October 13nd, 2011

Dr. Andrew Rawicz
School of Engineering Science
Simon Fraser University
Burnaby, British Columbia
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Re: ENSC 440 Functional Specifications for an RFID Smart Fridge

Dear Dr. Rawicz:

The document attached outlines the functional specification for Cyber-Flux Innovations' RFID Smart Fridge. Our team is designing a smart refrigerator which will keep track of its contents and provide useful information to customers through a website and mobile phone application. Our functional specification document describes the high level requirements of our solution.

This document will be used throughout the design process as a guiding resource, and it will direct the development and testing of our design process.
Our team is comprised of four talented undergraduate students from Simon Fraser University: Damir Jungic, Mitchell Joblin, Renato Pagliara and Steven Verner.

If you have any questions or concerns regarding our functional specifications, please do not hesitate to contact us at rfridgeidtech@googlegroups.com.
Sincerely,

Renato Pagliara

Renato Pagliara
Project Lead
Cyber-Flux Innovations

Enclosure: ***RFID Smart Fridge Functional Specifications***

RFID SMART FRIDGE

FUNCTIONAL SPECIFICATION

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Submitted to:

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Issued Date:

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EXECUTIVE SUMMARY

The exponential growth of technology during the past decades and its implications on our everyday lives has led to a mass demand for information and convenience. We live in the era of quantification where anything can be measured and transformed into numbers with a meaning. Nowhere is this more obvious than in our perception of health and nutrition. We are told we should control the amount of fat, cholesterol, iron, calories, sugar, carbohydrates and many other elements and molecules present in our food. We know all some of this information is readily available in the back of almost every product in the nutritional facts table, but we don't really know how to make sense out of it. At the same time, our fast paced lives do not allow us to spend much time looking at the back of products or remembering what is inside our fridge in the first place.

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 high-level requirements of the Smart Fridge system, placing a focus on the two main components of the system: The hardware module placed inside the fridge and the software features which will be available to the user through the website and mobile phone application. Throughout the document we divide the requirements of the system into meaningful categories that apply to each component in our solution. As well, we consider RFID standards and frequencies to ensure compatibility across our system. The document ends with a detailed testing plan which focuses on the integration of the hardware and software component of our solution which will ensure the described requirements are met.

Although our current goal is to develop a working prototype for the transitional period where most products do not come with an RFID tag, we list the functional requirements which would allow this system to work as expected after the transitional period. The four month development cycle of this prototype is targeted for completion on Dec 10th, 2011.

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1. INTRODUCTION

This document outlines the functional requirement that the RFID Smart Fridge System must adhere to when completed. Individual components, such as in-fridge hardware, the software backend and the mobile application each will have standalone requirements. Further, interaction between components will have integration requirements in the form of a system-wide functional specification and requirements. Finally a test plan and development/integration/testing lifecycle is outlined to insure a high-quality and user-friendly product.

1.1. SCOPE

This document will serve to guide Design Engineers when developing individual components. The requirements outlined herein should be referenced when critical design decisions are made, to ensure adherence to the functional specification of both individual components and the system as a whole. Upon the completion of individual components, this document will be referenced and adherence will be confirmed. Deviation from this functional specification must be justified (in writing), noted as a limitation of the system or addressed so that the specification is adhered to. System-wide validation will also rely on this functional specification when determining the completeness of the system as a whole.

1.2. INTENDED AUDIENCE

Interested parties, including overseeing managers, investors and everyone at Cyber-Flux Innovations can use this document as a reference of developmental progress.

2. SYSTEM OVERVIEW

The RFID Smart Fridge will consist of a modified fridge that detects items being put in or taken out via their RFID tag (using an RFID reader), sends this information to a server via the internet where the information will be processed and made available to the user through a simple mobile application and website as seen in the diagram below. The server will process this large amount of information and make it available in a simple, convenient, useful manner through its interfaces to give the user a list of the fridge's current contents, a list of foods which will expire soon, an automatically generated grocery list based on the user's eating habits and some simple and relevant nutritional information about the fridge's contents and recent history.

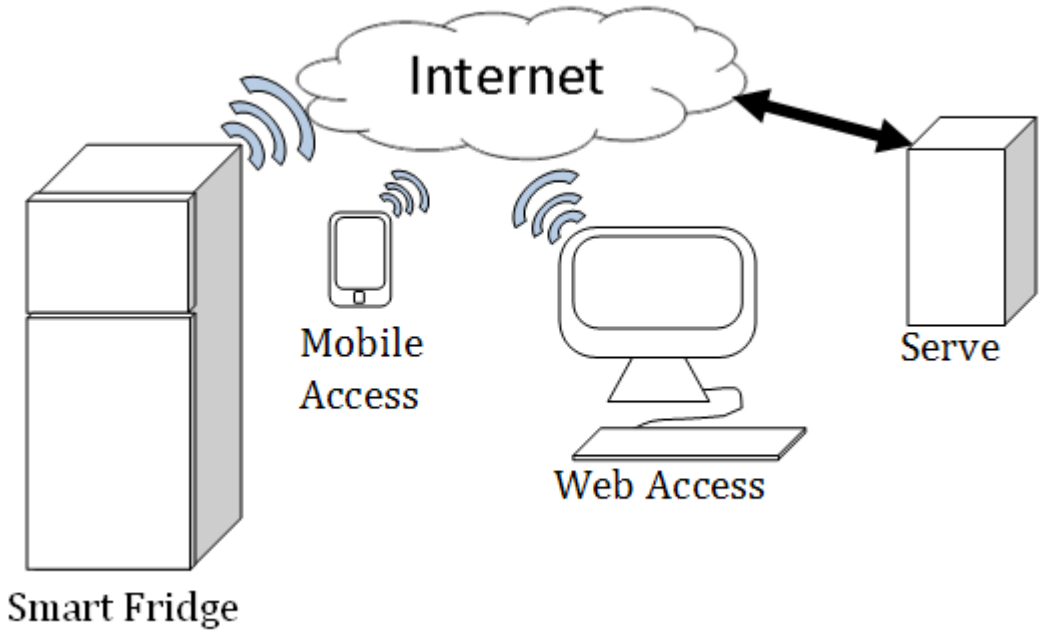

Figure 1: System Overview

3. HARDWARE REQUIREMENTS

3.1. RFID READER/WRITER UNIT

The RFID Reader/Writer Module is in charge of collecting, writing, transmitting and receiving information from the RFID tags placed inside the fridge to the server and vice versa. The module comprises the RFID Reader/Writer, the microcontroller and the Wi-Fi shield.

GENERAL REQUIREMENTS

- The unit's reading range must cover a strategic area of the fridge where all products must pass through while being placed inside the fridge.
- The unit's reading range must be larger than 10cm with the peak point at the centre of the unit's antenna.
- The unit must identify RFID tags within the reading range through the tag´s unique identification number (UID).
- The unit must read specific blocks of memory from a RFID tag within the reading range.
- The unit must write data into specifics block of memory of a RFID tag within the reading range.
- The unit must deal with the presence of more than one RFID tag in the reading range at any time ensuring that all tags within the range can be read and written on.
- The unit must recognize when a new RFID tag enters the reading range.
- The unit must inform the user that the RFID Reader/Writer is powered.
- The unit must inform the user when the RFID Reader/Writer is performing a read or write action.
- The unit must inform the user if there is an error preventing normal functioning.

PHYSICAL REQUIREMENTS

- The unit must lie within the fridge's main area.
- The unit must not prevent the user from placing products inside the fridge.
- The base of the unit must not exceed 30cm x 30cm.
- The height of the unit must not exceed 5cm.
- The unit's internal components must not be visible to the user.
- The unit's external case must be made of an insulating material.
- The unit must blend in with the rest of the fridge.
- The unit's feedback LEDs must be visible to the user.
- The unit must have a manual reset button.

ELECTRICAL REQUIREMENTS

- All electronics must be concealed from physical interference.
- The electronic components must not interfere with other electronic appliances in use.
- The unit must not interfere with other RFID enabled devices outside of the fridge.
- The unit must draw power from the internal circuitry of the fridge while not affecting the normal functioning of the fridge.
- The network element must be powered on at all times to maintain communication with the server.
- The RFID Reader/Writer must be powered on only while the fridge's door is open.

NETWORK REQUIREMENTS

- The unit must communicate with the server through a Wi-Fi Local Area Network (LAN) connection.
- The unit must be able to communicate with the server using Transmission Control Protocol (TCP).
- The unit must be able to receive requests from the server
- The unit must be able to send information to the server.

ENVIRONMENTAL REQUIREMENTS

- The unit must operate as expected under the expected temperature and humidity conditions inside a common fridge of 1°C-6.5°C and 30%-95% humidity. [1] [2]
- The unit must operate reliably within an elevation range from sea level up to medium altitudes (1500 – 2500 m).
- The unit must remain dry at all times.

STANDARDS

- The RFID Reader/Writer hardware must be compatible with 13.56MHz ISO15693 standards for RFID tags.

RELIABILITY AND DURABILITY REQUIREMENTS

- The unit must be resistant to forces which would arise while moving and installing the fridge.
- The unit must be resistant to possible forces arising from products hitting the unit while being placed inside the fridge.
- The unit must not overheat with continuous usage
- The unit's performance must not degrade with normal use.
- The unit's internal components must be easily accessible to repair technicians.

SAFETY REQUIREMENTS

- Unit's failure must not harm the user.
- The unit's location and enclosure must prevent water from entering the unit.
- The unit's electrical connections must be enclosed away from the user.

PERFORMANCE REQUIREMENTS

- The unit must be able to read RFID tags' UID in less than 250ms.
- The unit must be able to write information to RFID tags in less than 250ms.
- The unit must be able to read information from RFID tags in less than 250ms.

- The unit must be able to receive information and send information to the server in less than 2s.
- The unit must have a boot time of less than 60s.

3.2. RFID READ/WRITE TAGS

The RFID Tags are used to tag objects which do not have an RFID tag already.

GENERAL REQUIREMENTS

- The tags must have a unique identification number (UID).
- The tags must at least 4 blocks of user writeable memory.
- The tags must be passive and use power from the RFID Reader/Writer radio waves.
- The unit must recognize when a new RFID tag enters the reading range.
- The tags must have a sleep state to avoid double readings from the RFID Reader/Writer.

PHYSICAL REQUIREMENTS

- The tags must be the size of a credit card (85.60 × 53.98 mm) or smaller.
- The tags must weigh less than 5.7g
- The tags must be made of a cheap water-proof material.

ENVIRONMENTAL REQUIREMENTS

- The tags must operate as expected under the expected temperature and humidity conditions inside a common fridge of 1°C-6.5°C and 30%-95% humidity. [1] [2]
- The tags must operate reliably within an elevation range from sea level up to medium altitudes (1500 – 2500 m).

STANDARDS

- The tags must conform to the 13.56MHz ISO15693 standard.

RELIABILITY AND DURABILITY REQUIREMENTS

- The tags must be resistant to forces which would arise from normal daily usage.
- The tags must retain the information for at least 1 year.

PERFORMANCE REQUIREMENTS

- The tags must be able to respond to a request in less than 250ms.

4. SOFTWARE REQUIREMENTS

4.1. BACKEND SERVER

The backend server stores all the information about which products have been in the fridge. Other software services, such as the auto-generation of grocery lists, rely on the data stored on the backend server. Further, the components responsible for presentation, such as the website and mobile application, serve to make the raw data stored on the server easily-accessible to the user in an atheistically pleasing manner. The server's requirements therefore stem from being a point of synchronization for other system components, and serving a large role as a service-provider.

GENERAL REQUIREMENTS

- Provide current contents of the fridge to the mobile application upon request
- Provide current and historic content information to other software features, including auto-grocery list generation and nutritional tracking
- Receive information about incoming/outgoing items from the in-fridge module
- Save the current and historic content data, in the case of failure
- Be able to load saved state data on startup
- Since all other components rely on the server, issues (bugs) on the server should be addressed with heightened priority
- The backend server will interact with a web-based catalogue service to map UPC barcodes to product information (ie product descriptions, nutritional information, etc). This information will be "cached" on the server, in order to reduce query times. Product information will then be made available to other services, such as the nutrition metric algorithms

FEATURE REQUIREMENTS

- Generate HTML for web-service upon request (presentation details, ie. stylesheets, are not the responsibility of the server – just the content)
- Negotiate the amount of content delivered to presentation-concerned components to ensure timely delivery: transmission of user-targeted data should be less than a second
- System state must be stored daily, ensuring minimal loss of information should the server go down
- Reduce the number of queries to external catalogue service, in order to ensure timely execution of algorithms (ie nutritional metrics)

4.2. WEB PRESENTATION

A web server will communicate with our Backend Server in order to deliver content to a user's browser. Note that these two server programs can reside on the same physical machine.

GENERAL REQUIREMENTS

- Display the contents of end user's fridges
- Display the results of nutritional metrics system
- Provide access to the automatically generated grocery list
- Allow for browser-independent presentation

FEATURE REQUIREMENTS

- Provide a simple and intuitive interface
- Ensure simple navigation of provided services
- Make detailed nutritional information available to users who are interested, but don't overburden users who aren't with these particulars

4.3. MOBILE APPLICATION

The mobile application will display all pertinent information from the RFID Smart Fridge in a convenient, easy-to-read format on the user's mobile platform. This information shall include the fridge's contents, food's about to expire, an automatically generated grocery list (discussed in detail in the next section), and nutrition metric information (discussed in detail in the Nutrition Metric Section). Initially this application will be designed for iPhone only.

GENERAL REQUIREMENTS

- Display the fridge's contents
- Display the results of nutritional metrics system
- Provide access to the automatically generated grocery list
- Provide Notifications about Expiring and Expired Foods
- Allow foods with an RFID Tag to be added to the fridge using a bar code

FEATURE REQUIREMENTS

- Provide a simple and intuitive interface
- Ensure simple navigation of provided services
- Make detailed nutritional information available to users who are interested, but don't overburden users who aren't with these particulars
- When a user is adding a food item via a bar code, capture the barcode image and decipher its upc code

RELIABILITY AND DURABILITY REQUIREMENTS

- System must not crash under any circumstances including the cases where the internet is unavailable, the SMART Fridge Server is down, or the camera isn't working

4.4. AUTO-GENERATION OF GROCERY LIST

Writing a grocery list is annoying and inconvenient yet without one we often forget the most important items and walk out of the store with many impulse bought items. With the smart fridge solution the user no longer needs to generate a grocery list themselves. The smart fridge system will utilize its database to auto generate a grocery list based upon dynamic usage patterns. Certain features will also allow the user to control how items are added. Between the monitoring of usage patterns and user specified parameters we are confident that our system will be capable of generating the ideal grocery list for every individual.

GENERAL REQUIREMENTS

- Automatically generate a grocery list of items considering several factors to produce high quality prediction of desired items
- Encompass a dynamic learning model together user input in order to generate a list of items which the user actually wants
- The grocery list shall be displayed in a way that allows the user to easily identify why an item made it onto the grocery list

FEATURE REQUIREMENTS

- Add to grocery list according to monitored consumption rates and initiate a pre-emptive buy
- Allow user to specify items that should always appear or never appear on the grocery list
- Allow user to specify a quantity of items which should always be maintained in the fridge and add this item to the grocery list when appropriate
- Smart color coding scheme to indicate why an item was included on the grocery list
- Add items to grocery list which appear popular to the user

4.5. NUTRITION METRICS SYSTEM

By keeping track of all items passing in and out of the fridge together with knowledge of the items nutritional facts information we can substantially improve the delivery of nutritional information to the

user. The standard nutritional facts label is not user friendly and requires the individual to take the individual item nutritional information and place it in the context of their entire diet. The smart fridge is able to use the nutritional facts information and place it in context automatically by keeping track of all items in the fridge. The smart fridge offers the ability to quantify and display nutritional information in a practical way the makes eating healthy easier than ever before.

GENERAL REQUIREMENTS

- Provide user with convenient and simple ways to track nutritional value of foods they consume
- The nutritional information shall include greater diet context then a single nutritional facts label can.
- Variable nutrition levels allows the user to specify how healthy of a lifestyle they would like to achieve and the nutrition metrics will dynamically adjust for this factor
- Offer a range of information to accommodate basic users and nutritional experts

FEATURE REQUIREMENTS

- notify the user when items contain ingredients publicly known to be very unhealthy
- display information regarding the nutritional value of the entire fridge contents
- display information regarding nutrition value and consumption rates of consumed items over past week, month or 3 months
- display lists showing the 5 most healthy and 5 most unhealthy foods in fridge or consumed within the past week, month or 3 months
- make alternative suggestions to an item for a healthier option, the user can specify whether they want the alternative to be selected from their own history of consumed items or a completely new item
- display nutritional value of items which have been taken out of the fridge to make a meal
- display time of day which sees the most unhealthy or healthy eating

5. SYSTEM REQUIREMENTS

System-wide requirements include the integration of individual system components. This includes the in-fridge hardware communicating with the backend server, as well as the mobile application retrieving data from the server. The various components previously described must be able to work together to adhere to the following requirements.

GENERAL REQUIREMENTS

- In-Fridge hardware must be able to transmit RFID tag ID information, as well as data stored on the RFID tag, including (but not limited to) UPC number and expiry date. The backend server must be able to receive and store this information in a suitable format.

- The server will be able to communicate the contents of the fridge to the mobile application in a timely manner. The amount of information transmitted "at once" must be balanced to ensure a convenient user experience: too much information transmitted at once might cause unacceptable delay, too little information will introduce overhead on the form of frequent connection setups and teardowns.

FEATURE REQUIREMENTS

- Users must be able to add RFID tags to products that only have tradition 1D barcodes. This process will involve taking a picture of the barcode with our mobile application, transmitting this data to the in-fridge hardware so that the appropriate information can be written to the newly-tagged incoming product
- Users must be able to add an RFID tag to containers which store leftovers. Through the web or mobile interfaces, users will indicate the name of the leftovers and when they will go bad. The system will then track the item like any other, making it visible through the web and mobile interfaces and notifying the user when the expiry date is approaching.

5.1. USABILITY REQUIREMENTS

Convenience is one of the most appealing services provided by the Smart Fridge System. Therefore, significant emphasis must be placed on simplicity of use. Though quantifying "ease of use" is difficult, a novice user should be able to navigate the contents of their fridge via the web-based or mobile interfaces with no formal training, and without consulting documentation.

The presence of configurable settings will be kept to a minimum, in order to avoid overwhelming the user. The settings that are made available through the website and mobile application will be presented as clearly as possible. Further, settings will be accompanied by a "Learn More" link, which will take the user to a page that concisely describes the particular behaviour affected by the specified setting.

USER DOCUMENTATION

The amount of documentation a user will be expected to read will be kept to a minimum. As discussed above, the Smart Fridge System is intended to provide convenient services, and should therefore avoid burdening the user with details. The documentation that will be available to the user will be written in order to accommodate users with no technical experience beyond basic web-browsing.

The process of how to add a leftover item into the Smart Fridge, as well as tagging an item that does not have an RFID tag, will be outlined on our website. The procedure will be designed for simplicity, but detailed instructions will nonetheless be provided. A reference to this documentation will also be available through the mobile app, through which users will be electronically adding newly-tagged items.

6. SYSTEM TEST PLAN

Our test plan will follow the same modularized bottom-up plan as our design and implementation based on the component, system and usability requirements listed above. We will begin by testing each of the main system components, the hardware, the server, the mobile application, the web presentation, the grocery list auto-generation algorithm, and the nutrition metrics system individually to insure that each feature is implemented and working. Next we will test integrate each component with the server and test the resulting system. Finally we will test the overall integrated system. These tests will be conducted by the design engineers most familiar with each component according to the requirements listed above. As the design and integration progresses more detailed test procedures will be developed and the results recorded for each requirement at each applicable stage of integration, to insure that functionality isn't lost during integration.

Hardware testing will follow the system requirements above quite closely until the final integrated system testing where a more detailed test plan will be developed to test for reliability and durability given the environmental factors in the fridge including temperature and humidity.

The software testing begin with the requirements listed above but as integration progresses a test plan will be continuously developed to thoroughly test all aspects of the software and all interfaces to insure that no break conditions exist for any element of the software. Potentially break conditions will be noted by our engineers during development and these notes will be used to develop a comprehensive ongoing test plan to insure that the system is fully functional before each stage of integration. This will save a great deal of time and energy as bugs will be identified as soon as possible and the whole system will not have to be revisited to find bugs when they inevitably occur. This ongoing development/integration/testing cycle will also insure the most reliable product which will perform under any and all circumstances.

Finally once the integrated system is completely functional and fully tested by our engineers a usability test will be developed based on the final product and test subjects unfamiliar with the RFID Smart Fridge will be asked to try out the product and give feedback. This will insure that our engineers don't overlook any usability issues because they are too familiar with the product. We will analyze this user feedback and use it to insure that all aspects of the RFID Smart Fridge are easy and convenient to use and understand.

Below is a series of typical systems tests carried out for the same feature at different stages of development:

6.1. TYPICAL ISOLATED SYSTEM COMPONENT TEST

1. Engineer taps Fridge Content Menu Button on mobile application
2. Artificially (within the app for testing purposes) generated list of fridge contents is displayed on the mobile platform's screen
3. Pass/Fail Recorded

6.2. TYPICAL SEMI-INTEGRATED SYSTEM TEST

1. Engineer taps Fridge Content Menu Button
2. List of Fridge Contents from the server is displayed on the mobile platform's screen
3. Pass/Fail Recorded

6.3. TYPICAL FULLY-INTEGRATED SYSTEM TEST

1. Engineer taps Fridge Content Menu Button
2. Actually contents from the RFID fridge are displayed on the mobile platform's screen
3. Pass/Fail Recorded

6.4. TYPICAL TEST SUBJECT USABILITY TEST

1. Test subject (without knowledge of RFID Smart Fridge) is given the fridge and mobile platform with mobile application installed and asked if they can find a list of the fridge's contents through the mobile application
2. Pass/Fail Recorded and any issues noted

7. CONCLUSION

This functional specification clearly defines the RFID Fridge in terms of its components, features and requirements. Development will proceed in three distinct and highly flexible stages: individual development of the system components which is mostly complete; integration of each of the main system components, hardware, mobile application, grocery list auto-generation algorithm and nutritional metrics system with the central server; and final system integration.

Our system test plan is clearly outlined following a development/integration/testing cycle used commonly in industry today and we are confident that our testing practices will insure the highest quality and most user-friendly product possible.

The individual system components are largely complete and operational and we confidently expect to finish initial integration of all components by November 12th and finally integration and testing by our target date of December 5th 2011.

8. REFERENCES

[1] Ezine Articles. (2010, January). Refrigerator's Air Circulation and Humidity: http://ezinearticles.com/?Refrigerators-Air-Circulation-and-Humidity&id=3657755

[2] Cooks Illustrated. (2011, March). Getting to Know Your Refrigerator: http://www.cooksillustrated.com/images/document/howto/MA01_ILRefrigerator.pdf

[3] Statistics Canada. (2005, July). Retrieved from Canadian Community Health Survey: http://www.statcan.gc.ca/daily-quotidien/050706/dq050706a-eng.htm