February 16, 2015

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

Re: ENSC 440 Functional Specification for the LiteSpeed Gate

Dear Dr. Rawicz,

Please find the enclosing functional specification for our LiteSpeed Gate project designed by ShopLite Solutions. Our LiteSpeed Gate is a retail store gate system which allows for customer's merchandise to be wirelessly scanned. The LiteSpeed Gate enables customers to instantly pay for their shopping items without going through the cashier using Radio Frequency Identification (RFID) technology.

Our functional specification document contains the high-level requirements for both the proof-of-concept and the final LiteSpeed Gate system. This document will be used by all of the engineers involved in the project for research and development.

At ShopLite Solutions, we have gathered together a team of six passionate, innovative and hardworking engineering students: Alex Yang, Brian Lew, Joyce Zhang, Kelvin Chu, Tim Chu Peng Lei and myself. If you have any questions or concerns, please feel free to contact me by email at nbalzer@sfu.ca.

Sincerely,

Noah Balzer

Noah Balzer
Chief Executive Officer
ShopLite Solutions

Functional Specification for LiteSpeed Gate

A pleasant, fast and light shopping experience

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Submitted to:
Dr. Andrew Rawicz – ENSC 440W Dr. Steve Whitmore – ENSC 305W School of Engineering Science Simon Fraser University
January 25, 2015

Executive Summary

Stores have spent a lot of time and money trying to improve their wait time at the checkout. The average customer reportedly “feels like” they wait longer than they actually do, and this consequently has a negative impact on their shopping experience [1]. The LiteSpeed Gate hopes to greatly reduce the current checkout wait time and thus improve the customer’s overall shopping experience.

The LiteSpeed Gate will be developed in two phases. The first stage will consist of developing a proof-of-concept device, and the final working product will be developed during the second stage. The proof-of-concept LiteSpeed Gate will include the following features:

- Wireless scanning of tagged items
- Automatic read-angle adjustment for improved accuracy
- Guide light indication
- Display of scanned items and total price

The LiteSpeed Gate will be designed to accommodate standard shopping cart sizes [2] and will take less than 10 seconds to complete a scan. The development of the proof-of-concept device will take four months and is projected to be completed and demonstrated by April 15th, 2015.

The final LiteSpeed Gate product will include a verification unit in order to further increase the scan success rate and eliminate potential theft. After the final development stage, the user interface unit will no longer be a standard computer screen, but will feature an interactive touch screen where customers can remove unwanted items if necessary. The final product will also feature a radar sensor allowing energy conservation when the gate is not active. Finally, the LiteSpeed Gate will comply with all related standards and guidelines including Environmental Radiation and EPCglobal standards.

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Glossary

AC	Alternating Current
CRU	Central Reading Unit
LFT	Legal for Trade
LSG	LiteSpeed Gate
NTEP	National Type Evaluation Program
POC	Proof of Concept
RFID	Radio Frequency Identification
UHF	Ultra High Frequency

1 Introduction

The LiteSpeed Gate is a retail store system allowing customer checkout at unprecedented speed. Checkout wait time is minimized by application of RFID technology. The high-level functional requirements of the LiteSpeed Gate, as outlined by ShopLite Solutions, are listed in this functional specification.

1.1 Scope

This document outlines the functional requirements of all LiteSpeed Gates produced by ShopLite Solutions. The functional requirements of all the major sub-systems are also outlined in order to guide the design and development process of both the proof-of-concept (POC) device and the final product.

1.2 Intended Audience

The specification is intended for all of the engineers at ShopLite Solutions. The document will be referred to during the design, implementation, and testing phases, to ensure that all of the listed requirements are met. Progress during the development of the proof-of-concept device will be quantified by comparing the device to the requirements articulated here. This document will also be referred to during the testing phase to ensure proper functionality.

1.3 Classification

In order to classify the requirements of the LiteSpeed Gate the following notation will be used:

[Rn-p]

Here, ‘n’ represents the requirement number and ‘p’ denotes whether the requirement applies exclusively to the final system, exclusively to the proof of concept system, or to both. We will use the following notation:

I	applies exclusively to the proof-of-concept system
II	applies to both the proof-of-concept system as well as the final system
III	applies exclusively to the final system

2 System Requirements

General system requirements for the LiteSpeed Gate are presented in this section.

2.1 System Overview

The following figure represents the LiteSpeed Gate as a high level block diagram:

FIGURE 1: LITESPEED GATE SYSTEM HIGH-LEVEL BLOCK DIAGRAM

As Figure 1 shows, the input to the system, which is an assortment of products with associated RFID tags, is presented to Central Reading Unit. The RFID reader takes a moment to read the tags, with the reading time roughly proportional to the amount of tags present. Thus, read time is dynamically allocated, but always within 10 seconds. A verification process occurs afterwards to ensure all products were scanned, and if so, the price and item list is displayed and the customer may advance to the payment phase.

In order to save power, customers approaching the gate will be automatically detected, triggering the power-up of the gate. This will be accomplished using a simple radar motion sensor positioned at the top of the gate. This sensor will be included in the final version of the LiteSpeed Gate but will be considered an extra feature for the purposes of the POC.

Due to various time and budget constraints, it may be impossible to create a completely infallible system. Thus the reader in the system will have an error rate of no more than 25%. This figure is better than literature values of 30% for similar experimental procedures [3], since we hope to improve on their performance.

In order to achieve an error rate of 25% or less during scanning, the system will automatically reposition the reader and rescan the shopping cart from different angles repeatedly. Repositioning of the reader is accomplished using a location control unit.

Lastly, the reader verification block from Figure 1 ensures even greater accuracy by using a validation method independent of RFID technology. A scale will be used in order to check that the total weight is consistent with the expected weight of the scanned items. This will reduce the total system error rate below 20%.

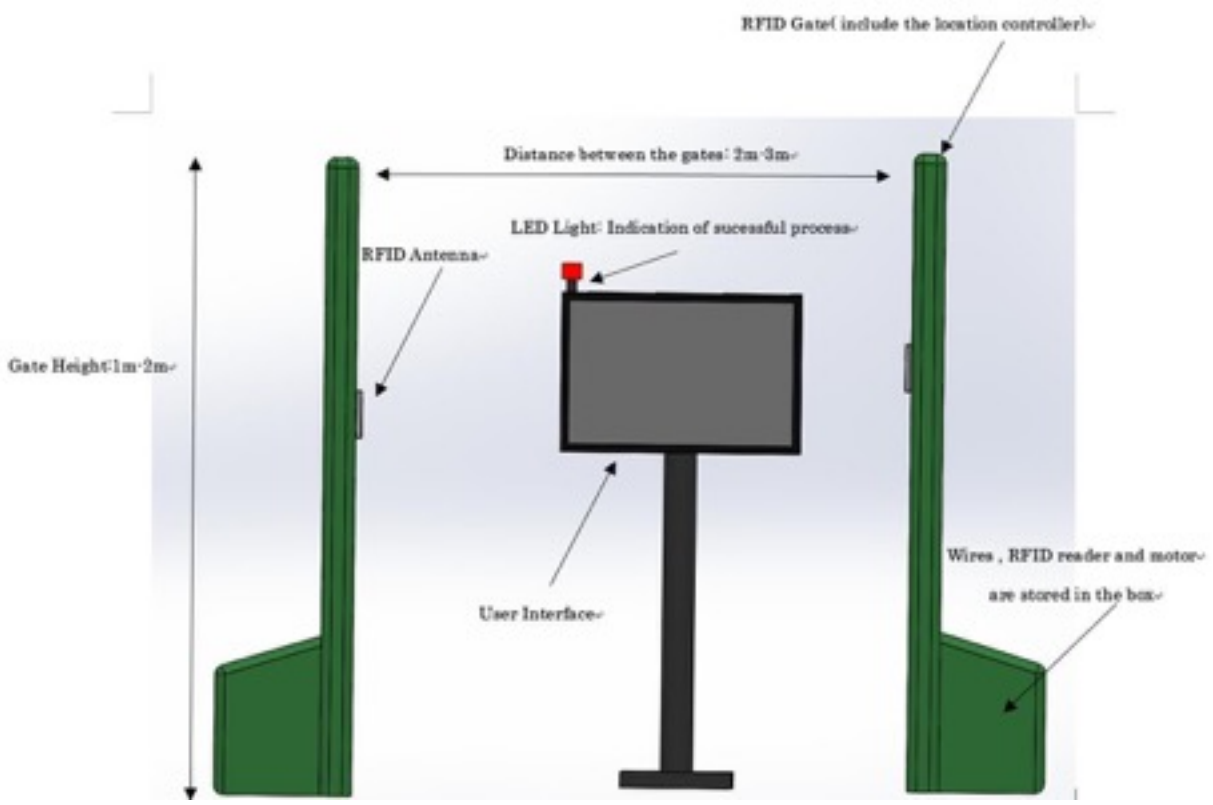

FIGURE 2: LITESPEED GATE VISUAL OVERVIEW

2.2 General Requirements

[R1-III] The retail price of a LSG unit will be less than $1500.

[R2-II] After traversing the LSG, both the scanned items and the total price will be displayed for the customer.

[R3-II] The LSG will provide feedback and clearly indicate success/failure of a scan.

[R4-III] There will be theft countermeasures which prevent people from stealing.

2.3 Physical Requirements

[R5-III] The motor unit and moving parts will be enclosed.

[R6-II] The LSG will accommodate shopping carts with standard widths up to 61 cm [2].

[R-7-II] The LSG will accommodate shopping carts with standard heights up to 103 cm [2].

2.4 Electrical Requirements

[R8-II] The radar motion sensor, RFID reader, motor unit, and user interface will be usable with a power supply of 110V/120V at 60 Hz AC, which is standard for North American power outlets.

[R9-III] The RFID reader and motor unit will not be powered unless the radar motion sensor detects an approaching customer, in order to conserve energy.

2.5 Environmental Requirements

[R10-II] The LSG will fully function under room temperatures (5-35°C).

[R11-II] The LSG will fully function on flat ground.

[R12-II] The LSG will fully function with humidity levels of less than 95%.

[R13-II] The LSG will fully function in any indoor location.

[R14-II] Noise generated during the active phase shall be less than 90 dB [3].

[R15-III] The RFID reader will be shielded from external electromagnetic fields.

[R16-II] The antennae will be protected from exposure to external electromagnetic noise (such as a radio generator), liquids and fire.

2.6 Performance Requirements

[R17-II] RFID tags will be scanned with an error rate less than 25%.

[R18-III] An error rate of less than 20% will be achieved after use of the scale for reader verification.

[R19-II] The accuracy of the system will not be diminished by the presence of metals or water.

[R20-II] The motor unit will be capable of rapidly repositioning the antennae along the frame of the LSG, and each movement sequence will be less than 3s.

[R21-II] The total scan time will be less than 10 seconds.

2.7 Reliability and Durability

[R22-II] All parts of LSG will be accessible to technicians for maintenance and repair.

[R23-III] The LSG will properly function for at least 2 years, with monthly maintenance.

[R24-III] The operating system and user interface will be updated whenever needed.

[R25-III] Mean time between failure will be more than 10,000 hours.

[R26-III] Subsystems will provide notification when inoperable.

[R27-III] The LSG will be capable of constant operation over regular store hours.

2.8 Safety Requirements

[R28-II] The LSG will have an emergency power switch.

[R29-II] The LSG will properly function even when electronic devices such as cellphones or laptops approach.

[R30-II] The LSG will be structurally stable.

[R31-II] The LSG will be able to withstand moderate incidental contact.

2.9 Standards

[R32-II] The LSG scanning unit will conform to the standards of Environmental Radiation [5].

[R33-II] The LSG will conform to UHF Air Interface Protocol Standard [6].

[R34-II] The RFID scanning unit will conform to International Standards Organization(ISO) 11784, 11785, 14443, 15693, 18047 and 18046 [7].

[R35-II] The LSG scanning unit will conform to Electronics Product Code Global Incorporated (EPCglobal) [8].

[R36-II] The LSG motor unit will conform to IEC 60034 standards (International Electrotechnical Commission) [9].

2.10 Sustainability Requirements

[R37-III] The gate will be completely composed of recyclable material.

[R38-III] The gate will be modularized so individual subsystems can be replaced independently.

[R39-III] The gate will have a power saving state.

3 Central Reading Unit

The central reading unit (CRU) is composed of a RFID module, two antennas, and a location control unit. It takes RFID tags as input. The reading unit is responsible for retrieval of serial numbers from any passive RFID tags within range. The RFID module is a frequency transceiver which generates an alternating magnetic field within the specified radio frequency range, and retrieves information from the RFID tags by measuring their induced magnetic field.

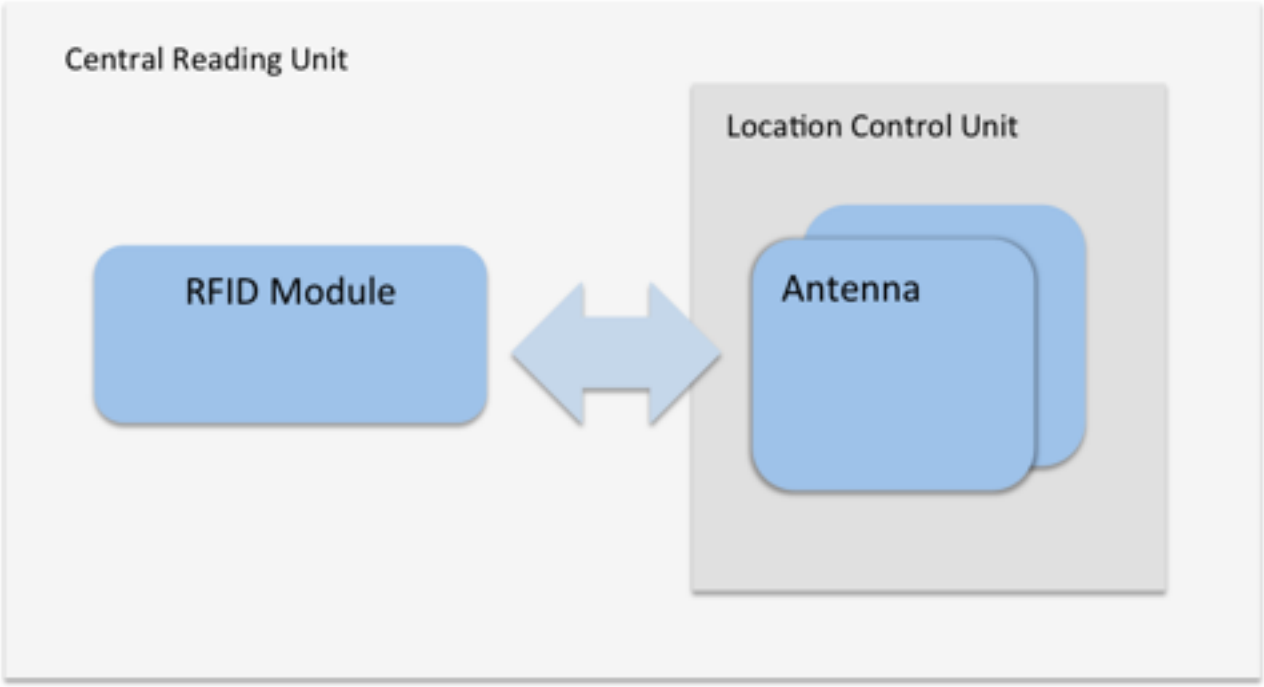

FIGURE 3: CRU BLOCK DIAGRAM

3.1 General Requirements

[R40-III] The CRU will have an average lifespan of at least five years.

[R41-III] The CRU will be reliable and require little need of maintenance.

[R42-III] The CRU will be easy to install or uninstall.

3.2 Physical Requirements

[R43-III] The CRU will be portable.

[R44-II] The dimensions of the antennae will be at most 50 cm x 50 cm.

[R45-II] The weight of each antennae will be at most 1 kg.

3.3 Performance Requirements

[R46-III] The CRU will be able to read tags in the spectrum range of 840MHz-960MHz.

[R47-III] The CRU will have a minimum read speed of 100 tags/second.

[R48-III] The RFID reader's output power precision will be less than 1 dB.

[R49-III] The RFID reader's output power flatness will be less than 0.2 dB.

4 Location Control Unit

The location control unit consists of two motors, one on each side of the gate, that functions to reposition the RFID antennae during the scan process. This increases the accuracy of the system since additional information may be gained with different geometric arrangements of the scanner in relation to the tags. Each antenna will mount securely onto a belt coupled to the motor, and the motor will be active when the scanning angle requires change.

4.1 General Requirements

[R50-II] One motor will be used on each side of the gate.

[R51-II] The location control unit will be able to provide feedback on successful or unsuccessful repositioning.

[R52-II] The location control unit will be easy to install, maintain and replace.

[R53-III] The RFID antenna will mount securely on to the location control unit.

4.2 Physical Requirements

[R54-II] The location control unit will be stable during movement.

[R55-II] The location control unit is capable of manipulating the load of the antenna.

[R56-III] The location control unit components such as the motor and belt, will be enclosed within the gate.

4.3 Safety Requirements

[R57-II] The antenna wires will not become tangled during movement.

[R58-II] The location control unit will comply with IEC-60529 [10].

5 Verification Unit

The verification unit consists of a scale, which will be connected to the CRU. The primary function of the scale is to measure the total weight of the merchandise and output this to the CRU. The CRU will calculate the expected weight of the merchandise using the central database, and will compare the expected weight with the actual weight in order to verify that all of the merchandise has been correctly scanned.

5.1 General Requirements

[R59-III] The scale will have level III classification [11].
[R60-III] The scale will have a maximum capacity of at least 50 kg.
[R61-III] The scale will be easily calibrated by store employees.
[R62-III] The scale will meet NTEP and LFT approval [11].

5.2 Physical Requirements

[R63-III] The weighing surface will accommodate a standard shopping cart length [2].
[R64-III] The weighing surface will accommodate a standard shopping cart width [2].
[R65-III] The weighing surface of the scale will be flush with the ground.

6 User Interface Unit

The user interface unit consists of a touch screen device, a payment device and an LED guide light. The touch screen device should give users the ability to preview item details, remove items from their list, and call for assistance. The payment device will accommodate cash, credit card and debit card purchases and accord with Payment Card Industry Data Security Standards [12]. All of the parts will be properly synchronized to make users' shopping experience as easy and intuitive as possible. The subsystems of the User Interface Unit are shown below:

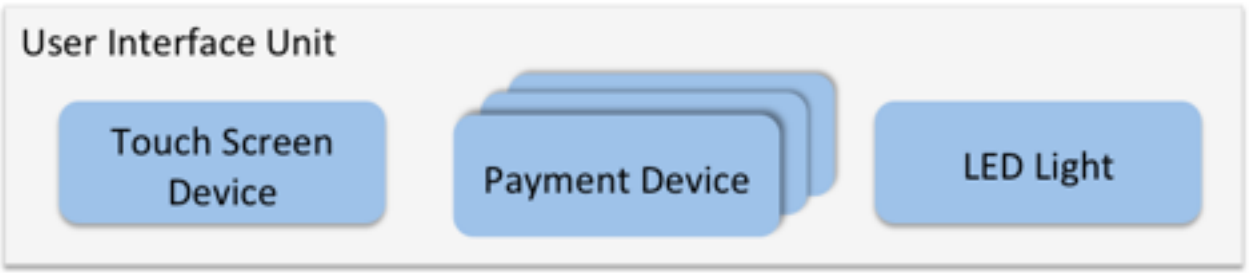

FIGURE 4: USER INTERFACE BLOCK DIAGRAM

6.1 General Requirements

[R66-II] The user interface unit will use an LED light to indicate the scanning status of the CRU (scan complete or item missing).

[R67-II] The user interface unit will receive item information from the CRU.

[R68-II] The user interface unit will deliver user interaction information to the CRU for processing.

[R69-III] The user interface unit will use a touch screen device for displaying information and user interaction.

[R70-III] The user interface unit will accept cash/credit/debit card payment.

6.2 Usability Requirements

[R71-II] User interface unit software will accommodate common store checkout errors (items not scanned, user's payment failed, etc).

[R72-II] The LED will use ubiquitous colour coding to indicate status (ex. red = fail, green = success).

[R73-II] The interface unit parts will be arranged intuitively for the user.

6.3 Physical Requirements

[R74-III] The aspect ratio of the software user interface will be 4 : 3 (width : height), and can be scaled up or down depending on screen size.

[R75-III] The touch screen device will be accessible to people with different heights or disabilities.

[R76-III] The LED light will be visible to people within the CRU detection range.

7 User Documentation

[R77-III] User documentation will be included in the detailed product setup guide for technicians.

[R78-III] User documentation will provide a website for customer support.

[R79-III] User documentation will assume an audience with limited knowledge of RFID technology.

[R80-II] User documentation will describe the product's features and any limitations.

[R81-II] The user documentation will include risk analysis and possible solutions for certain product limitations.

8 System Test Plan

The goal of the LiteSpeed Gate is to accelerate the retail checkout process in order to reduce the amount of time spent in lineups. This will make the shopping experience more smooth and efficient, and generate more profits for the store. The targeted clientele are clothing and grocery stores. With insufficient testing, however, large financial losses could be incurred by the clientele due to system inaccuracies or insecurities. Complications may also arise due to integration of numerous subsystems. For these reasons, industry-standard testing approaches will be used to ensure the final design is fully functional and secure. Initial testing will focus on the subsystems individually. Each unit test will be performed on the relevant sub-system by the chief design engineer of that particular sub-system. The test will ensure that the sub-system is capable of producing the expected output given an input, without any assumptions of other parts of the system.

Integration testing will then be performed by combining together combinations of subsystems. The chief design engineers of both subsystems will be responsible for these tests. Aside from the functionality, testers will also focus on the compatibility of the different components.

In the proposed project schedule, approximately one week is allocated for system testing. System tests will be performed after each phase of iterative implementation. The system tests are the most important part of testing because a lot of special cases can only be tested when a working system is available. Our project's system testing will focus on its end-to-end workflow, compatibility of parts, performance, security features and usability. After the system test, the engineering team will discuss any problems and create a prioritized task list to be completed before the second round of project implementation.

Regression tests will be completed after the second round of project implementation to ensure that the problems discovered in the system test are indeed fixed or improved, and that the fixes do not cause new problems.

Before the final POC demonstration, at least one round of final acceptance tests will be performed. The scope of these tests includes the project's top level functionality, performance, and security. The testing results will be compared against the requirements in this document as previously articulated. If new problems are found during this stage, the engineering team will attempt to fix them without introducing more problems. If it is impossible to fix a problem within the proposed schedule, it will be documented in further paperwork as a known system limitation.

Conclusion

This functional specification outlines the high-level requirements of the LiteSpeed Gate to be produced by ShopLite Solutions. The requirements are divided into those which pertain to the proof-of-concept device, those which pertain to the final product, and those which pertain to both.These requirements will be frequently referred to during the design and implementation of the proof-of-concept LiteSpeed Gate which is projected to be completed by April 15th 2015.

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