paper display were primarily the short frame of time within which I had to work in.

Furthermore, for integration with the receiver we had to design a bitmap library for all the characters (A-Z and 0-9) which was conducted simultaneously when the driver module for the e-paper display was being written. This turned out to be particularly challenging for the people working on the bitmap library as they were devoid of any visual feedback as the driver module for the e-paper display had not been completed.

Moreover, team dynamics within our team during the semester was quite good. The delegation and completion of tasks were done in a very efficient manner. Additionally, working amongst the other Precision Wireless team members, I got to practice revising my own implementations and to reflect upon other team member's valuable feedback in a timely manner. All in all, even though Capstone has been quite a grueling and stressful experience, I feel by the end of this process I am a much better engineer.

6.3 David Negrabee

At the beginning of the semester I was very excited to get to work on this wireless price tag system. I was the one who initially came up with the idea and our team members all really liked it. I was even met with enthusiasm from Lucky One when I proposed the idea last semester which was even more encouraging. Having the chance to work on a complex project such as this with a group of friends sounded like a lot of fun but I did not count on the various difficulties we would face.

We were all quite busy this semester but we managed to keep our communication at a sufficient level whether it was via meetings, emails or texts. The bulk of my work began once the Atmel development kit was shipped to us. I was initially tasked with researching how to make two wireless nodes "talk" to each other. My job was to basically find out how RF communication could be programmed on the boards.

As far as the RF portion of the project went, I was only supposed to work on the transmission of wireless signals to the price tag units, however blindly sending signals was meaningless unless I could verify that they were being received so in the end I also wrote the logic that received signals and parsed the data when it was integrated with the e-ink display.

I initially started by running an example project that was provided by Atmel. This was probably the most challenging part of the project. The framework and library written by Atmel is very complex and somewhat obfuscated with many nested levels of callbacks, #define macros, functions and such. But after a few days of exploring the code I figured out which parts were required for sending RF messages and where my program's logic would be written. From there I came up with our initial packet format and within the span of a day I figured out how to send, receive and parse packets. Of course it took a lot more work to refine the code to make it more maintainable and flexible for future changes. This was shortly prior to the progress report meeting.

The next step was to figure out a way to control our transmitter through computer-hosted software. At first I thought I would have to handle this with some low level USB functions. I started out by downloading some sample USB related projects from Atmel but none of them were meant for our board and they weren't quite what I was looking for either. At some point I realized that this whole time that I was testing the transmission and reception, I was using printf to send messages to my IDE through a COM connection. So it immediately became clear that all I needed to do was communicate via the same COM port. Output was easy, printf was working right out of the box. Input was the difficult part. Atmel's standard C library requires some special setup code to be written in order for scanf (the input counterpart of printf) to work properly. Rather than doing this I found a function inside the serial IO header file which received a single byte from the USB connection. Since this IO port was not buffered anyway, there wasn't a way to make it any faster. From there I wrote some of my own functions for receiving message from the COM connection.

Writing the computer-hosted software was not very difficult. Since I chose to work with C# I had the convenience of the .NET framework to lean back on. There is a SerialPort class that makes it very easy to open and talk on COM connections. I installed and set up a SQL Server database on my laptop next and created table for storing item information. The .NET framework also has classes for conveniently making SQL queries as well. Before long I had a program written that would monitor the database for changes, figure out what the changes were then send those changes to the transmitter which would then send them as packets of data to the price tag units.

It wouldn't be accurate to say the execution of this project went smoothly. I think one thing that we all needed to improve on was scheduling. Had I known how much of my time capstone would take, I would not have enrolled in three other courses this semester. We were also quite late to start on our implementation. We received the parts at the start of October, at the same time that my first wave of midterms began. So even when I had the parts it took a while until I had enough free time to start working on it. Aside from that I also think there was some room for improvement in terms of communication. Although this wasn't very detrimental to our project since the RF and e-ink developments didn't require us to communicate; we were able to work separately and integrate later. Overall, I gained a lot of technical experience from working on this. I also learned a great deal about working well in a team of peers and managing my time more wisely.

6.4 Tauseef Alwaris

I would deem the Capstone Project as the bulk of engineering science projects I have worked on so far at SFU. It helped me reflect back on what engineering skills I have learned over the past few years and how well I can use them in order to approach a certain problem. Throughout my undergraduate courses at SFU, I have been going through a thought developing process on problem solving and it was Capstone Engineering science project that tested this skill of mine to tackle both technical and interpersonal problems related to this project.

Being the main hardware lead at Precision Wireless, I took the full responsibility of designing complete hardware design for our project. Ahead of the actual design, I identified major hardware components such as SPI port and FPC connector etc within E-ink display shield. Due to unavailability of data sheets for our old E-ink display, we had no idea of programming and interfacing this new device. This was the most challenging part of our project and it was my responsibility to do my best in terms of research to identify the pin connections needed to program the EPD display. I figured out the pin connections and wiring layout by analyzing the Gerber files associated with the hardware design. After we moved to the new EPD shield (because of hardware problems), once again my job was to figure out the pin connections for microcontroller-EPD interfacing. It was more like a green light for us to advance with our tasks once the wiring configurations and basic hardware components were clear to the software team. Furthermore, I optimized the final AccuTag hardware design by combining the display module and the receiver microcontroller into one unit. As per hardware design requirements, I prepared hardware schematic and PCB layout for the final display prototype using the Eagle software. I selected all the necessary electronics components out of both modules and added to them to the schematic file in Eagle. There were many parts that were not predefined in eagle library or any other online libraries for which I had to pick substitute parts that were the closest to the original parts both in terms of functional and operational requirements. After consulting with experts in PCB design such as Lucky One and Fred Heap, I was finally able to revise the final PCB design of our product. Although it took two full weeks to learn the software, it was worth it to accomplish the major milestone of our product's hardware design.

The four month project not only helped me acquire engineering skills but also made me realize that strong team work skills such as team coordination and team integrity, are equally vital to technical skill set in order for a successful execution of any project. It was our hard work, dedication and the persistence of our team that paid off and helped us accomplish our goal. I am very delighted that I take away from this course many significant skills: PCB design, finance administration, project management, team organization and above all, professionalism. Since Capstone project has tested my cumulative skills, I genuinely think I am ready to step in the industrial world and I am quite sure this is the closest I would get to Engineering work culture.

6.5 Steven Hoang

In spite of being a biomedical engineering undergraduate student, the idea for this project had no relation to some of the concepts learned through my specialization courses. Instead, from a discussion between members the semester before this term, we decided on an actual project that would be worth marketing. Due to previous work experiences in the supermarket industry, it seemed like wireless digital price tags would be a compelling project to work on not only for the sake of capstone but for interest and actual real world usage. In an attempt to sum up the knowledge gained through many years at SFU and to venture into unknown fields of engineering, we chose a difficult yet satisfying project to make our final engineering project memorable.

Roles in the project were assigned at the beginning of the semester and I was initially in charge of the firmware relating to the Seeeduino E-Ink display in terms of powering the LCD and programming it to display the required information. After weeks of playing around with the first E-Ink display using Arduino Mega, I was able to display full product information in terms of product name, price and information. This took much longer than expected due to poor connection problems relating to the SPI which was deemed to be a product malfunction. Regardless, deadlines were required to be met and integration with the ATmega256RFR2 Xplained Pro was initiated which included analyzing the code given for Arduino and trying to understand how the E-Ink was programmed. After full group consent and due to lack of proper datasheets, the Seeeduino E-Ink display was scraped and a new E-Ink display from Pervasive Displays was purchased. I aided with pin configuration and analyzing example code for the new E-paper display along with a full analysis of the datasheets in order to explain the steps necessary to the software team in charge of powering the new display. After the COG driver was powered and the E-Ink initialization was complete, I was in charge of designing the character bitmap library for letters A-Z along with numbers 0-9 for price, product name, product info and barcode. The sizes ranged from 32x32 pixels for product name to 66x48 pixels for price. After the character map was created with the aid of a program called The Dot Factory, functions were created to display name, info and price at proper locations on an image array before it could be sent to the E-ink display. This was a trial and error step that required many revisions of character bitmaps to be created and slight manipulations of character position to obtain a proper visible final image.

Overall, through the process of designing AccuTag and working with my fellow group members, I developed many skills which I previously did not have in terms of understanding firmware, interpreting and implementing data from a variety of sources, sharpening my C coding skills and most importantly, adapting to any problems or drawbacks in order to complete tasks in a ordered and timely fashion. As an engineer, I feel that solving problems is our greatest concern and due to the huge setback halfway through the semester, it allowed me to get a full grasp on the expectations I should have if I were placed in a project group later in my working career.

7 Work Distribution Chart

	Task Name	Duration	Start	End	Resources
1	**Capstone**	**63 days**	**09/09/2013**	**04/12/2013**	
2	**Documentation/Presentations**	**58 days**	**16/09/2013**	**04/12/2013**	
3	Project Proposal	6 days	16/09/2013	23/09/2013	Dave;Joe;Tauseef;Steven;Mahyar
4	Functional Specifications	11 days	01/10/2013	15/10/2013	Joe;Tauseef;Steven;Dave;Mahyar
5	Milestone: Functional Specifications Report Due	0 days	16/10/2013	16/10/2013	
6	Design Specifications	12 days	21/10/2013	05/11/2013	Dave;Joe;Tauseef;Steven;Mahyar
7	Milestone: Design Specifications Report Due	0 days	06/11/2013	06/11/2013	
8	Progress Presentation/Demo - part 1	4 days	14/10/2013	17/10/2013	Dave;Joe;Tauseef;Steven;Mahyar
9	Presentation/Demo - part 2	4 days	04/11/2013	07/11/2013	Joe;Tauseef;Steven;Dave;Mahyar
10	Written Progress Report Preparation	10 days	18/11/2013	29/11/2013	
11	Milestone: Written Progress Report Due	0 days	02/12/2013	02/12/2013	
12	Milestone: Final Presentation/Demo - part 3	0 days	03/12/2013	03/12/2013	Joe;Tauseef;Steven;Dave;Mahyar
13	Post-Mortem	9 days	22/11/2013	04/12/2013	Dave;Tauseef;Joe;Steven;Mahyar
14	**Research**	**54 days**	**09/09/2013**	**21/11/2013**	
15	Project Selection	6 days	09/09/2013	16/09/2013	Joe;Tauseef;Steven;Dave;Mahyar
16	Cost Benefit Analysis - part 1	4 days	09/09/2013	12/09/2013	Tauseef;Joe;Dave;Steven;Mahyar
17	Environmental Risk Assessment - Part 1	5 days	11/09/2013	17/09/2013	Joe;Tauseef;Steven;Dave;Mahyar
18	Modulation and Demodulation Schemes (WiFi, Bluetooth, RF ...	6 days	12/09/2013	19/09/2013	Dave;Steven;Tauseef;Mahyar;Joe
19	Cost Benefit Analysis - part 2	10 days	21/10/2013	01/11/2013	Mahyar
20	Environmental Risk Assessment - Part 2	10 days	08/11/2013	21/11/2013	Joe
21	**Hardware**	**53 days**	**12/09/2013**	**25/11/2013**	
22	Initial Component search (Transceiver and Display)	5 days	12/09/2013	18/09/2013	Joe;Mahyar;Tauseef;Steven
23	Component compatibility check	4 days	16/09/2013	19/09/2013	Mahyar;Joe
24	Hardware Integration	26 days	21/10/2013	25/11/2013	Joe;Steven;Tauseef;Mahyar
25	Phase I completed	0 days	28/10/2013	28/10/2013	
26	Phase II Completed	0 days	18/11/2013	18/11/2013	
27	**Transmitter (Main Controller) Prototype**	**41 days**	**27/09/2013**	**22/11/2013**	
28	Rat's Nest Prototype #1 (using DEV board)	20 days	27/09/2013	24/10/2013	Mahyar;Dave
29	Architecture Design Prototype #2	14 days	14/10/2013	31/10/2013	Mahyar
30	Simulations/debugging	14 days	28/10/2013	14/11/2013	Mahyar;Joe
31	PCB Layout Design Final Prototype	10 days	11/11/2013	22/11/2013	Mahyar;Joe
32	**Price Tag (Display) Prototype**	**41 days**	**27/09/2013**	**22/11/2013**	
33	Rat's Nest Prototype #1 (using DEV board)	20 days	27/09/2013	24/10/2013	Tauseef;Dave
34	Architecture Design Prototype #2	14 days	14/10/2013	31/10/2013	Steven
35	Simulations/Debugging	14 days	28/10/2013	14/11/2013	Steven;Tauseef
36	PCB Layout Design Final Prototype	10 days	11/11/2013	22/11/2013	Steven;Tauseef
37	**Software**	**48 days**	**23/09/2013**	**27/11/2013**	
38	Programing the Controller and Display Prototypes #1	30 days	23/09/2013	01/11/2013	Dave;Mahyar;Tauseef
39	Building the computer Interface	30 days	01/10/2013	11/11/2013	Dave
40	Firmware Implementation & Integration	33 days	14/10/2013	27/11/2013	Joe;Steven;Dave
41	Firmware Debugging	28 days	21/10/2013	27/11/2013	Tauseef;Mahyar
42	**Testing**	**3 days**	**28/11/2013**	**02/12/2013**	
43	Final Prototype Testing	3 days	28/11/2013	02/12/2013	Joe;Tauseef;Steven;Dave;Mahyar

Table 3 - Work Distribution Chart

8 Conclusion

The Precision Wireless team's execution of the AccuTag system has been a successful one. We were able to deliver a fully functional prototype of the wireless price tag system that we came up with at the start of the semester. Some of the functional and design specifications had to be discarded, mainly due to our time constraints but the prototype we built was an excellent realization of the system's overall objective, which was to wirelessly update e-ink price tags. There were several challenges faced along the way, as we expected. There is room for improvement for us in terms of scheduling. The biggest challenge we faced this semester was finding times to work on the project as well as documents for Ensc-305. Communication was facilitated well via whatever was convenient. We aimed to use canvas more spuriously at the start but it quickly became apparent that none of us wanted to have to check the website constantly. The writing for the Ensc-305 documents were divided up evenly and one team member was in charge of "gluing" everyone's parts together. The technical work was divided up according to the team members' abilities and the free time they had. Overall, the Precision Wireless team is very proud of what we have delivered this semester and hopes that the AccuTag system may one day make its way into the market.

A. Appendix - Meeting Minutes

Meeting Summary (September 15, 2013):

All team members were present, and following topics were covered:

1- Meeting times: *as discussed by all group members the meeting times are as following:*

Mondays and Wednesdays: 10:30 – 12:15

Fridays: 2:30 – 4:30 in case there is no 440 lecture; or 4:30 – 6:30 if thereis.

NOTE: attendance for all group members is mandatory unless 24 hour prior notice and update is provided to the group leader or at least 2 of the members are updated with current status of the tasks that were undertaken by the person taking the absence.

2- Project selection: *Finalized our project idea by considering what is out there already and what needs to be in the market instead. Considered the available technology to make such improvements.*

- Considered and researched the competitors in the current market and their design pros and cons.
- Discussed the functional specifications of the final prototype.
- Researching the super markets and their use of similar devices and trying to account for shortcomings such as the battery life (more than 5 years) and display visibility (for prices, characters and sale items) and communication options available.
- Looked at available technology such as single chip communication and processing for faster and more compact processing while running on low power. Atmel has great line of products for RF Transmission and processing.
- Researched available displays for low power consumption and high visibility. DOT matrix and e-ink are good options so far…
- Looking at possibilities for the integration of the LCD with
- Including LEDs and etc. for further notifications such as low batter, lost signal, sale items, and…

3- Applying for the project Funding: *Considering available options for funding and resources. ESSS parts library is a good option and source for parts. Also applied for the Funding through ESSS.*

On the agenda for next meeting: (Monday September 16th, 2013)

- 4. Finalizing the documents for funding and starting the presentation.
- 5. Working on design proposal and resource allocations.
- 6. Assigning individual responsibilities and tasks.
- 7. Discussing functional specifications in details. Battery, size, display options, distance of communication, number of price tags
- 8. Researching the products available for prototype and integration. The transceivers and the display, also the interface of main device (transceiver) with the user/data base.
- 9. Finalizing the design of device after further user interface research. Buttons, LEDs, and etc.

Meeting Summary (September 16, 2013):

All team members were present, and following topics were covered:

4- Finalizing the documents for funding and starting the presentation: *All the members signed the funding application and it was submitted at ENSC office. Tauseef made the presentation. Presentation was later edited by Mahyar and Dave and is going to be uploaded on canvas.*

5- Working on design proposal and resource allocations: *Mostly not done, some research done by Joe, Steven and Mahyar on design proposal and product selection but no tasks assigned so far except for Dave. Dave was given the AVR raven starter kit to start working on software development.*

> *NOTE: The prototype (3 Atmel AVR Raven development boards + Dot Matrix / LCD + USB Transceiver + Programming unit) that we have currently is going to be different than the one that we are purchasing. So it would be good practice but DO NOT UNDERESTIMATE the amount of upcoming tasks at the time of shipment arrival.*

- *Steven found e-ink display website links for the screen only and with the microcontroller unit. Later it was discussed… Can be assembled in house later but could take a long time and be time consuming. Further discussion postponed to next meeting.*
- *Mahyar and Joe researched the Hardware. Found the starter kit to purchase. The total price is (150 +taxes and shipping). Documents available on Canvas under consideration. Mahyar contacted the company for further details about display programming options available on the starter kit. Looking into buying a display module for the ATMEGA256RFR2 starter kit.*

This will have to be discussed further at the next meeting so it will remain first on the agenda.

On the agenda for next meeting: (Wednesday September 18th, 2013)

- 5. Working on design proposal and resource allocations.
- 6. Assigning individual responsibilities and tasks.
- 7. Discussing functional specifications in details. Battery, size, display options, distance of communication, number of price tags
- 8. Researching the products available for prototype and integration. The transceivers and the display, also the interface of main device (transceiver) with the user/data base.
- 9. Finalizing the design of device after further user interface research. Buttons, LEDs, and etc.

Meeting Summary (September 20, 2013):

All team members were present, and following topics were discussed with Lucky:

5. Working on design proposal and resource allocations:

Tasks for writing the proposal were divided (List available on Canvas posted Tauseef). Some clarifications were made in the meeting with Lucky regarding the expectations for the final prototype. He suggests a Rat's Nest prototype (3 boards) and then working towards the next phase or second prototype. That requires hardware architecture design and simulations through SPICE (needs to be clarified more). Next phase would be the PCB layout and schematic design. AnalogDevices is a good source. Also we need to apply for Dean Funding.

Draft Proposal has to be put together and submitted on Monday, Final Document Due on the 26th

6. Assigning individual responsibilities and tasks:

At the meeting with Lucky he suggested to buy three development boards so more of us can work on the prototypes. Hence, tasks are divided into three main groups; Hardware for the Transmitter, Hardware for the Display, and programming the interface and database. Each hardware component requires development of Rat's Nest prototype, hardware design and simulation, PCB layout and schematic design.

On the agenda for next meeting: (Sunday September 22nd, 2013)

- 5. Still not Done
- 7. Discussing functional specifications in details. Battery, size, display options, distance of communication, number of price tags
- 8. Researching the products available for prototype and integration. The transceivers and the display, also the interface of main device (transceiver) with the user/data base.
- 9. Finalizing the design of device after further user interface research. Buttons, LEDs, and etc.

Meeting Summary (September 22, 2013):

All team members were present, and following topics were discussed:

5. Working on design proposal and resource allocations:

Mainly was spent working on the proposal and submitting the draft. First draft of the schedule and Gantt chart was made, and to be modified before the final submission.

Note: Due to lack of planning and communication this draft was not done well, therefore the deadlines assigned for the future documentation tasks will be 3-4 four days in advance to the draft deadline to provide more time for editing and discussions.

To be addressed further at the next meeting.

6. Assigning individual responsibilities and tasks:

Refer to Gantt chart - draft 1 for details.

On the agenda for next meeting: (Sunday September 29th, 2013)

- 7. Discussing functional specifications in details. Battery, size, display options, distance of communication, number of price tags
- 8. Researching the products available for prototype and integration. The transceivers and the display, also the interface of main device (transceiver) with the user/data base.
- 9. Finalizing the design of device after further user interface research. Buttons, LEDs, and etc.

Meeting Summary (September 29, 2013):

All team members were present, and following topics were discussed:

7. Discussing functional specifications in details. Battery, size, display options, distance of communication, number of price tags

various functional specifications were proposed and discussed. The AccuTag should diplay various information such as name and information of the product, price, and include notification LED to display sale items. Battery is required to operate the device as a stand-a-lone mode both for the main transmitter and the AccuTag display. Number of the price tags and is also decided to be one for the fist prototype and shall be increased for future products.

8. Researching the products available for prototype and integration. The transceivers and the display, also the interface of main device (transceiver) with the user/data base.

Researched various online or in-store electronic resources and so far few candidates for e-paper display has been found. The required microcontroller/transceiver has also been researched and proposed to be Atmel ATmega256RFR2. Dave is in charge of database and user interface and the due date for that task has been postponed until further functional specifications have been discussed.

9. Finalizing the design of device after further user interface research. Buttons, LEDs, and etc.

Other features of the prototype were also discussed briefly.

On the agenda for next meeting: (Sunday October 6th, 2013)

- 10. Finalizing and ordering the parts
  11. Finalizing functional specifications in more details.
  12. Discussing the design specifications and considerations of the device after further user interface research.

Meeting Summary (October 6, 2013):

All team members were present, and following topics were discussed:

10. Finalizing and ordering the parts

The processor and the transceiver were decided upon and finalized for ordering. Also the display was also decided to be the seeeduino E-INK shield.

11. Finalizing functional specifications in more details.

Other functional specifications and features were also discussed. Including having a long battery life and high contrast display and fast rate of transmission and display updates.

12. Discussing the design specifications and considerations of the device after further user interface research.

All members were assigned tasks to review the required documentation to ensure the project is able to meet the scheduled deadlines on time.

On the agenda for next meeting: (Sunday October 13th, 2013)

- 13. Update of the tasks
  14.Discussing design specifications
  15. Starting the write up for design specifications

Meeting Summary (October 13, 2013):

All team members were present, and following topics were discussed:

13. Update of the tasks

All the members gave an update for the tasks and responsibilities.

14. Discussing design specifications

The design specifications were discussed and members have been assigned to do the necessary research on various topics of interest.

15. Starting the write up for design specifications

All members were assigned tasks to review the required example design specification documentation and start the draft version.

On the agenda for next meeting: (Sunday October 20th, 2013)

- 16. Update of the tasks
  17. Discuss design specifications
  18. Begin the write up for the design specifications

Meeting Summary (October 20, 2013):

All team members were present, and following topics were discussed:

16. Update of the tasks

- All the parts (New Epaper display from Pervasive Displays) have arrived and have been given to group member in charge of that task (Steven, Mahyar, Joemini).

- David currently exploring performance analyzer example project provided by Atmel for RF transmission/reception framework

- Tauseef has begun studying PCB software

17. Discuss design specifications

The design specifications were discussed.

18. Begin the write up for design specifications

The write up was revised by all members all changes have been noted and respective member is assign to revised the assigned tasks.

On the agenda for next meeting: (Sunday October 27th, 2013)

19. Update of the tasks
20. Finalizing design specifications write up
21. Starting the integration of the parts and preparing for the progress demo and presentation.

Meeting Summary (October 27, 2013):

All team members were present, and following topics were discussed:

19. Update of the tasks

- Work on the Epaper display has begun. No example codes to be found so far. Require more research.

- David successful in transmitting and receiving packets between 2 wireless nodes.

20. Finalizing design specifications

The design specifications were finalized and decided upon by all members.

21. Finalizing the write up for design specifications

The write up was revised by all members all changes have been noted and respective member is assign to revised the assigned tasks.

On the agenda for next meeting: (Sunday November 3, 2013)

22. Update of the tasks
23.Finalizing design specifications write up
24.Finalizing design specification

Meeting Summary (November 3, 2013):

All team members were present, and following topics were discussed:

22. Update of the tasks

- David having problems figuring out how to interface between computer software and transmitter unit

- All areas of design in full implementation

- Joemini is examining all source codes available to learn about PWM, SPI and ADC

23. Finalizing design specifications

The design specifications were finalized and decided upon by all members.

24. Finalizing the write up for design specifications

The write up was revised by all members all changes have been noted and respective member is assign to revised the assigned tasks.

On the agenda for next meeting: (Sunday November 10, 2013)

25. Update of the tasks
26.Finalizing design specifications write up
27. Perfecting Design specification

Meeting Summary (November 10, 2013):

All team members were present, and following topics were discussed:

25. Update of the tasks

- David decided to the serial COM connection and some standard IO methods for the problem he was previously faced with

- Datasheets being carefully analyzed and studied for the Epaper display between Steven, Joe and Mayhar

- Tauseef currently working on PCB design

26. Finalizing design specifications

- Due to a extended deadline, design specification will be properly revised and looked up again carefully due to new E-Ink display

27. Perfecting the write up for design specifications

- Finishing touches to design spec to be finished

On the agenda for next meeting: (Sunday November 17th, 2013)

28. Update of the tasks
29. Finalizing design specifications
30. Revising design specification document to be handed in

Meeting Summary (November 17, 2013):

All team members were present, and following topics were discussed:

28. Update of the tasks

- David has successfully finished the host software

- Tauseef has successfully completed the PCB layout with 100% connections

- Steven is working on functions for displaying price, info, name along with character maps

- Joe and Mahyar proceeding with E-Ink initialization, PWM function is complete, SPI function next

29. Finalizing design specifications

- Final parts need to completed by all members today on design specifications hand in to Mike before he gets up tomorrow. Joe, Tauseef and Mahyar are fully done their parts.

30. Revising the write up for design specifications to hand in

- The write up needs to be fully revised by all members and all changes to be made and turned into Steven and David before midnight

On the agenda for next meeting: (Sunday November 24, 2013)

31. Update of the tasks
32. Finalizing Integration
33. PowerPoint presentation

Meeting Summary (November 24, 2013):

All team members were present, and following topics were discussed:

31. Update of the tasks

- There are still issues with the E-Ink display initialization (powering on is complete, data transfer next)

- Functions for displaying name, product info, price and character complete (need testing)

- Character map in progress

32. Finalizing Integration

- Require more time, group meetings for software team to continue throughout the week to work on proper integration and testing

33. Preparing for presentation

- slides must include following:

- motivation, background, overview

- hardware and software components

- budget

- marketing components

- Questions slide

TO DO BEFORE PRESENTATION:

- Powerpoint (Separate Tasks for Slides)

- Get proper dress attire ready --> need group photo for team introductions

- Finish Integration of E-Ink with data reception logic

- Video tape working prototype

- Possible Snacks for Demo? Mahyar to deal with