September 22nd, 2011

Dr. Andrew Rawicz
School of Engineering Science
Simon Fraser University
Burnaby, British Columbia
V5A 1S6

Re: ENSC 440 Project Proposal for an RFID Enabled Smart Fridge

Dear Dr. Rawicz:

Our team at Cyber-Flux Innovations proposes to design and implement a Smart Refrigerator that will keep track of its contents and provide useful information to customers through a website and mobile phone application. The enclosed document outlines our proposed design, provides an overview of the system and its features and, summarizes the planned budget, funding, scheduling and organization of the project.

Cyber-Flux Innovations is comprised of four highly motivated and talented fifth-year engineering students: Damir Jungic (Electronics stream), Mitchell Joblin (Biomedical stream), Renato Pagliara (Biomedical stream) and Steven Verner (Computer stream).

If you have any questions or concerns regarding our proposed project, please feel free to contact us at rfridgeidtech@googlegroups.com.

Sincerely,

Renato Pagliara

Renato Pagliara
Project Lead
Cyber-Flux Innovations

Enclosure: ***RFID Enabled SmartFridge Project Proposal***

RFID ENABLED SMART FRIDGE PROJECT PROPOSAL

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Submitted to: Dr. Andrew Rawicz – ENSC 440
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Issued Date: September 22nd, 2011

EXECUTIVE SUMMARY

The exponential growth of technology during the past decades and its implications on our everyday lives has lead to a mass demand for information and convenience. Social networks and search engines provide information about our friends, our community and our world; all while making tasks such as planning a party and writing an essay much easier. It is this demand for information and convenience which drives the development of smart devices. From cars that park themselves through coffee makers that prepare your coffee to be ready when you wake up to pill bottle caps that let you know when it is time to take your medicine, the world is moving towards active devices which provide more complex services. Smart Appliances alone are expected to surge to $26.1 billion annually by 2019 [1]. Existing high end refrigerators offer internet access, the ability to play music and even complex temperature regulators which make sure that your ice cream will always be creamy. However, none of them take advantage of the vast amount of information that lies in the products stored inside.

Our proposed solution at Cyber-Flux Innovations consists of a Smart Fridge capable of tracking its contents through readily available and user-registered RFID tags. This information will then be stored and processed to provide beneficial applications for the user. The Smart Fridge will allow users to take control of their diet by presenting nutritional information in a user-friendly manner, warn users of products with upcoming expiration dates to avoid wasting food and even help users create their next grocery shopping list based on what they usually buy. All this features will provide users with a convenient way of planning and managing their groceries and eating habits.

The remainder of this document outlines the Smart Fridge system, presents an overview of the system architecture, illustrates the system's features and outlines our strategy to complete this project on time and on budget. We have divided the project into three main areas: hardware integration, system communication and software development. All three areas will be tested separately and after integration to have a complete working prototype by the first week of December, 2011. The entire project has a tentative budget of $980.00 and a funding plan is already in place.

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1. INTRODUCTION

Home automation is a rising trend; people are expecting more and more from the devices they interact with. It is now possible for a shower to know your preferred temperature, or to adjust the lights in a room through your phone. We intend on adding a new "smart" device to the home: the refrigerator. An internet-connected fridge that is aware of its contents will lead to endless possibilities.

With a Smart Fridge, people will be able to see the contents of their fridge through their phones from anywhere! Not sure if you're out of milk? All you need is an internet connection to find out. Further, by keeping track of what items are regularly in the fridge, our system will be able to automatically generate grocery lists and notify users when something runs out. The Smart Fridge will even be able to recommend recipes based on what food is available.

For a lazy teen, the ability to see what's in the fridge without leaving the couch is a novel and attractive idea. However, the convenience of the Smart Fridge means a lot more to individuals who suffer mobility challenges (for example, due to age or disability). The ability to decide what to eat before approaching the fridge can reduce the physical exertion that occurs while physically perusing the fridge, or even save an unnecessary trip. Further, if an individual with limited mobility is brought food by a caregiver, they are conveniently able to make an informed decision about what foods that person will need.

The advantages of the Smart Fridge go well beyond convenience. By keeping track of nutritional information, the fridge will be able to recommend healthier food alternatives. The system will also inform users about how quickly products are consumed. If a mother concretely sees that her child drinks twenty cans of Coke per week, she may change how much Coke is kept in the house! Furthermore, a Smart Fridge will be able to notify the household about upcoming expiry dates. Once made aware of an expiry date, individuals will be more likely to consume the item before it expires, thereby reducing the amount of food that is wasted and saving money.

Many individuals will appreciate the added convenience of a Smart Fridge. Those looking for ways to eat healthier will be able to monitor their food consumption more closely and easily through the Smart Fridge System. However, one of the shining aspects of the Smart Fridge is the ability to cleanly and simply present nutritional information to users as they peruse the fridge's contents online. In this way, we have an opportunity to make nutritional information more clearly available even to users whose forefront concern isn't healthy eating. By appropriately highlighting healthy choices, we believe the Smart Fridge system can significantly assist all users to eat healthier foods.

We propose to design the system presented in Figure 1. The fridge will detect the products that are present inside and relay this information to a server through the internet. The contents of the fridge, as well as the many features introduced above, will be made available through both mobile and web interfaces.

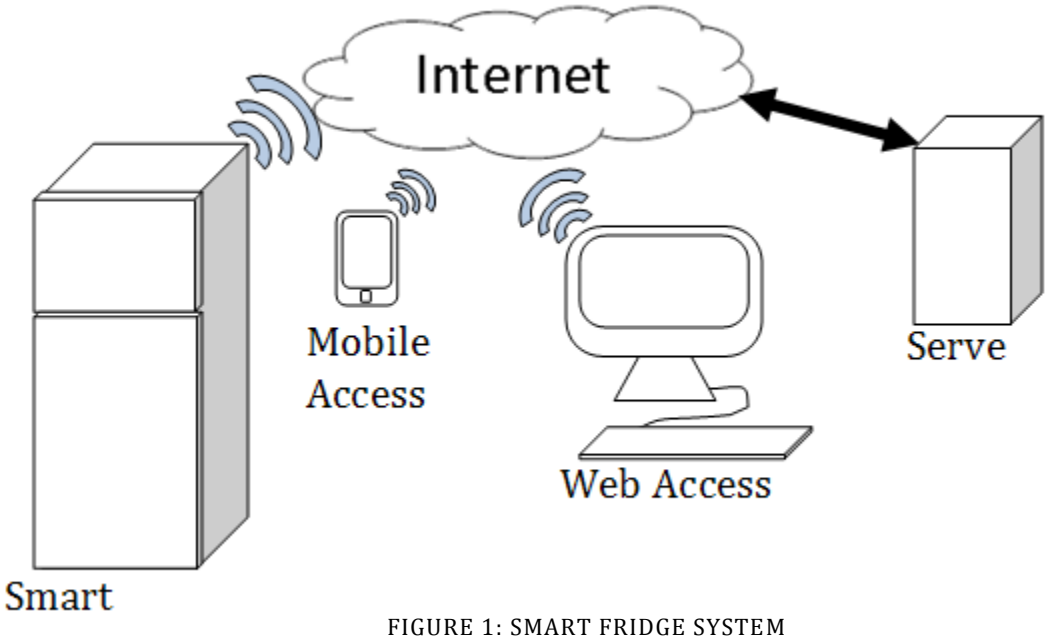


FIGURE 1: SMART FRIDGE SYSTEM

The concept of a Smart Fridge is not entirely new. Discussion about the potential of a fridge that is aware of its contents has being occurring for the past decade. Products currently in the market [2], however, ask users to manually scan in each item as it is added to the fridge. This puts an unacceptable burden on the user, particularly when one considers that a major motivation for the Smart Fridge is convenience. Our system will instead rely on RFID tags present on the products within the fridge, thereby allowing the Smart Fridge to wirelessly read which items are present without asking anything of the user.

Though RFID tags are not currently placed on products by manufacturers, the continually declining costs of RFID tags along with Walmart's expressed desire for such tags to be placed on individual products suggest that the added convenience of RFID tags will eventually outweigh the costs [3][4][5]. Stores like Walmart benefit from RFID tags through both the per-item tracking and further automation of point-of-sale procedures that become possible should RFID tags replace UPC barcodes, which is becoming more and more likely as RFID tags become cheaper and easier to produce [6].

Though our system is built in anticipation of RFID tags replacing barcodes, we will still implement a mechanism for users to manually apply RFID tags to products. Not only does this feature bridge the gap between RFID tagged products and those with only a barcode, but it further allows users to make the Smart Fridge System aware of leftovers that are present within the fridge. Users can also indicate when the leftovers will go bad by, and be notified when this date is approaching.

There are many advantages to the Smart Fridge System. Users will be attracted by the convenience of being able to peruse what is in the fridge from afar, expiry date notifications, and more. Further, through the presence of clear and accessible nutritional information, the Smart Fridge promotes healthier eating habits.

2. SYSTEM OVERVIEW

The RFID EnabledSmart Fridge system will consist of a modified fridge that includes a RFID scanner and WiFi device (hardware), a wireless communication protocol (wireless communications), and online software which will receive, store and analyze the fridge's content.

2.1 INTEGRATED HARDWARE

A standard fridge will be modified to implement the functionality of the proposed Smart Fridge System. Radio Frequency Identification (RFID) technology will be utilized in order to make the fridge aware of its contents. An RFID receiver module will be located directly inside the fridge. The receiver will act as a sensor capable of recognizing when an item has gone in or out of the fridge. By using RFID technology, we are able to sense objects in the fridge without ever making contact with them. Our system therefore does not ask the user to alter their behavior; the user can act as if the RFID system was not even there. The RFID reader passively reads RFID tags that are located on each item in the fridge.

Though few products are currently shipped with RFID tags attached, the decreasing cost of tags coupled with their ability to simplify tracking and point-of-sale procedures suggest that RFID tags will replace UPC barcodes. We will address the issue of products without RFID tags by allowing the user to attach RFID tags to products. The RFID receiver module will also have write capabilities. For items that do not already have an RFID tag, users will be able to scan the UPC barcode of the product (with either a physical barcode scanner or by taking a picture with their phone) and associate the UPC with an RFID tag. The system will further leverage the write capabilities of the RFID module and tags by associating a container of leftovers with an RFID tag. In this way, users will have a complete view of the contents of their fridge, including both store-bought products and leftovers. By also keeping track of when leftovers entered the fridge, the system can assist users in determining whether or not an item has gone bad.

An overview of the system's hardware components and their interactions is provided in Figure 2.

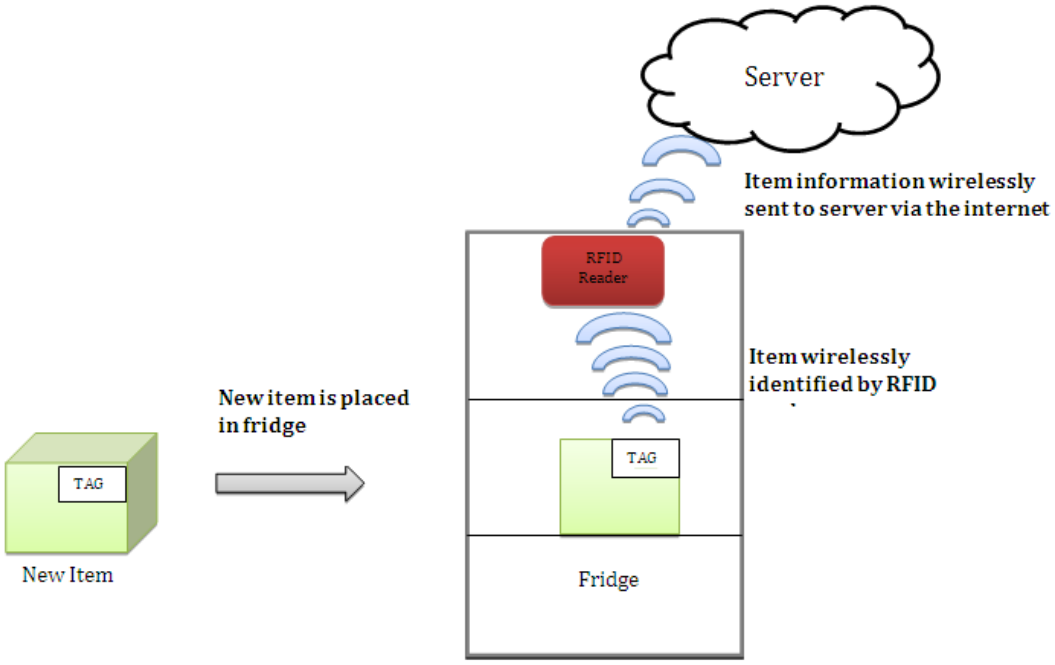


FIGURE 2: HARDWARE OVERVIEW

2.2 WIRELESS COMMUNICATION

Product information collected by the RFID reader module inside the fridge will be sent to a server through the Local-Area-Network's (LAN's) internet connection. At the server, information will be further processed in order to achieve a variety of functionality, including automated grocery list generation and nutritional tracking. By taking advantage of the user's network to send the information to our server, we avoid unnecessary software and firmware installations in the costumer's home computer. This also allows the information to be accessed any time on any running client such as a home computer, laptop, tablet device or smart phone. The system therefore ensures a friendly and easy setup, and is accessible to several individuals simultaneously, regardless of whether they are nearby the physical system.

2.3 SOFTWARE FEATURES

Once the product information has been obtained and stored in the database through the local area network, it only takes some imagination to think of the many beneficial applications our system could provide for families, individuals, and people with physical disabilities. All these features could be easily accessed through any client, such as a home computer, tablet or even a smart phone, making our solution versatile and user friendly.

Below, we list the central software features which we intend to support to a full or partial degree in our system:

2.3.1 PRODUCT NUTRITIONAL INFORMATION AND CONSUMPTION HISTORY

According to a report from the CHMS (Canadian Health Measures Survey) based on data collected in the last 30 years Canadian boys and girls are not only taller now than they were in 1981, they are

also fatter [8]. Among teen boys in the age group 15 to 19, overweight and obesity rates rose from 14% to 31% between 1981 and 2009. Among teen girls, obesity rates increased from 14% to 25%. The report highlights how this upturn among adolescents is of particular concern because overweight or obese conditions in adolescence often persist into adulthood. During the 2007-to-2009 period, fewer than 38% of Canadian adults were at a healthy weight. About 1% was underweight, 37% were overweight and 24% were obese [8]. Within this group, the percentage with a waist circumference that placed them at a high risk for health problems more than quadrupled.

As might be expected, the likelihood of being obese was related to diet and exercise [9]. In a world where kids spend more and more time in front of the computer and office jobs are more than common, people have a hard time finding time to exercise. Keeping track of what we eat seems to be the easiest way to keep our body and the bodies of our young ones healthy. Our solution will be able to store nutritional information for every product placed inside the refrigerator, providing the consumer with the information they need to improve their eating habits. At the same time, our solution will be able to provide the consumption rates for different types of food, informing individuals and families about their eating habits and giving them an insight into how they could reduce personal or family spending.

2.3.2 GENERATION OF GROCERY LISTS

Nowadays every big grocery store offers the option of completely automated checkout lanes which no longer require a cashier. Costumers scan their own items and handle the payment themselves. However when it comes to creating grocery lists at home, people still depend on a piece of paper and a pen. Existing alternatives such as mobile phone applications which allow users to create grocery lists often depend on user input and are tedious and slow. Our product provides a quick and easy solution for creating grocery shopping lists with minimal user input. Based on the history of products and their consumption rates, our system creates a grocery shopping list which can be easily accessed through any mobile phone with a data plan. As well, grocery items could be cross-referenced against all of the grocery stores in the area to let costumers know if any of the items they need are on sale or can be purchased at a discount with a coupon.

2.3.3 COOKING RECIPES

What can I make for dinner? This is one of the fundamental questions in life for many hard working adults who come back home after having a long day at work. Tired and starving, they must look inside their refrigerator to check what ingredients they could use while hoping to have a eureka moment and come up with a recipe that uses whatever is in the fridge while being decently tasty. Our solution will take advantage of the many websites that offer a recipe match based on the ingredients to match the products inside the refrigerator to possible dinner recipe options.

2.3.4 SMART NOTIFICATIONS

Most products come with an expiration date which no one will read until it is too late. The same problem happens when individuals and families cook more food than needed and place the leftovers in a container where they will be discovered 3 weeks later in the back of the refrigerator. Our Smart Fridge System allows users to keep track of expiration dates by a smart notification system which will inform users that a product is close to its expiration date and should be consumed or taken out of the refrigerator. In the case of leftovers which do not have an expiration date, our solution permits users to tag containers and record a date by which the contents of the container should be eaten.

3. BUDGET & FUNDING

3.1 BUDGET

Figure 3 below depicts the cost incurring components in the RFID Enabled Smart Fridge system. Table A lists the components and their estimated price. The numbers listed in the Estimated Cost column have been overestimated by 5% to 20% to provide for contingencies and shipping costs. Notice that all cost incurring components lie within the refrigerator unit.

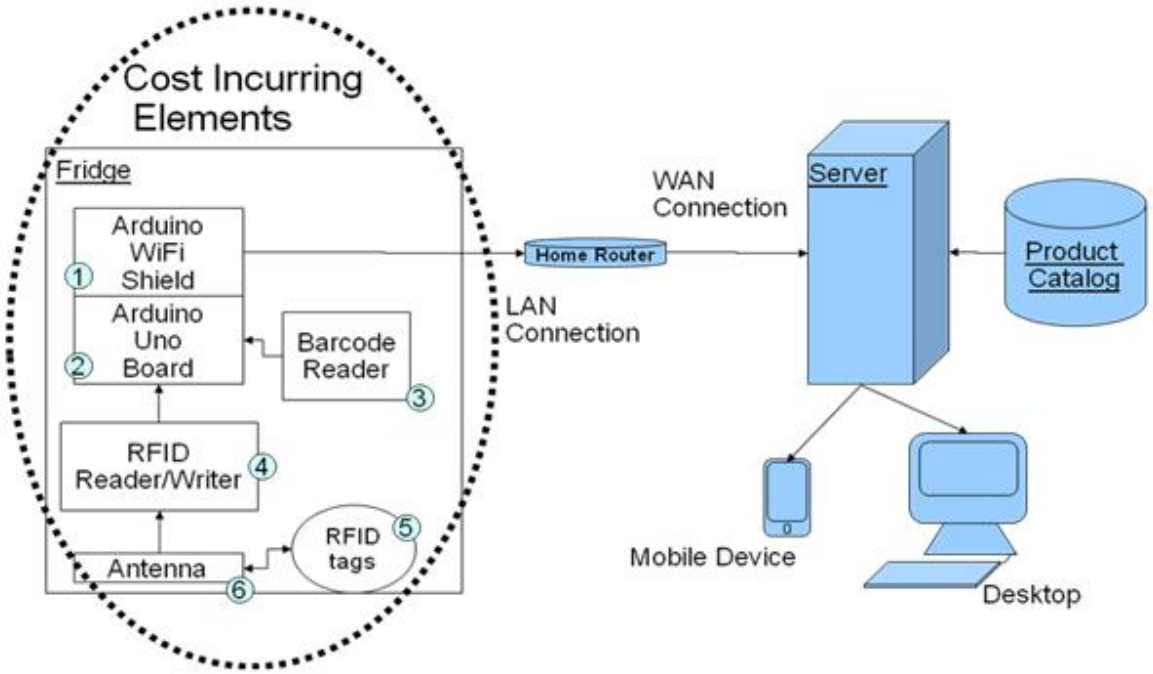


FIGURE 3 PRODUCT NAME COST INCURRING COMPONENTS

TABLE A PRODUCT NAME COST INCURRING COMPONENTS

COMPONENT	ESTIMATED COST
Refrigerator	$250
1) Microcontroller WiFi Module	$60
2) Microcontroller	$35
3) Barcode Scanner	$100
4) RFID Reader/Writer	$400
5) RFID tags	$35
6) Antenna	$100
Total Cost	$980

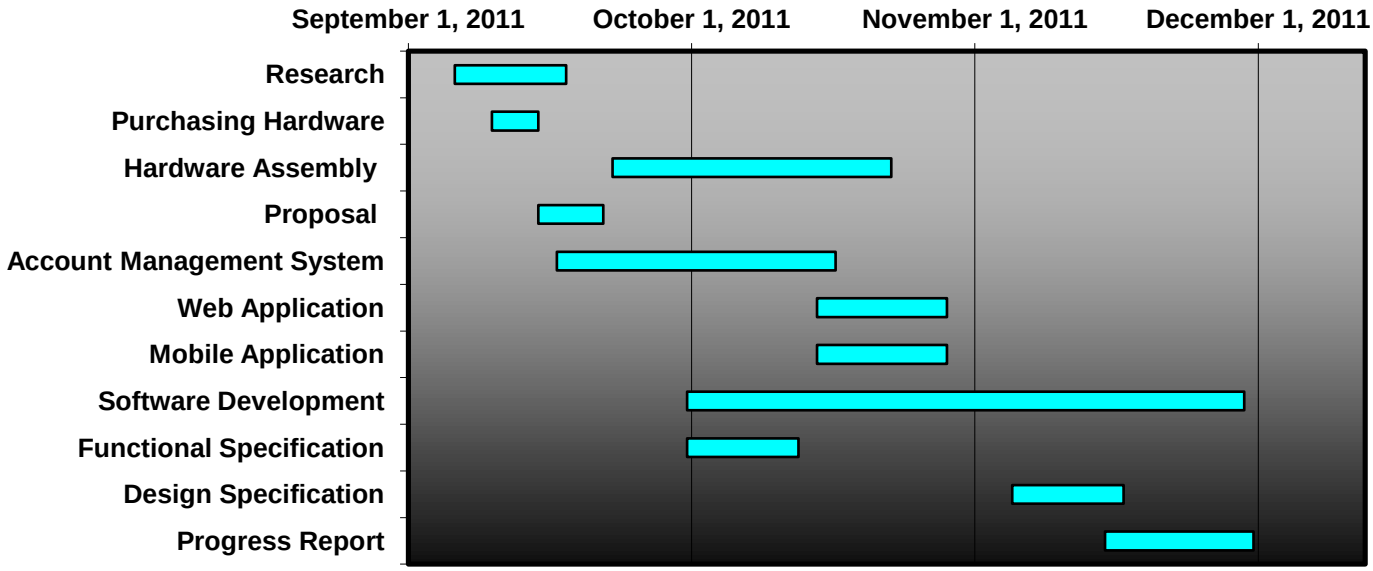
3.2 FUNDING

Given that our project addresses a high-end market of luxury smart home appliances, we expect the development of the prototype to require enough capital to create a high quality product which will meet the high standards of our user base. Once the prototype has been developed and tested, the mass production of our system should bring costs down as most of the product cost is due highly specialized hardware components which can be purchased in high quantities for a much lower price. Currently our project is being partially funded by the Engineering Student Society Endowment Fund (ESSEF). However, the amount of funding they were able to provide to us is not enough to cover all the costs associated to the project. At the same time, we have been in touch with hardware and software companies to see if it is possible to obtain hardware samples and software licenses for free. To cover the rest of the costs, we will look for more funding opportunities from different sources such as the Wighton Development Fund. As well, if completely necessary, our team members are willing to contribute to the project with hardware parts and capital. All financial transactions including purchases and contributions will be recorded and kept in the files to ensure all team members are well informed about the project finances.

4. SCHEDULE

Table B shows the Gantt chart for the project specifying duration and completion of the various project components while Figure 4 shows the Milestone chart shows the expected completion dates

TABLE B GANTT CHART



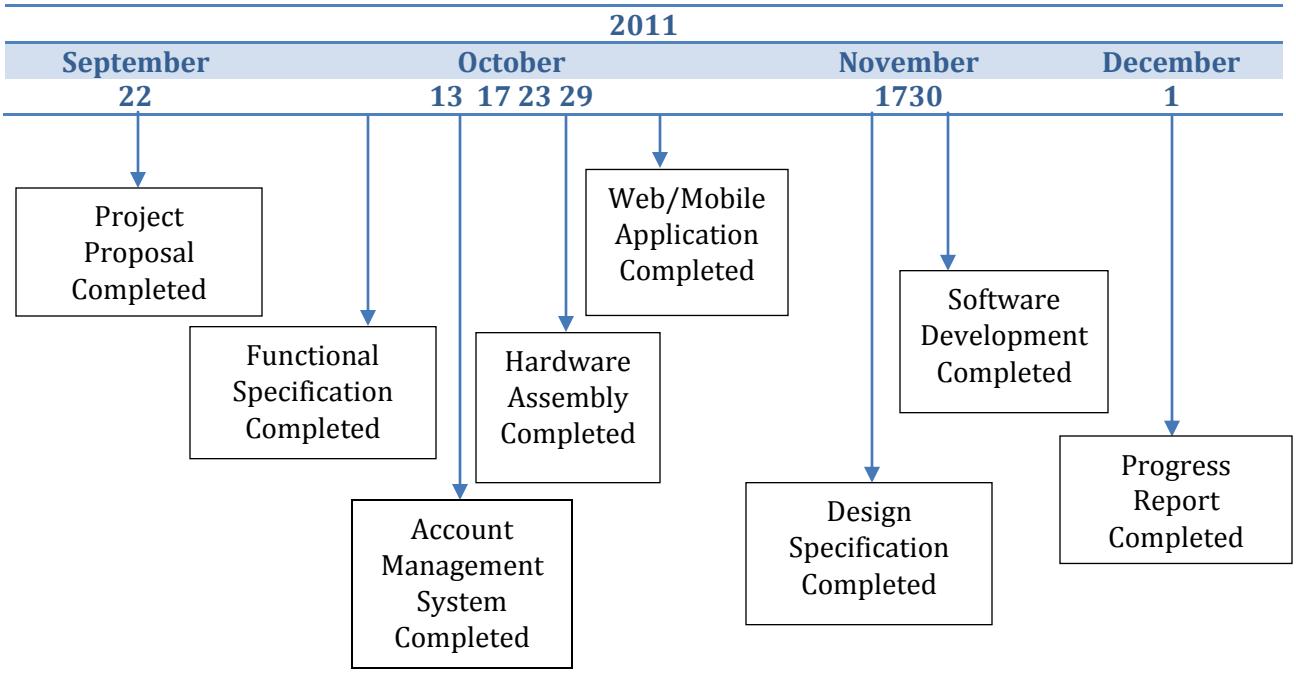


FIGURE 4 MILESTONE CHART

5. TEAM ORGANIZATION

Our team is loosely organized so that each of the four members is responsible for a specific area (see Section 6, Team Profile). This is mainly to simplify management and make sure all aspects of the project are covered, since work from each section will almost certainly be shared among several if not all four team members.

Renato Pagliara, the Team Lead, is responsible for ensuring that all areas of the project are proceeding on schedule and coordinating with all members to make sure deadlines are met and work is distributed fairly and efficiently. Damir Jungic, the Lead Integration Manger, is in charge of integrating the software and hardware aspects of the project, which will include most of the low-level programming and communication between the hardware and software. Mitchell Joblin, the Lead Hardware Designer, will be in charge of hardware design, construction and testing. Steve Verner, the Lead Software Designer, will be in charge of the server-side software, as well as acting as treasurer. Note that each of our team members is in charge of a certain section, which does not necessarily mean that he will be doing that section alone, but rather that he will be in charge of coordinating the team's efforts in that area.

Our team has designated a weekly meeting time as well as exchanging emails, phone numbers and Facebook, in order to ensure open and consistent communication. We plan to keep the meetings as open and flexible as possible. Only in the event of an unproductive level of team conflict will Renato, the Team Lead, be required to take charge of a meeting.

We plan to use our milestone and Gantt chart as a general guide, but to break the project up into small, manageable modules as we go, in order to better monitor our progress and to keep motivated as modules are successfully completed. We believe this approach will give our team both the flexibility to complete all required tasks and the structure to do so on schedule.

6. TEAM PROFILE

6.1 RENATO PAGLIARA – PROJECT LEAD

Renato is a Biomedical Engineering student entering his fifth year of studies. His experience includes working at Ericsson as a co-op Software Developer, as an Undergraduate Researcher in the Biomedical Physiology and Kinesiology Department at SFU and being the President of the Latin American Students Association at SFU. These experiences have taught him to successfully complete complex self-guided projects while ensuring high quality results. Combining a solid technical background in both software and hardware with a natural interest in project management, Renato provides technical experience and leadership skills to ensure the successful completion of the tasks required to produce a high quality product.

6.2 DAMIR JUNGIC – LEAD INTEGRATION MANAGER

Damir is an Electronics Engineering student entering his fifth year of studies. He completed an eight month co-op at Ericsson, where he learnt many new programming languages (including Perl, PHP, TCL and XML) and greatly improved upon is software skills in general. This software-intensive coop encouraged him to complete the coursework necessary for a minor in Computing Science. Due also to the hardware courses necessary for his electronics concentration, Damir feels confident designing in both hardware and software. Computer networking and web-based technologies are a particular interest of Damir's, which will be further explored while working on the Smart Fridge.

6.3 MITCH JOBLIN – LEAD HARDWARE DESIGNER

Mitchell is a Biomedical Engineering student entering his fifth year of studies. The engineering coursework coupled with co-op work experience has provided him with the motivation and skills to be an expert hardware designer. An eight month co-op at Siemens gave Mitchell the opportunity to work side-by-side with some of the most advanced engineering professionals under the ideal conditions for cutting edge innovation. At Siemens Mitchell worked at the research and development facility for magnetic resonance imaging and was exposed to complicated hardware challenges on a daily basis. During this time he quickly recognized his strong passion and talent for hardware design. The Smart Fridge project will give Mitchell the opportunity to investigate further into the world of hardware design.

6.4 STEVE VERNER – LEAD SOFTWARE DESIGNER

Steve is a Computer Engineering student in his final semester of studies. The computer engineer program, three software-based co-op terms and a personal passion for programming have made Steve an excellent programmer in many programming languages such as Java, C, PHP and Objective C. He has already created his own iPhone app and at his last co-op as a digital signal processing software developer Steve learned how programming projects are divided up, executed and integrated in a professional setting, complete with hard deadlines and modularized software development. Steve's experience and passion for programming make him an ideal choice for lead software designer for the Smart Fridge.

7. CONCLUSION

The demand for technology that provides information and convenience in our lives, from social media websites to cars that parks themselves, has exploded in the past decade. Our team at Cyber-Flux Innovations is committed to meeting this ever growing demand by creating a fridge which will automatically track its contents, analyze the household's dietary needs and make this information easily accessible from anywhere in the world. People spend a great deal of time making shopping lists, planning meals, and trying to eat a healthy diet. With today's technology, these tasks can be simplified and streamlined without any extra effort from the user – which is exactly what our the Smart Fridge System will do.

By automatically scanning every item that is placed inside a fridge and making this information available, our RFID Enabled Smart Fridge System has the potential to revolutionize the way people shop, cook and eat. The convenience of checking the exact contents of your fridge from your phone while shopping is just the beginning. Our Smart Fridge will also analyze your food history, calculate how long items usually remain in your fridge, determine what might be running low, notify you about what is about to expire, and more. With all this information, the system will create a personalized recommended shopping list and offer recommended meals and advice on healthy eating. By analyzing the nutritional contents of the foods passing through your fridge, our Smart Fridge will also be able to provide an in-depth nutritional analysis for the whole household. Further, an option will exist to ask the fridge to always recommend healthier options and healthier meals when creating your shopping list. This will create one of the simplest and easy-to-stick-to diets in existence, something that millions of people around the world are looking for.

The milestone and Gantt chart in the Schedule section show that this project can be completed by December, 2011. We have outlined the need for this product, our solution, and exactly how we intend to implement the discussed system. With four motivated students with diverse skillsets and a common passion for this project we will be able to overcome any obstacles and complete this project on time.

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