Transnet RFID System

April 10,2012

TransNet

Team Members

Alex Moore (Chief Executive Officer)

- Database query processing
- RFID reader programming

Daniel Frigo (Chief Operations Officer)

- Image processing development
- Integration of complete system

Bilal Nurhusien (VP Operations)

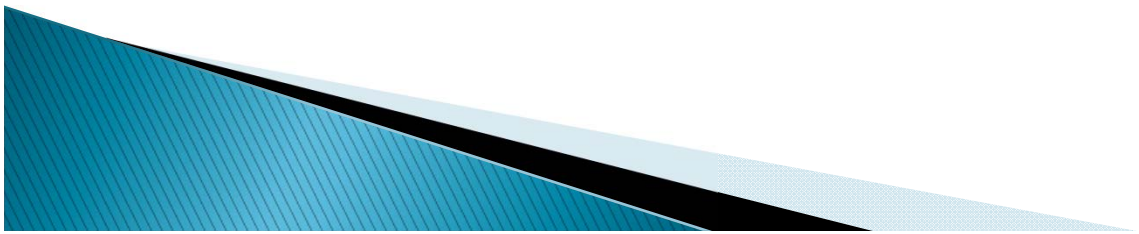
- Database/Network architect
- RFID reader programming

Maxim Soleimani-Nouri (Chief Marketing Officer)

- Main liaison with TransLink
- Integration of complete system

Mohammad Osama (Head of Development and Design)

- Image processing development
- Head researcher



Outline

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  - Team Members
  - Motivation
  - Overview/Background
- System Design
  - RFID Reader/Tags hardware components
  - Database
  - Payment/Zoning Algorithm
  - Video Processing for people detection
- Business Aspects
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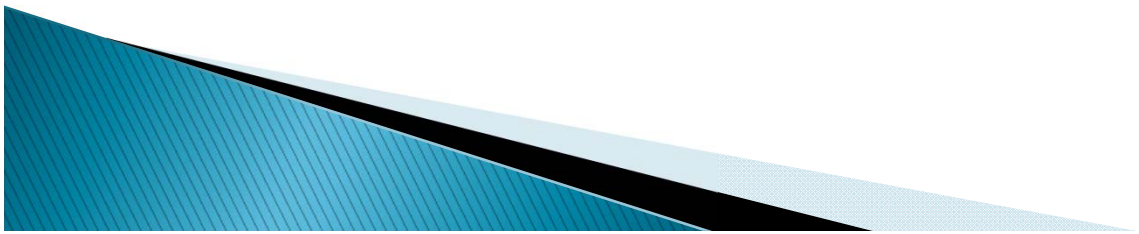
- Summary
  - Lessons learned
  - Future Work
  - Conclusion
  - Acknowledgment

Motivation

Problems

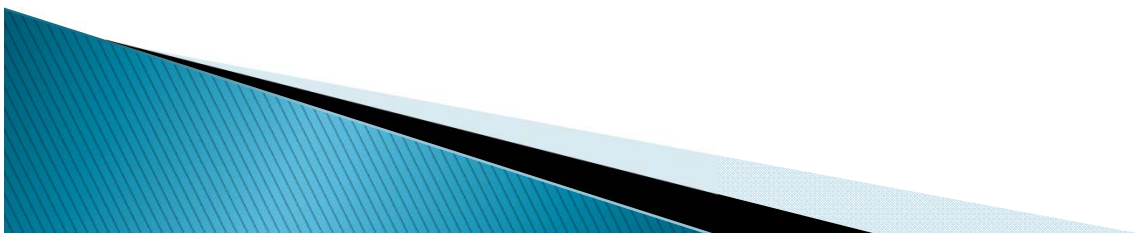
- Cumbersome fare system
- Poor methods of data collection
- Inefficient means of policing fare evaders



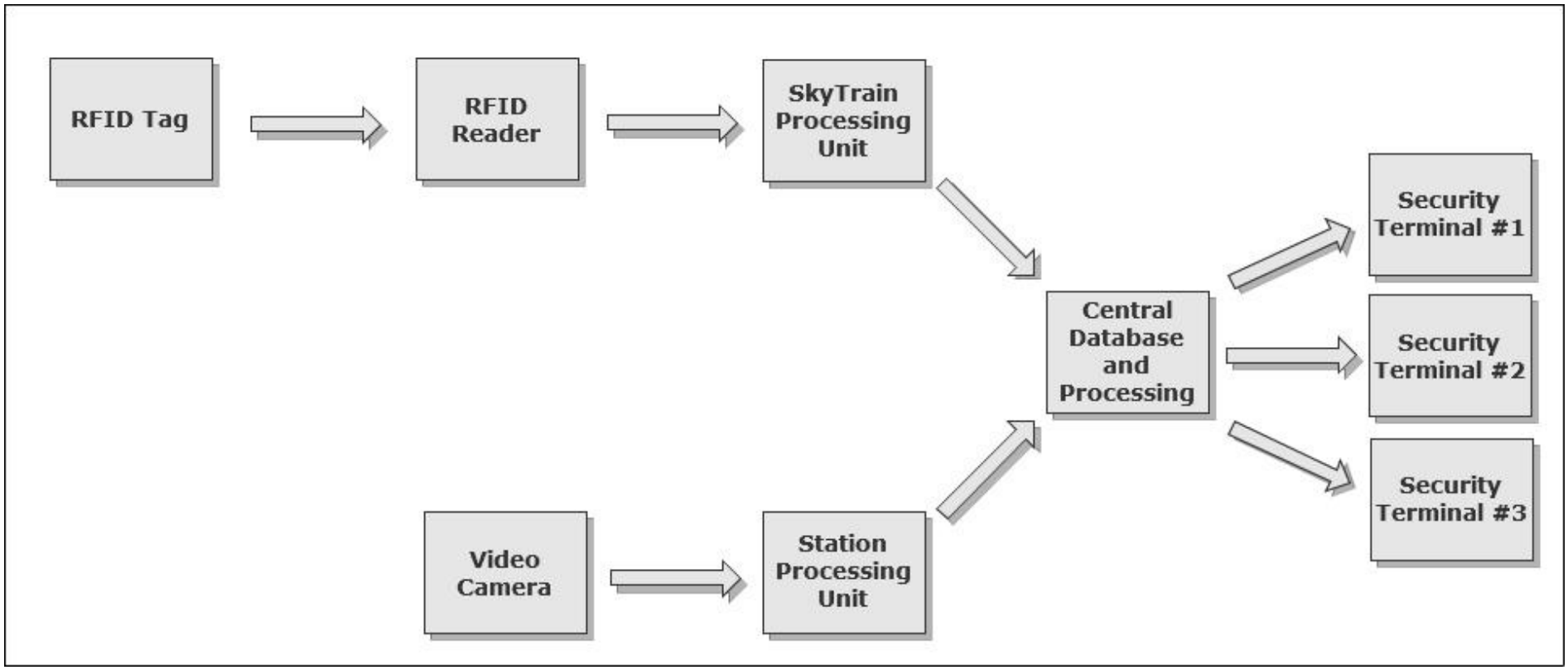
Mission Statement

To provide cost-effective tools for transportation companies to monitor, manage, and adapt their services and to provide a simplified, stress-free, and convenient riding experience to the general public.

We will accomplish this by integrating state of the art RFID systems and image processing techniques.

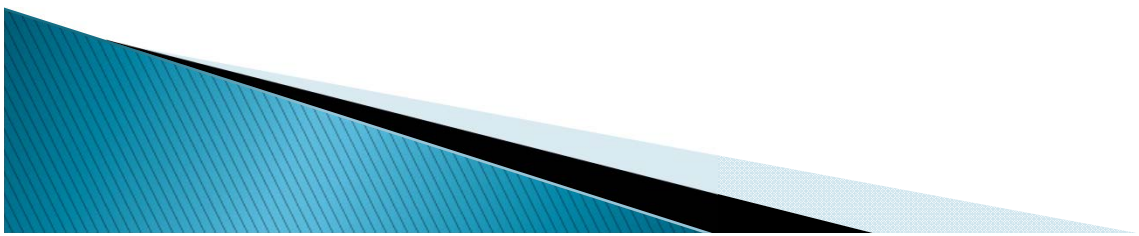


System Overview



Radio Frequency Identification (RFID)

- Method for transferring data using radio-frequency signals without physical connection
  - Identification
  - Tracking
- RFID Reader is a two way transmitter/receiver which emits RF signal(electromagnetic wave) picked up by tags
- RFID tags have built in circuitry consisting of a RX/TX module
  - Encoded RF signal is picked up by the tag's RX and tag's ID is sent out through the TX
- RFID reader picks up the response from the tag and analysis of identification is done through software interface



RFID Tags

- Three types of RFID tags
  - Passive tags
    - Does not require power
    - Very small and thin
    - Signal induces a small amount of current activating the IC long enough to receive a response(usually tag ID)
    - Very limited distance
  - Battery Assisted Power tags(BAP)
    - Bigger in size compared to passive tags
    - Offers greater read range and functionality for use on human bodies
    - Battery lasts about 4 years
  - Active tags
    - Offers the greatest read range
    - Biggest in size and dimensions

RFID Tags

- Originally received sample passive tags from Avery Dennison
  - Tested range was about 4 meters
- Intelleflex and Power ID offered the best tags according to the stated requirement
  - Power ID :Unable to purchase them until June 2012
  - Intelliflex: Out of price range
- Purchased 10 passive tags from Omni ID
  - Omni ID Max HD
    - Tested and achieved a range of 10-12 meters

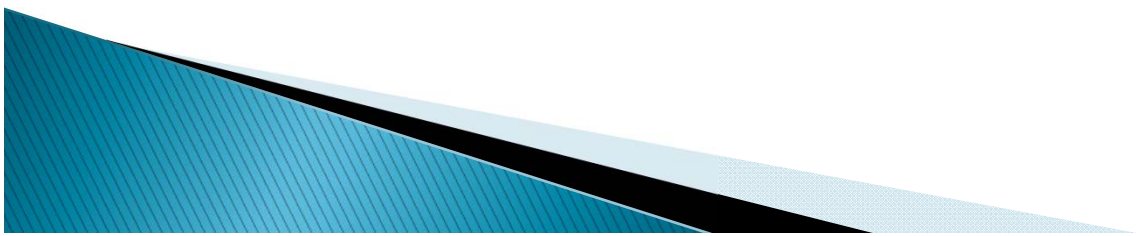
Operation

1) Once passengers have entered the skytrain cart and doors have closed, RFID reader initiates 20 seconds after the train has left the station and polls the tags

2) Collected tag IDs along with timestamps are then converted into a simple text file for transmission

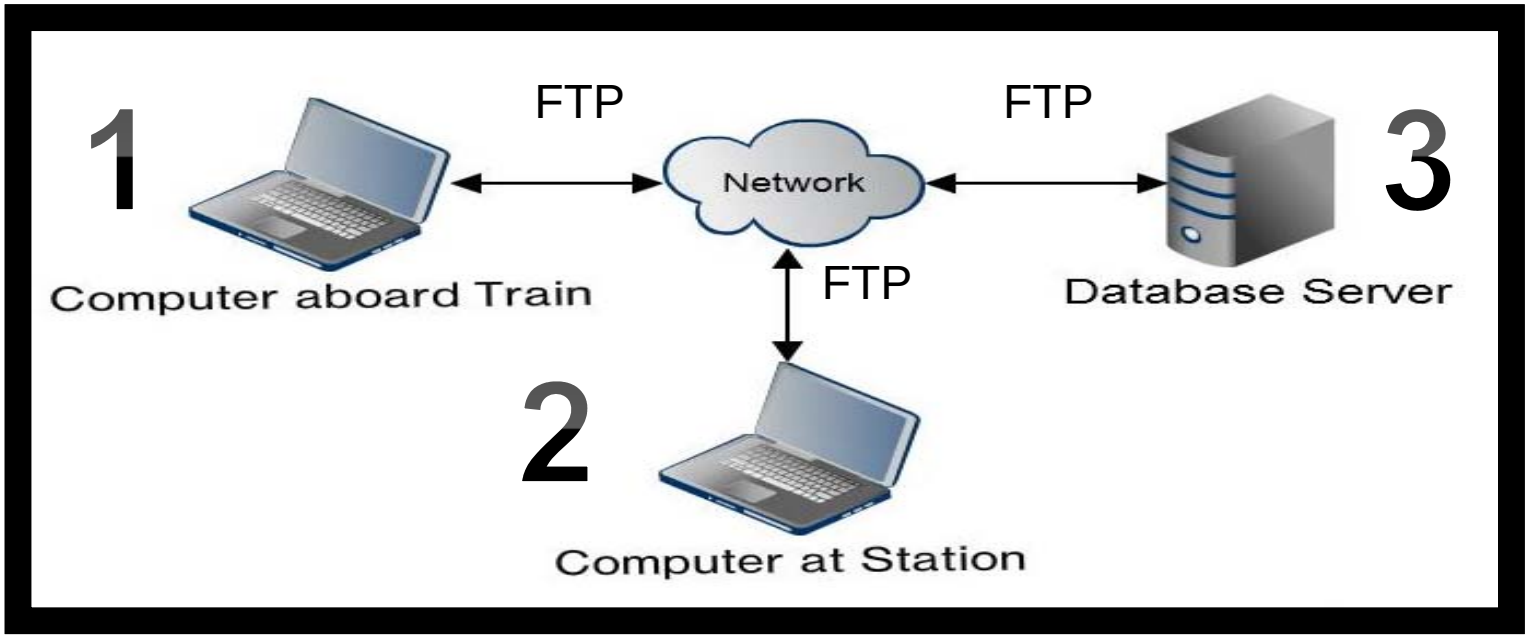
3) This information is passed via FTP over 3G network to central database

4) Zoning algorithm used to determine how much each person should pay depending on usage



Computer Networking

1.) The computer aboard the train sends the number of detected tags to the database server (as well as other relevant data)

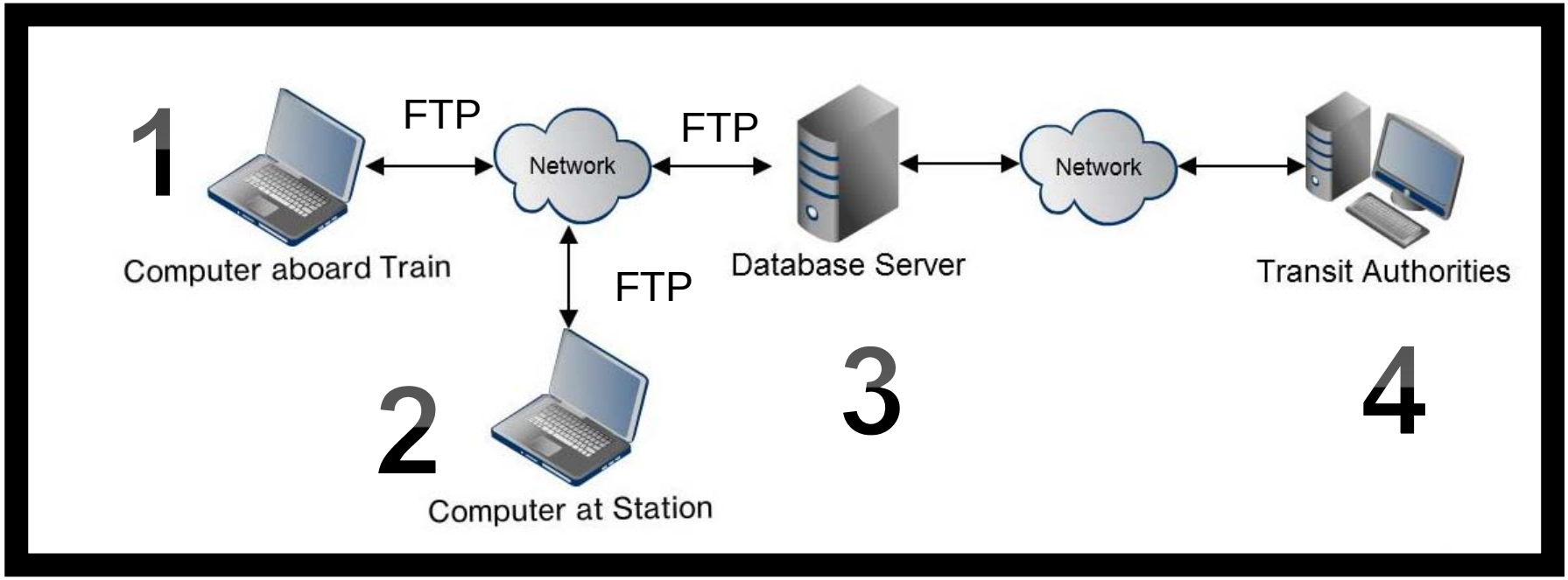


2.) The station computer sends the number of individuals detected entering and exiting the train

3.) The information is stored in the database for billing purposes and to find fare evaders

Computer Networking

4.) The contents of the database can be viewed using a web browser

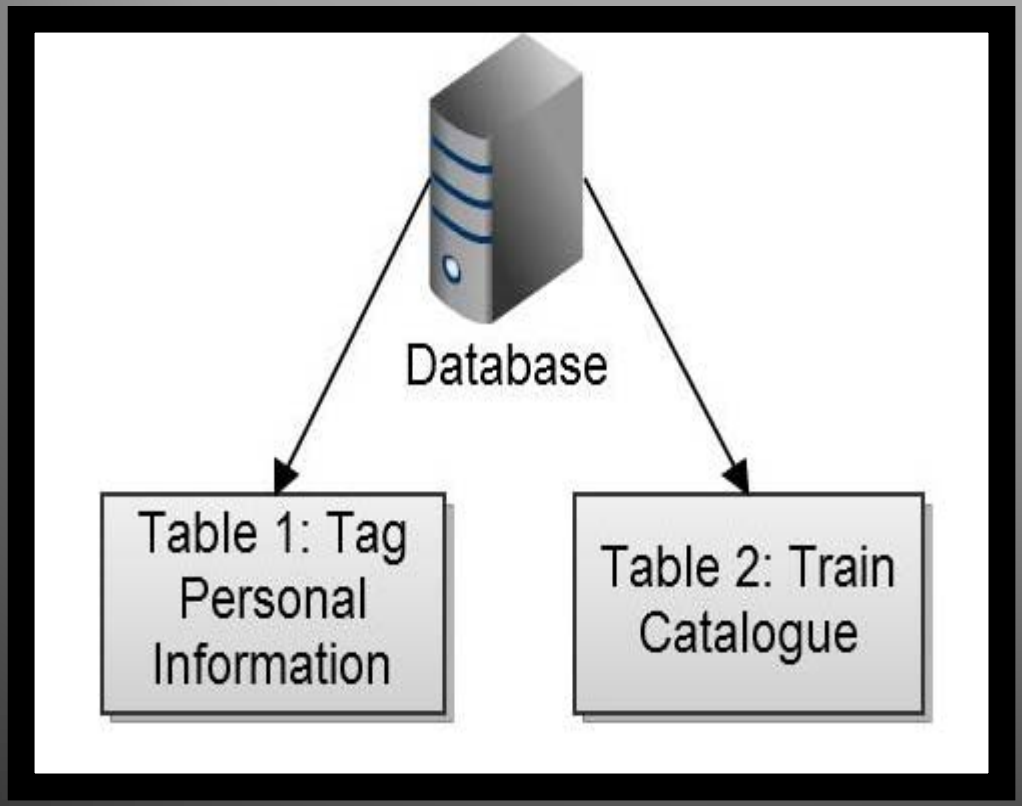


- Information displayed to transit authorities is updated by the database as it receives new data

Database

Database is composed of 2 tables and stored in a MySQL database management system

- Table 1 contains all the billing data



- Table 2 contains information about trains in use

Database Structure

Table 1: Tag Personal Information
Tag ID
Last Name
First Name
Address
Postal Code
Phone Number
Start Time
Zone 1
Zone 2
Zone 3
Zone 4
Month Total
Day Total

- An account is created when a fare card is issued
- Billing information is stored as well as the monthly and daily balance on the card
- As passengers travel through the transit system, the database will automatically bill their account

Database Structure

1.) The station computer sends the number of detected passengers entering/exiting the train

Table 2: Train Catalogue
Train ID
Previous Station
Next Station
Recent Time Stamp
Number of Tags
Number of Passengers
Number of Fare Evaders

2.) When a train leaves a station, it sends a file to the database containing the information to the left

Algorithm

- Used PHP to process the incoming data and display the contents of the database to users via website
- Billing for zone transfer auto-determined by software (cheapest payment method)
- Passengers are billed at completion of billing cycle

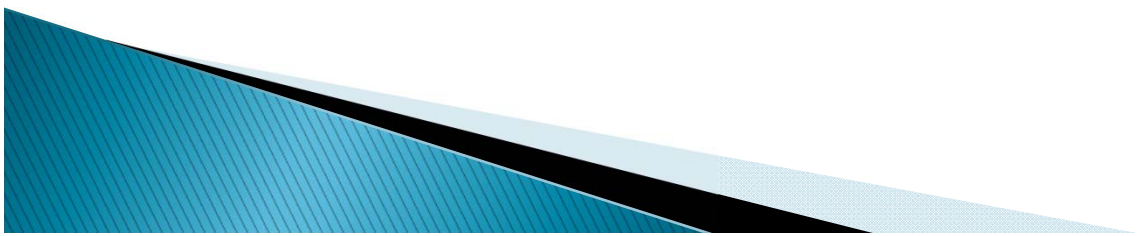


Image Processing

- Why image processing ?
  - Affordability, Reliability and Feasibility...
- Camera
  - Standard webcam (i.e. no special effects an
  - Larger field of view
  - HP 3100 (free)

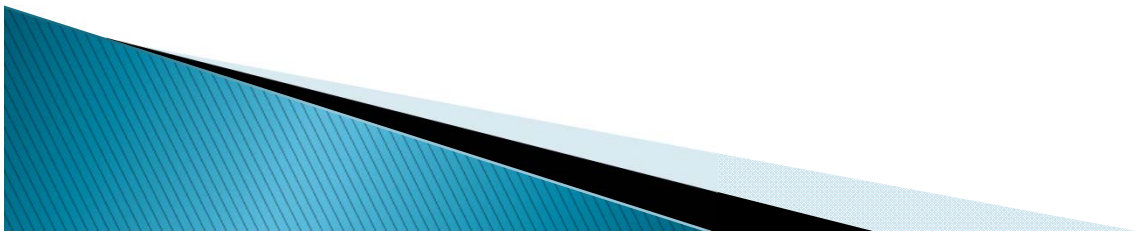
- Mounting

  Solid mount (does not jerk/rattle from external factors)

  Overhead position – removes any occlusion issues for optimal detection
- Wired vs. Wireless Connection
  - Wired connection provides faster data rate transfer – boosting performance, in comparison to wireless

People Counter Image Processing

- Background Acquisition
- Blob Detection
- Blob Matching
- Real-time vs. Non-Real-time

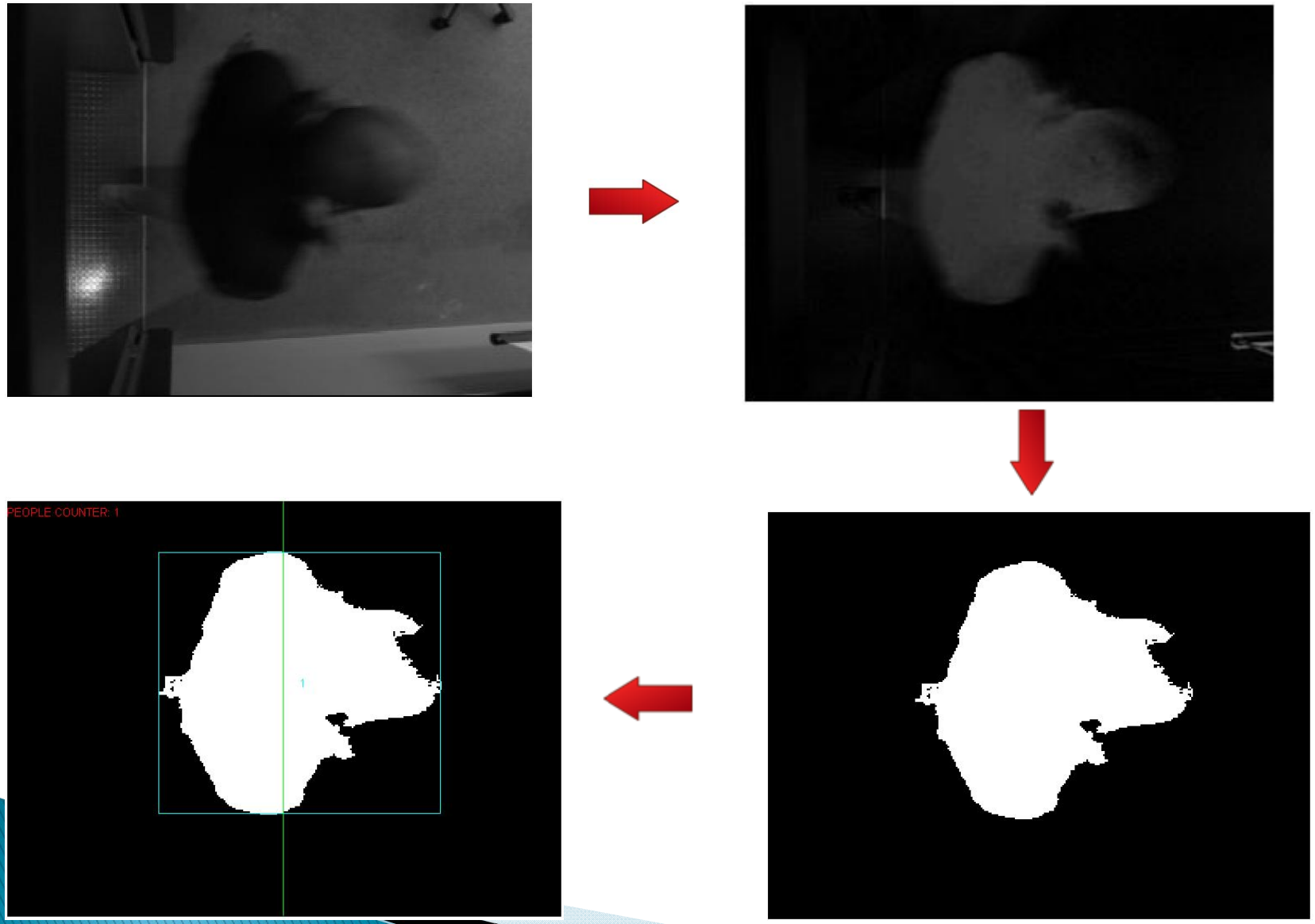


Background Acquisition

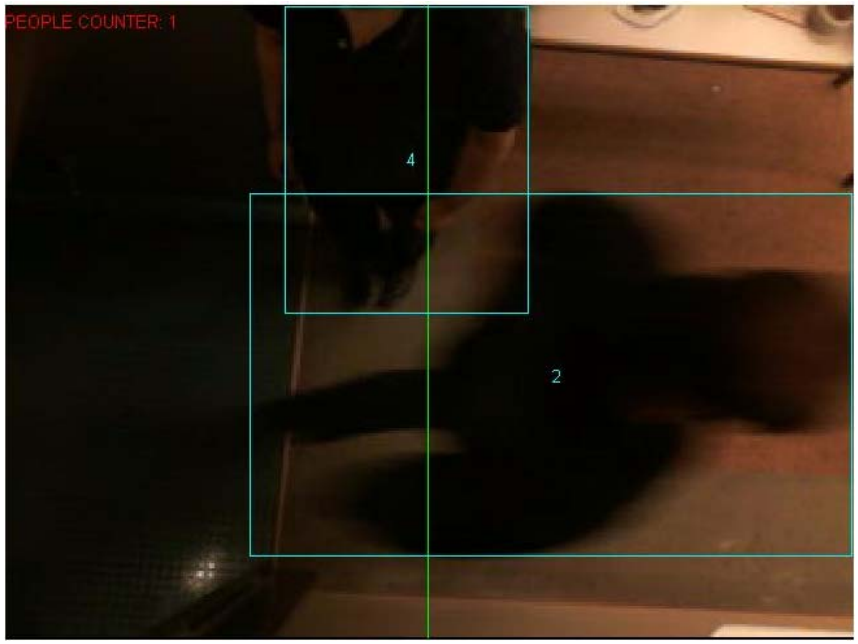
Background

Current Frame

Blob Detection



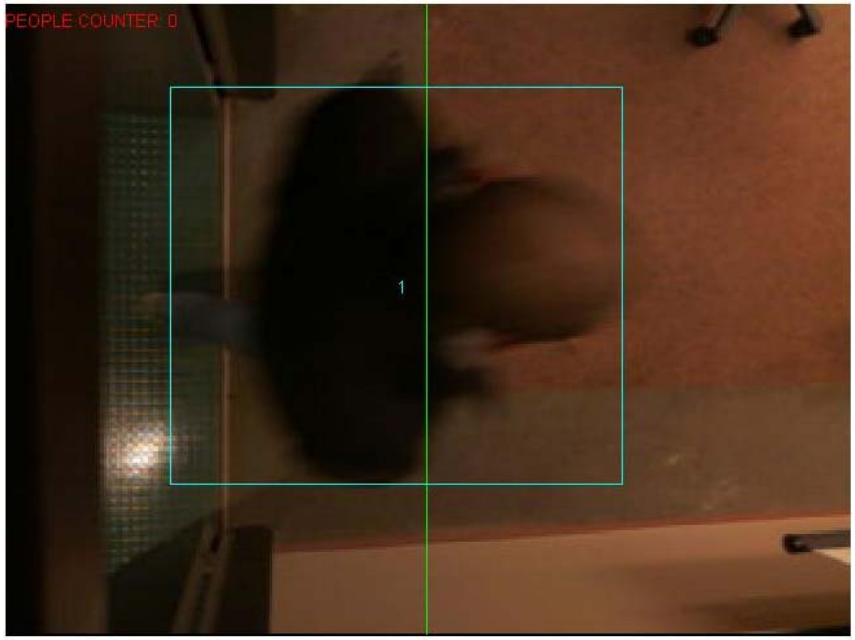
Blob Matching



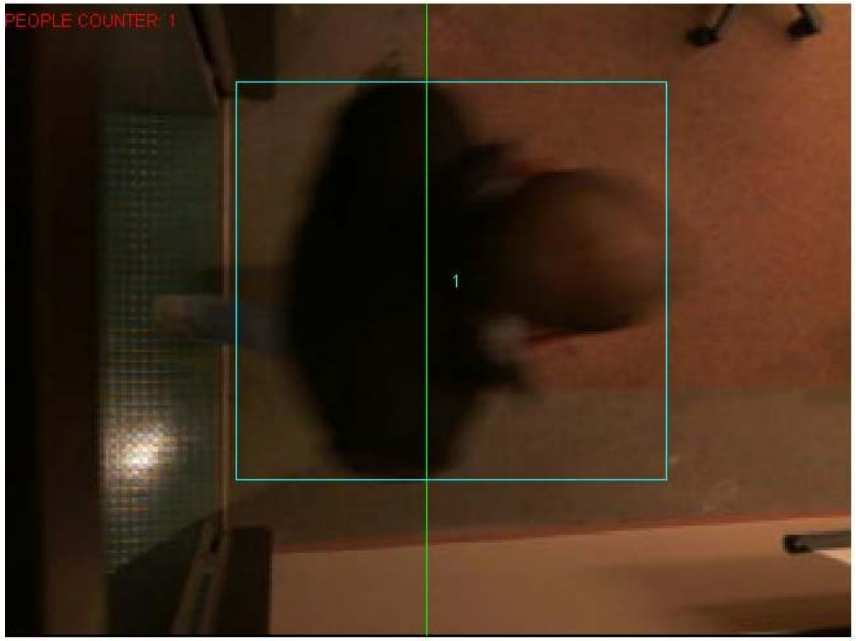
Previous Frame

Current Frame

Counter-Incrementation



Previous Frame



Current Frame

Counter +1

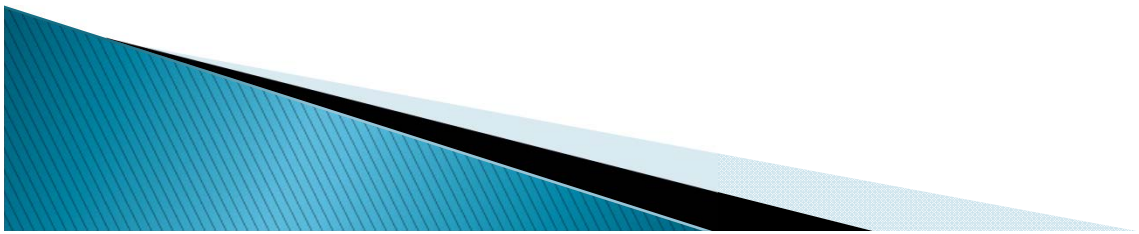
Real-time vs. Non-Real-time Processing

Not Real Time Processing

- Current implementation is *not* a truly Real-time; however, data is updated in relatively short interval
- Camera frames are stored into a buffer for duration of the time train doors remain open.
- Utilizing a pipelined approach, stored frames are processed and data sent out to the database.
- Latency time for processing every 30 seconds of data is approximately 6 seconds.

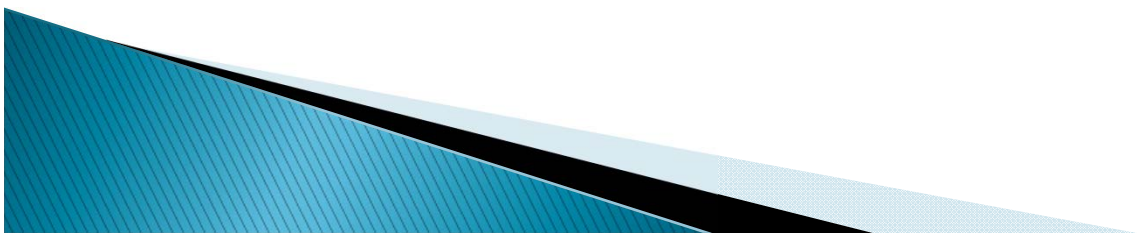
Real Time Processing

- The Beta version of the code which processes data in real-time is unstable and requires more testing before release
- Definitely realizable and would perhaps serve better purposes.



Implementation Cost

Readers for trains	$108,000
Tags for riders	$3,000,000
Cameras for stations	$112,800
CPUs for stations	$564,000
Central database	$10,000
Total cost	$3,794,800



Competition

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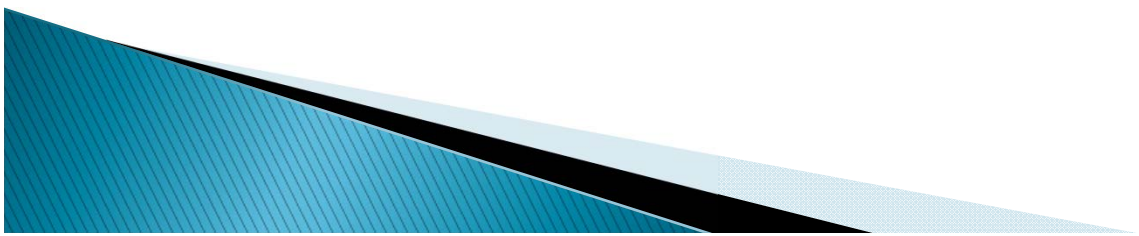
- TransLink has already committed $100,000,000 to implement their Compass Card system
  - Very similar to Opus Card



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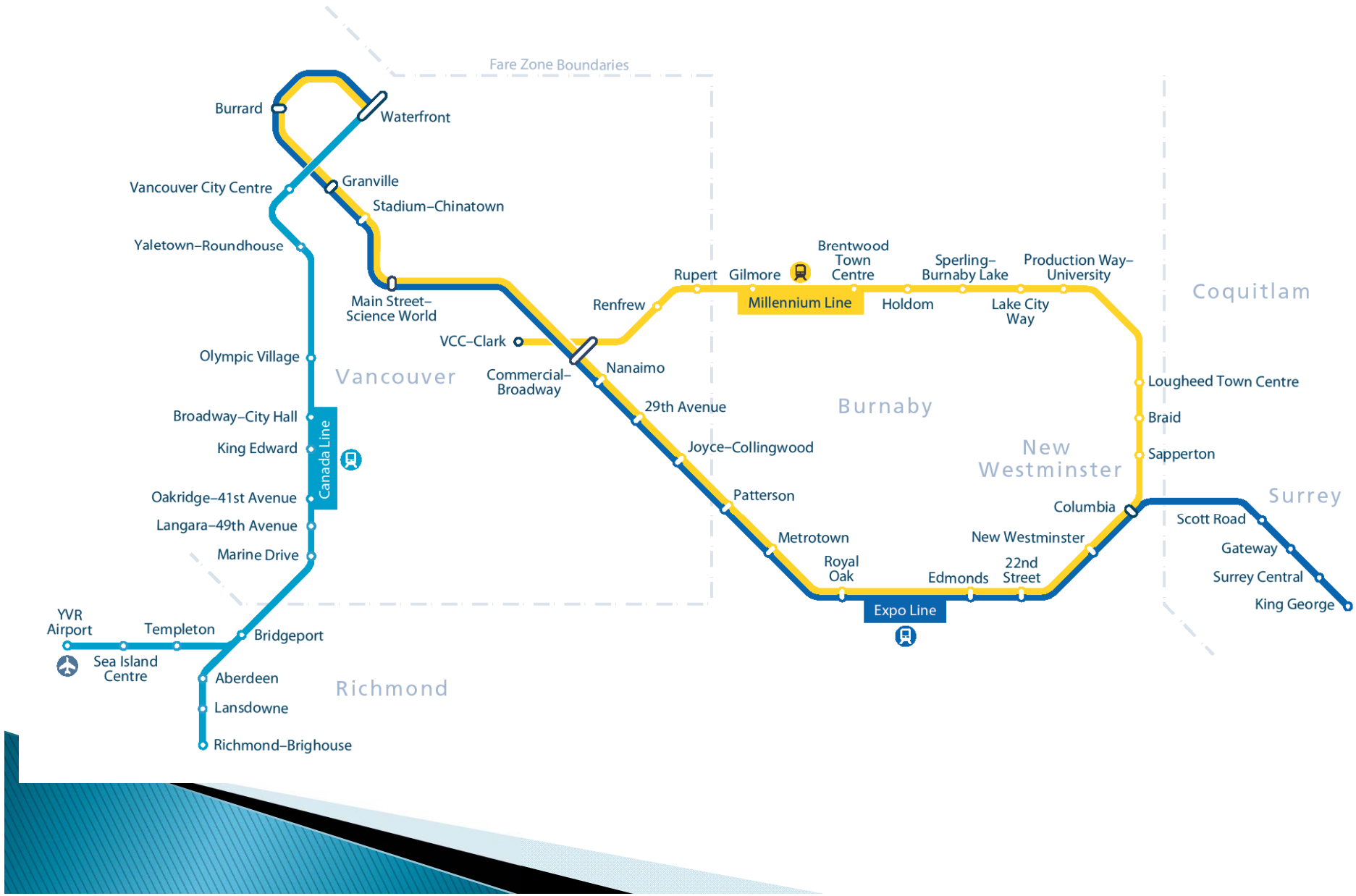
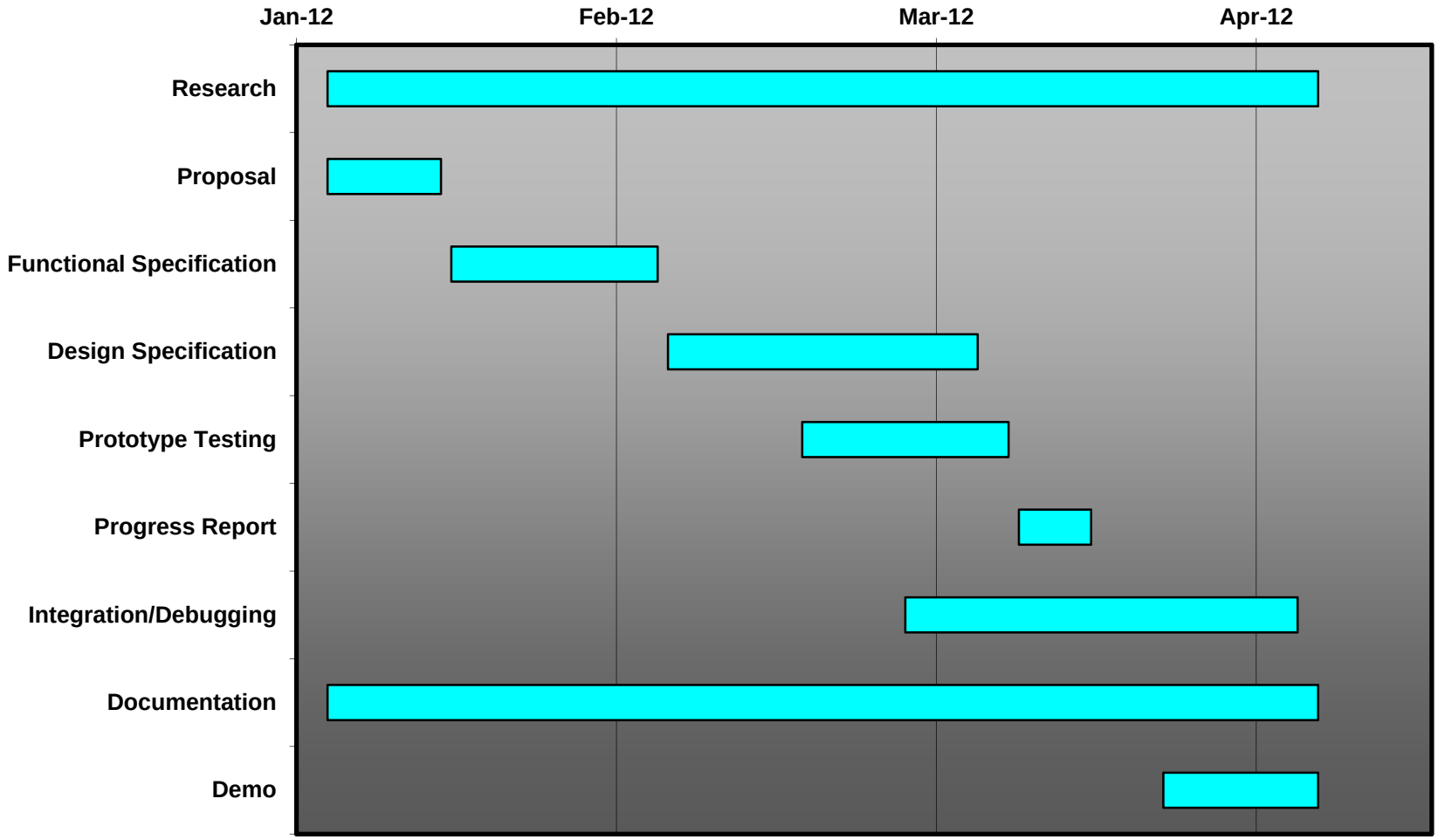
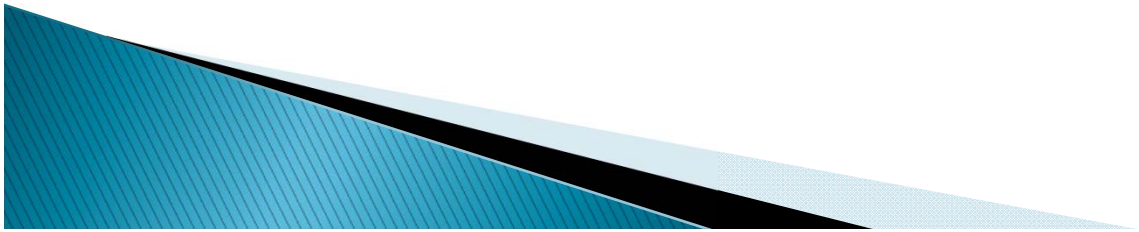

Fare Zone Boundaries
Burrard
Waterfront
Vancouver City Centre
Granville
Stadium–Chinatown
Yaletown–Roundhouse
Main Street–
Science World
Olympic Village
Broadway–City Hall
King Edward
Canada Line
Oakridge–41st Avenue
Langara–49th Avenue
Marine Drive
YVR
Airport
Templeton
Bridgeport
Sea Island
Centre
Aberdeen
Lansdowne
Richmond–Brighouse
Richmond
Vancouver
VCC–Clark
Commercial–
Broadway
Renfrew
Rupert
Gilmore
Brentwood
Town
Centre
Sperling–
Burnaby Lake
Production Way–
University
Millennium Line
Holdom
Lake City
Way
Coquitlam
Nanaimo
29th Avenue
Joyce–Collingwood
Patterson
Metrotown
Royal
Oak
Edmonds
22nd
Street
Expo Line
Burnaby
Lougheed Town Centre
Braid
Sapperton
New
Westminster
Columbia
New Westminster
Scott Road
Gateway
Surrey Central
King George
Surrey

Timeline


Jan-12
Feb-12
Mar-12
Apr-12
Research
Proposal
Functional Specification
Design Specification
Prototype Testing
Progress Report
Integration/Debugging
Documentation
Demo

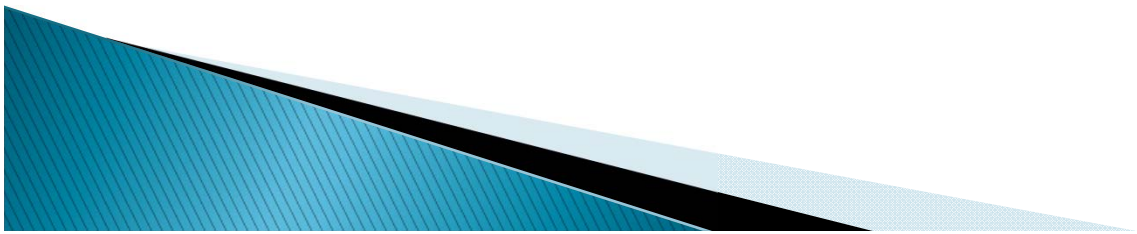
Budget

Impinj Speedway R220 RFID Reader	$999
Antenna	$99
Power Supply	$85
Passive RFID Tags	$48.70
Shipping	$136.55
Taxes/Duties	$50.69
Total	$1418.94



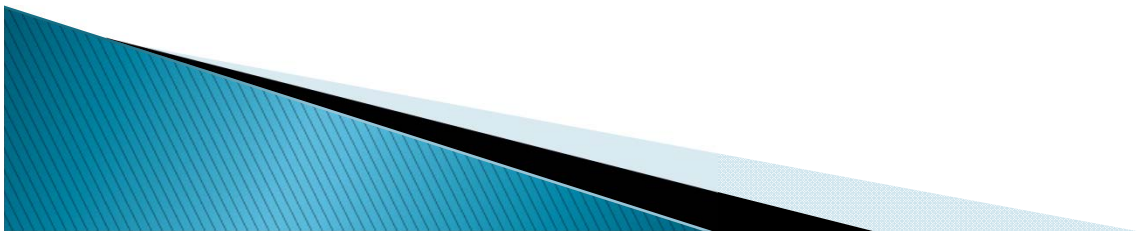
Funding

ESSEF	$700
Wighton Fund	~$800
Total	~$1500
Budget	$1418.94



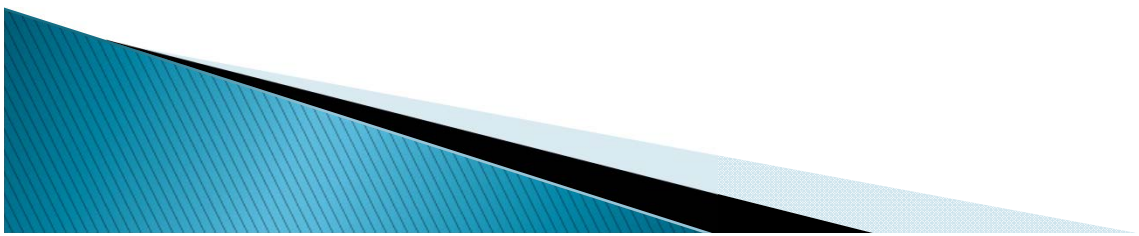
What We Learned

- Completing project tasks is deceptively long
- Image Processing was much harder then expected, too difficult for a 4 month project
- Co-ordinating meetings with 5 group members is a real challenge
- Learned a lot about image processing algorithms
- Learned about the wide range of applications of RFID technology



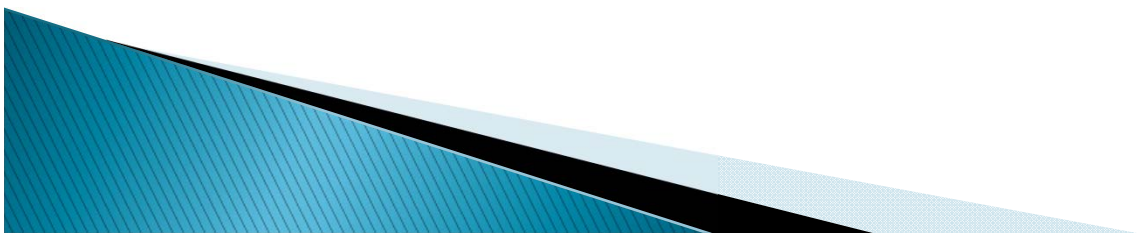
Future Work

- Real-Time Implementation
- Better (usually more complicated) algorithm could supplemented (i.e. Color segmentation)



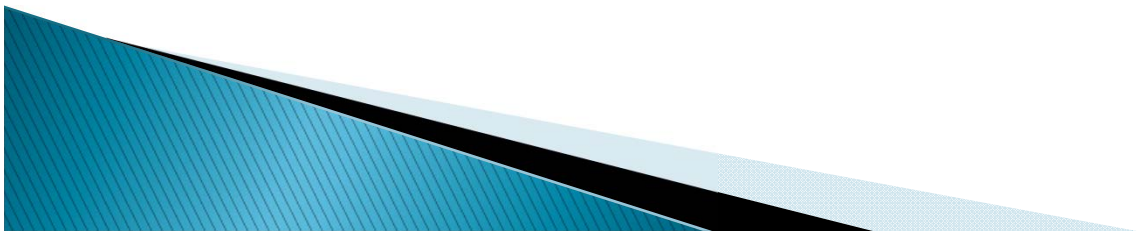
Information Sources

- http://www.translink.ca/en/Be-Part-of-the-Plan/Electronic-Fare-Cards/FAQs.aspx
- http://www.translink.ca/~/media/documents/about_translink/corporate_overview/annual_reports/2010.ashx



Acknowledgments

- Thanks to ESSEF and Wighton Fund for making this project possible
- Thanks to Andrew and Steve for their support and guidance
- Thanks to the Lukas-Karim, Ali, and Shaghayegh for taking the time to read, review, and pose suggestions on all of our documents



Questions

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