Proposal for Smart TransLink System

January 16, 2012

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

Re: ENSC440 Project Proposal for Smart Translink System

Dear Dr. Rawicz:

Our project entails development of a smart transit system specifically targeted towards improving train service (i.e. SkyTrain), with possible future expansion towards buses, trams and others. As outlined below, this approach will work towards reducing traffic during peak times, efficiently counter fare-evaders, generate revenue via targeted advertisement and reduce the environmental footprint.

TransNet consists of five highly skilled engineers pertaining a wide-variety of skills: Bilal Nurhusien, Daniel Frigo, Alex Moore, Maxim Soleimani-Nouri and Mohammad Osama. If you have any questions or concerns, please contact us at 778-828-3012 or via email at TransNet.contact@gmail.com.

Sincerely,

Alex Moore,
CEO
TransNet

Enclosure: Project Proposal for Smarter Translink System

Proposal for Smart TransLink System

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Submitted to:
Dr. Andrew Rawicz – ENSC 440
Steve Whitmore – ENSC 305
School of Engineering Science
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Issued date: January 16, 2012

Proposal for Smart TransLink System

Executive Summary

"The goal is to transform data into information, and information into insight"

--Carly Fiorina, Executive and president of Hewlett-Packard Co. in 1999.

Increasingly, data and information derived thereof is being used to develop smarter and more intelligent systems. TransNet seeks to use such an approach to improve transit experience for riders while increasing profitability for service providers. Peak hours are especially frustrating when you are trying to arrive to work/home and finding the SkyTrain clogged to a maximum. TransNet seeks to monitor (real-time) the number of users using train services and relay that information to staff where it can be processed to increase the number of trains at peak times or decrease empty trains from running. Moreover, instead of carrying change or going down to the local convenience store to buy a new pass every month – it's possible to increase the monetary value on your designated (re-useable) card and have fare deducted as you travel throughout the system. This not only saves you from the monthly hassle but also serves as a more environmentally friendly and cheaper alternative to the non-reusable paper version.

Transit service providers encounter similar problems in relation to fare-evasion. For example, Translink has lost over 11 million dollars during the last 3 years from individuals using the system without payment [1]. Moreover, the inefficiency introduced from random checking of fares or high cost of installing physical barrier system is both inconvenient and unreliable. TransNet introduces the idea of 'Smart Checks' which provide staff with a live monitoring of individuals who have not paid fares thus allowing security personnel to target those specific areas on the transit system (implemented via specialized camera hardware and image processing analysis).

Revenue generation is a major consideration for any successful business. Data collected through TransNet can be transformed into information from which insight can be derived – particularly, for advertisement purposes. Individual cards given to rider contain basic information regarding age, etc for identification purpose, which can be extracted to establish passenger profiles during different times allowing for targeted advertisement to increase profitability. Moreover, TransNet will serve as an exemplary model to similar models (e.g. do not contain all features of TransNet) already implemented in that it will be a fraction of the cost (e.g. Translink is considering implementing a similar system at tune of $100 Million) [2] convenient (no physical barrier) and easily integrated into the current transit system (little infrastructure construction involved).

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Glossary

BAP	Battery Assisted Passive
RFID	Radio Frequency Identification

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1. Introduction

"Is there such thing as a free ride?"- TransLink is losing a considerable amount of profit on fare evasion throughout the lower mainland. According to CKNW, Translink has lost $11 million over the past 3 years to customers who don't pay for fares [1].

TransLink spends a considerable amount of money and resources on security to ensure payment of fares. Currently, they are planning on implementing a project, aiming towards fraud prevention amounting to a total cost of approx $100 million [2]. TransNet plans to implement a similar project which operates more efficiently and at a fraction of the cost.

The idea behind this project is to assign each rider a "personalized card" which has an integrated RFID tag built into it. The passenger would place his card into a machine at any sky train station, pick a fare plan that he wants, add money to the card, and go ride the sky train. RFID readers installed throughout the sky train carts will detect these tags as the person enters, and will automatically deduct the corresponding fare amount from his card. All this without any need for the passenger to show anyone his card or inserting it into a validation machine.

An additional aspect of our system is to count the total number of people that are on a SkyTrain. By seeing the number of RFID tags detected and comparing it to the total number of people inside, TransLink will be able to see how many people are evading their fares and will be able to take immediate action.

Currently the only way TransLink has of preventing fare evasion is by sending someone to manually check everyone for their fares, this is a very inefficient, time consuming, and costly method.

Through the use of our system, TransLink will be able to enhance security as well as save costs relating to security expenditures.

Another issue our system aims to solve is optimum vehicle allocation. Currently, there are times when a sky train will be jam packed and the next one comes in 15 minutes, while at other times, 3 sky trains go by within the range of 10 minutes, almost empty. With the use of our system Translink will be able to use the data our system collects to optimize the trains in service at any given time which will ensure convenience and result in better customer service. This proposal will provide and discuss possible designs of the system, organization and time management by providing Gantt charts, budget and different sources of funding, and different sources of information.

2. System Overview

TransNet's system is based around three stages of detection/processing which all communicate with one another as shown in Figure 1.

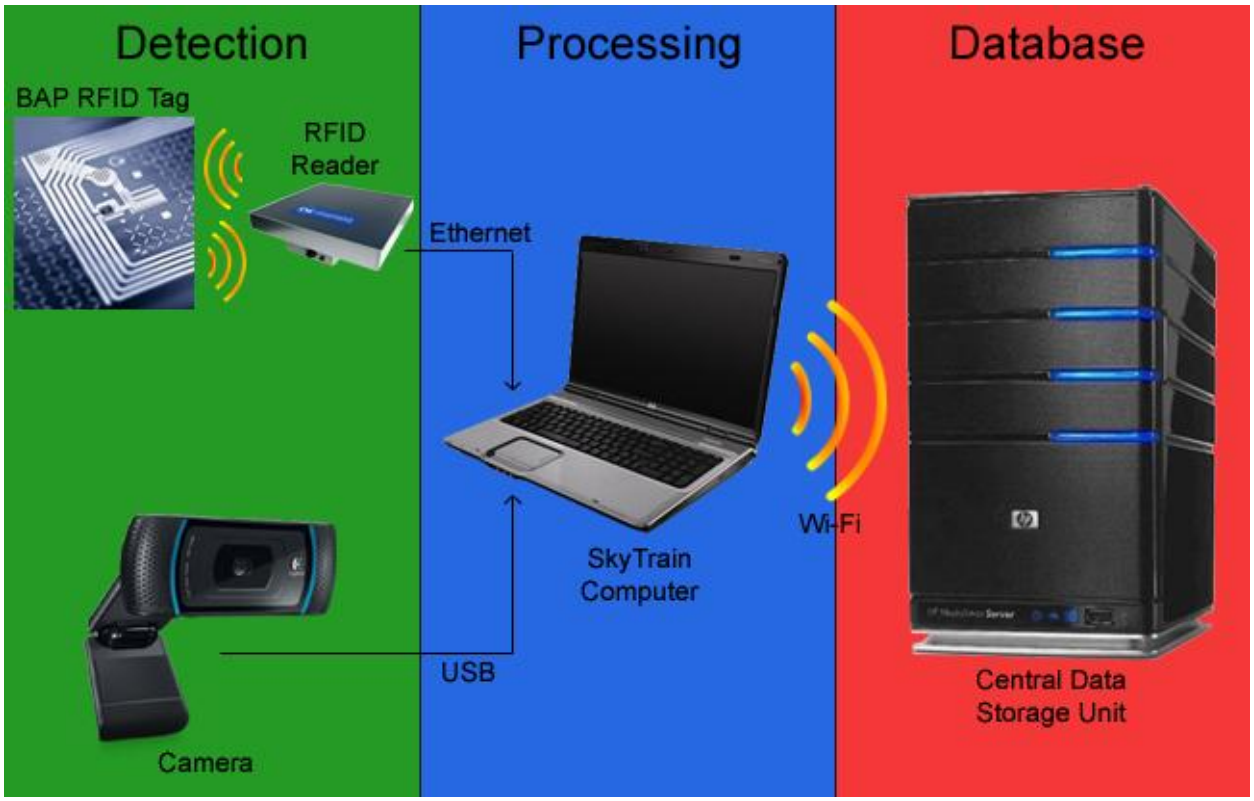

Figure 1: Conceptual Overview

Stage 1: Detection

A BAP RFID tag embedded in the rider's transport card is detected by an RFID reader mounted in the ceiling of each SkyTrain cart. The reader identifies the tag's ID, and sends it via ethernet to the SkyTrain's local computer for processing.

There is one camera mounted above each door for each SkyTrain cart. The camera records all riders entering and leaving through its respective door. This footage is sent to the SkyTrain's local computer for processing.

Stage 2: Processing

The on-board SkyTrain computer compiles a list of all the RFID tags, along with the time of reading, what location the train is currently at, which cart the tags/train were detected in, and the total number of tags detected in each cart/train. This information is then updated to the database over Wi-Fi at each station.

The footage from the cameras is processed by image processing software on the SkyTrain computer which keeps a numerical count of the number of riders entering and leaving the train at each respective door. For example, say a train has only two doors, during a stop at a station Camera 1 detects a net of 5 people entering through its door and Camera 2 detects a net of 3 people leaving through its door, then NewRunningTotal = OldRunningTotal + 5 – 3. OldRunningTotal is initialized to 0 at the start of each day. The running total for each cart updated to the database over Wi-Fi at each station the train comes to a stop at.

Stage 3: Database

The database contains all of the live information received from each train. This information is viewable by security personal in real time, allowing them to identify trains with large numbers of fare evaders and act accordingly. The database also takes routine snapshots of current data and archives them for any desired statistical analysis at a later date.

3. Possible Design Solutions

As mentioned above, one of the biggest challenges the engineers at TransNet are faced with is to determine the total number of people in each train and to compare that to the number of people who have paid. Additionally, the proposed system will be able to identify each paying passenger and associate him/her with a customizable fare account which he/she previously creates. Thus, in the design, two main problems have to be solved. The first problem is to count the number of people in the sky train who have paid the fare and identify them. The second is to obtain a physical count of the total number of people in the sky train, regardless of whether they paid or not. By comparing these two numbers, Translink can then determine how many people haven't paid the fare. There are a number of ways for doing this using different types of sensors thus a number considerations are outlined below.

Different Solutions for Counting Total Number of People

Turnstiles

One of the simplest solutions out there is to use turnstiles. These turnstiles effectively allow only paying customers to pass through while denying access to non-paying customers. In addition, they have the advantage that anytime a person passes through the turnstile, that person can be easily counted automatically as a person entering a station. Non paying turnstiles can be placed at the exits to count the number of people leaving a station. Turnstiles, however, can only be used in sky train stations or sea bus stations. There is little practical implementing of these devices to future expansions such as bus stops and others. Moreover, the most significant disadvantage of using turnstiles is that they can create huge bottlenecks, especially at peak times, and passenger traffic. As well, implementation costs are high and infrastructure construction introduce disruption to passenger and SkyTrain schedules.

Proximity sensors

Proximity sensors are widely used in the industry to detect presence of people or objects. There are many different types of proximity sensors and their usage is dependent on the type of application or environment of operation. Along with a counter system, proximity sensors can be used to detect the total number of people on each sky train cart, and hence on each train. The main advantage of using these sensors is primarily affordability. However, using these sensors to count the total number of people in a SkyTrain cart can be an extremely difficult task, perhaps

impossible. The main problem is that there can be many people in the SkyTrain, huddling close together, blocking other people, some people are taller or shorter, etc… thus it is a very difficult task to differentiate each and every person. A similar problem arises if we try to use video cameras for this purpose; although theoretically possible, it's extremely challenging given our 4 months time frame.

Infrared Sensors

A simple and cheap solution would be to use infrared sensors on the doors of the sky trains. By having an infrared sensor at one position of the entrance to the sky train and another one a little further back, the dual sensor should be able to detect if a person is entering the sky train or if a person is exiting. If a person is exiting, the system would subtract 1 from the total number of people counted. The main problem with this solution, however, is that it would work if only one person was walking through the door of the SkyTrain at any given time which clearly is not the case. If two individual pass through, the sensors will detect only one person thus failing on a number of different scenarios.

Thermal Imaging

Thermal imaging can be a fairly accurate way of counting the number of people in a cart by counting the number of blobs that appear in the thermal camera. The main problem with this solution is that good thermal imaging cameras are expensive and due to budget constraints, this solution is not realizable.

Counting and Identifying Paying Passengers

There different ways of counting the number of paying passengers, some simple while other more complicated. A basic approach is to place a card reader in each sky train cart and have each person place their fare ticket in the reader. With a smart card, this method can count and identify paying passengers. Unfortunately, this could create a huge back log of people at peak times and is a very cumbersome approach. The proposed project aims at a solution that automatically counts and identifies each person as he/she enters the SkyTrain without him/her having to physically perform an action. This approach will be outlined and discussed in detail in the proposed design solution section.

4. Proposed Design Solution

The proposed solution for this project is to have a battery assisted passive RFID tag implemented in each fare card purchased. Each passenger would buy one of these farecards every two years or so. It would be inserted into a machine at any SkyTrain station and an amount added to the specific account associated with the card. Each account created will be stored in a centralized data base and associated with his/her RFID tag.

RFID reader will be installed in each SkyTrain cart and will scan for these RFID tags every time after passengers have entered into the individual carts at each station and train doors closed (i.e. no further movement of riders). A unique code for each RFID tag (i.e. signature) on board will be detected by the reader and this signature will be sent to a computer inside the sky train. All the system needs to do is count the number of RFID tags detected to count the number of paying passengers on board. In addition, the on-board computer will relay these signatures and associated information (e.g. location of the train, etc) wirelessly to a centralized database. These codes can then be associated with individual accounts and money deducted from their account balance.

As mentioned before, the other aspect of the project is to count the total number of people that enter the train. The solution to this problem is to use video cameras installed on the doors to monitor passengers entering and exiting. Using advanced image processing algorithms, it has been shown that it is possible to detect whether a person is entering or exiting through a door covering a range of different scenarios (e.g. two individuals entering while another exiting simultaneously). Although this solution is cost-effective and is practical to implement, it requires very complicated solutions and an enormous amount of research and work. We intend to implement this feature, however, due to the tight time constraints – possible bugs/failure in the system might not be worked out by the scheduled completion date. Given more time, a far more reliable system could be made.

Advantages of our system are that fare cards need to be purchased every 2 years or so saving money in production of fare tickets as well as a smaller environment footprint. Moreover, passengers will be able to have one card for all travel and removes the need to identify proof of payment to transit authority.

A final advantage is that this system can be easily implemented on buses and sea bus. Implementing it on a bus would mean that the bus driver wouldn't need to check every single person has their fare ticket; people would be able to just get on thus greatly improve pedestrian traffic flow.

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Some of the disadvantages of our system are its increased complexity and cost. The initial costs however would most likely be compensated in better security and perhaps advertisement potential through specialized marketing. For this system we plan on building a single prototype consisting of a single RFID reader, a webcam and a few RFID tags for testing. Building this simple prototype is well within the project's budget. Ideally, this system would need to be tested on the actual SkyTrain. For this project, the plan is to build the prototype and simulate its performance on the SkyTrain. Inevitably some minor changes would need to be made when installing it on the actual SkyTrain, however, our design will take into account such requirements.

5. Sources of Information

Throughout the research process, we plan to gather information from several different sources: course textbooks, encyclopaedias, manufacturer datasheets, research papers, and most importantly, experts in the field.

Currently, we're in communication with several RFID distributors and manufacturers to discuss different solutions that we could use to implement our project. Our main objective is determine which RFID readers/tags would be appropriate for our approach.

We will need image processing to detect humans as they enter a SkyTrain which will require massive amounts of research. Furthermore, examinations of computer vision techniques are required to process and analyse images effectively. As well, further investigation of open source software that can be used to track humans like OpenCV and OpenKinect might be required. Computer vision is a relatively new field of study and has been used in video games, surveillance and navigation systems.

Implementation of a database system will also be a requirement for our project. Online sources as well as course textbooks will be used to further investigate the topic. In order to transmit data to the server (which contains our database) a comprehensive understanding of computer networking and internet protocols is necessary.

Finally, our fellow group members we'll be essential sources of information. We have a diverse set of individuals on our teams each with skills that will prove useful in our project. Consultation with faculty members in the computer science and engineering departments will also be utilized.

6. Budget and Funding

6.1 Budget

Table 1 outlines the costs incurred for the TransNet Fare Data Security System. Note that we have a 100 dollar contingency cost to account for any unforeseen expenditures. The equipment list does not include the cost of the server, since we already have one at our disposal.

Table 1: Tentative Costs.

Equipment List	**Estimated Cost**
RFID Tags	$100
RFID Reader	$725
Camera	$130
Micro-controller	$35
Contingency	$100
Total Cost	**$1090**

6.2 Funding

The cost of building a prototype for our system is partially being funded by the Engineering Student Society Endowment Fund (ESSEF). Exploration of other sources of funding such as the Wighton Development Fund as well as Translink itself to determine if they're interested in investing in our company.

Our group members are prepared to equally share any extra costs that the project may incur. All costs and transactions for the project will be recorded so that team members have up to date information on the state of our finances.

7. Schedule

Table 2 depicts the Gantt chart we will use to plan our project over the semester. We have overestimated the time some of the tasks may take to account for any delays in debugging equipment and unexpected problems.

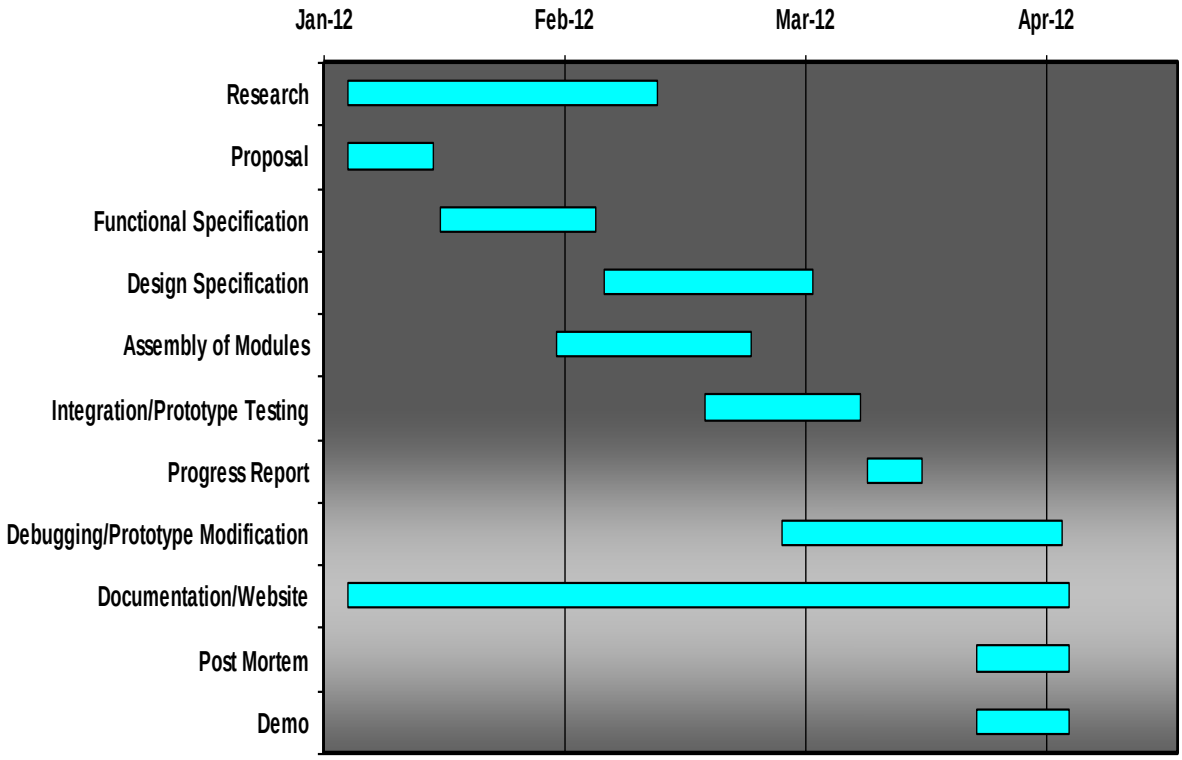

Figure 2: Gantt chart for our project

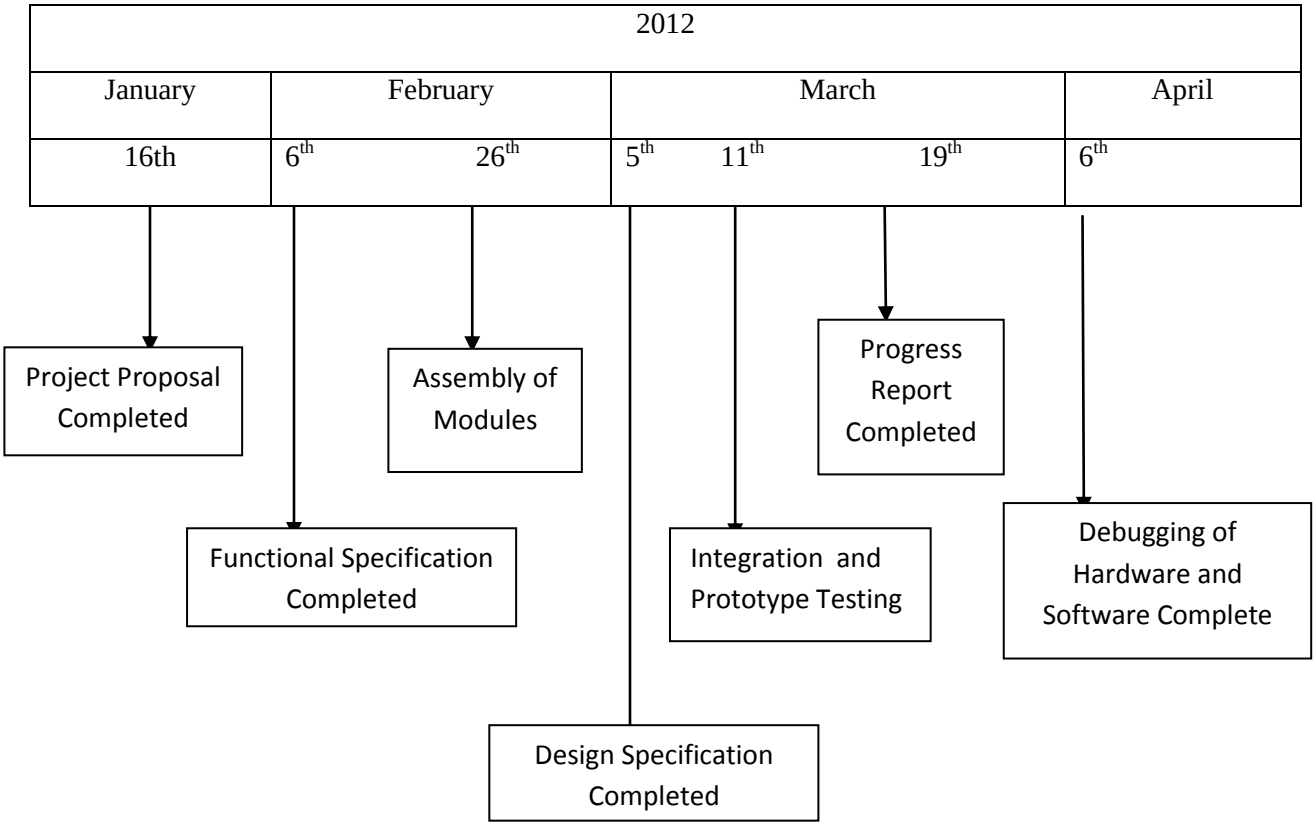

Figure 3: Milestone Chart

8. Team Organization

TransNet consists of 5 highly talented 4th and 3rd year undergrad engineering science students in the systems and electronics options. Each member has a different set of skills valuable to the project, discussed in the company profile section.

The structure of the company is based on each member of the team assigned a specific role in the company based on his skills. Alex – CEO – Chief Executive Officer, will be in charge of overseeing the whole project, resolving any conflicts, and assigning tasks to different team members as they're needed. Daniel – COO - Chief operating officer, will be in charge of ensuring deadlines are being met, and progress is being made in a timely and efficient manner. Bilal – VP of Operation will ensure materials and equipment arrive at desired dates, and each member is adequately contributing to the project. Maxim – CMO - Chief of Marketing will be in charge of ensuring sources of funds and will be responsible for ensuring the project always has enough resources to continue. Mohammad – Head of Development and Design will provide solutions to various technical issues that might arise.

The team will be divided with 1-2 people assigned to specific tasks relating to his area of expertise. Deadlines for specific tasks will be set and strictly enforced to ensure timely completion of the project. With a project this complicated, time management and organization will be crucial for the successful completion of this project within 4 months.

Communication will also be crucial to ensure efficiency of the work being done. It was decided that the team will meet every week after either the 440 or 305 class. During these meetings, discussions will be made regarding the progress of the tasks each member of the group is working on. These meetings will also be a good place to bring up any problems that arise regarding the project or team dynamics and solutions to these problems will be discussed. It was decided that meetings lengths will be kept under one hour unless absolutely necessary to continue.

With proper time management, communication, and organization, we are confident that we will complete this project within 4 months.

9. Company Profile

Alex Moore – Chief Executive Officer (CEO)

Alex is a fourth year Biomedical Engineering student at Simon Fraser University. His software skills in Perl, Java, and C++ are complemented nicely with his aptitude for digital circuit design. He also has extensive experience programming and debugging digital circuits on FPGAs in VHDL. These tools will prove useful when designing, building, and testing the complex data and communications system at the core of this project. Alex also has outstanding leadership, organization, and presentation skills which will serve him well in his position as CEO of TransNet.

Daniel Frigo - Chief Operations Officer (COO)

Daniel is a 4th year electronic engineering science student at Simon Fraser University. He has a previous co-op work experience doing research on a dead-reckoning system used to track a person's movement. Through this co-op work term as well as various courses, he has acquired a lot of experience with data processing, programming in MATLAB and simulating many different systems. In addition, past projects he's been involved in, have allowed him to develop his programming skills in C/C++ and assembly programming. These projects include using multithreaded programming to write software in C capable of detecting specialized blocks being passed under a conveyor belt in real-time. In addition he is capable of quickly learning new programming skills that may be required and he's a committed and patient worker.

Bilal Nurhusien – Vice President of Operations (VP of Operations)

Bilal is entering his fourth year of studies in Electronics Engineering at Simon Fraser University. After taking several computing science and hardware engineering courses, Bilal has found a real passion for integrating and learning about hardware and software systems. He has Experience working with the Arduino Uno and Motorola HC12 Microcontrollers and has working knowledge of C/C++, Java, and VHDL programming languages. Moreover, Bilal has good knowledge of Data Communication and Networking principles, particularly Socket Programming which will be useful in creating server and database application for our project.

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Maxim Soleimani-Nouri – Chief Marketing Officer (CMO)

Maxim is currently a fourth year Engineering Science student majoring in the Systems option. He is an advanced user of lab equipment such as oscilloscopes, DMMs, power supplies, and function generators. Furthermore, he is able to build and troubleshoot electrical circuits and designs and he has a basic understanding of single layer PCB design and fabrication. Having spent his two co-op terms at Nokia as a software test engineer,he developed a good understanding of testing/troubleshooting software and has become familiar with all stages of software development lifecycle. He has also worked on a biomedical project as research assistance on his last co-op term which in turn has helped him familiarize himself with mechanical design and assembly. he has worked with several microcontrollers such as Motorola HC12 and PIC Microchip series in the past. Through previous co-op terms, courses and projects, he has gained good organizational, prioritization, and analytical skills. Furthermore, he has gained Strong problem solving and hands-on debugging skills along with great communication and documentation skills.

Mohammad Osama – Head of Development and Design

Mohammad Osama is a 4th year electronic engineering student with strong background in analog and digital circuit design, programming (C/C++), real-time embedded systems and electronic circuitry. Moreover, having finished a Co-op at IBM working on Compiler-Optimization has experience working in a collaborative team environment and understands product development cycle, in addition to gathering a larger set of technical skills. As well, performing a second Co-op at NetApp has enabled him to become familiar in working with servers and develop better background into differing networking protocols.

10. Conclusion

TransNet seeks to improve the transit experience for riders. Our system is convenient and offers paperless fare cards which are environmentally friendlier, longer-lasting, and cheaper than the alternative.

Moreover, our system aims to deliver reliable, real-time data collection and robust security features for transit service providers. TransNet gives its clients the ability to monitor the number of users using train services and relay that information to staff where it can be processed to increase or decrease the number of trains that are operating.

Using RFID technology and image processing techniques, our system automatically detects valid transit fare cards as well as the total number of individuals on a train. The security system provides this information to staff; thus, allowing security personal to target specific areas on the transit system when fare-evaders are detected. By preventing fare-evasion and providing real-time data in a cost-effective manner, TransNet is certainly the superior option to other fare collection service providers.

11. References

[1] http://www.cknw.com/Channels/Reg/NewsLocal/Story.aspx?ID=1578357

[2] http://www.translink.ca/en/Be-Part-of-the-Plan/Electronic-Fare-Cards/FAQs.aspx