KTT Auto21

EMERGING TECHNOLOGIES FOR TRAFFIC MODELING USING BLUETOOTH AND CELLULAR ENABLED DATA COLLECTION

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PART I

A Serious Games Framework

TRAFFIC MODELING USING CELL PHONE DATA

- Ryan Neighbour
  - PhD Student – ECE University of Manitoba
- Research Interests
  - Agent Based Modeling
    - Disease Spread Modeling
    - Traffic Modeling
    - Artificial Life
  - Procedural Content Generation
- More Importantly!

Outline

- Introduction/Useful Data
- Software
- Simulation Construction
- Simulation Environment
- Agent Behaviour
- Shortcomings
- Initial Validation and Results
- Conclusions and Future Work

Problem

- Vehicle, pedestrian, infrastructure interactions complex
- Highly stochastic dynamical system
- How do we go about modeling this type of system?

- Likely “computationally irreducible”

Useful Data

- >Q1 2012, Canada has 28 million subscribers in total, or a 80.25% penetration rate
- Locational cellular data both abundant and inexpensive to gather
  - Infrastructure already in place
  - Service provide or OEM
- Use this data to model urban population movement and infrastructure changes

Solutions?

- Differential Equation style models
  - Well vetted
  - Can be difficult to understand/communicate
  - Unable to capitalize on emerging data sources
- Agent Based Model
  - Easy to construct/understand
  - “correct by construction”
  - Emerging data is inherently agent based

Our Direction

- We choose ABM as
  - Cell phone data is relatively simple to integrate into agent behaviour
  - It is easy to extend it to other areas of research

Agent Based Model

- Consist of:
  - Autonomous agents that can interact in some way
  - An Environment where the agents exist

Cellular Data

- Provided by MTS Allstream
- 1 ID = 1 Cell phone – anonymized
- Location and timestamp
  - Each entry for a given ID states:
    - Time stamp
    - Cellular Tower and Sector Code
- Data collected over five week days in Fall 2010

Software

- Off the shelf software
  - Can reasonably assume that the software is used in/by a variety of environments/people
  - More rigidly tested than in a single setting
- Software used:
  - OpenStreetMap.org
  - CityEngine
  - Unity

OpenStreetMap.org

- OSM is to Google Maps what Wikipedia is to Encyclopedia Britannica
  - Collaborative
  - Free

CityEngine

- Developed by Esri
- Uses procedural modeling to quickly create highly detailed 3D urban environments
- Cities can be created from scratch or using existing GIS Data
  - Artificial or real

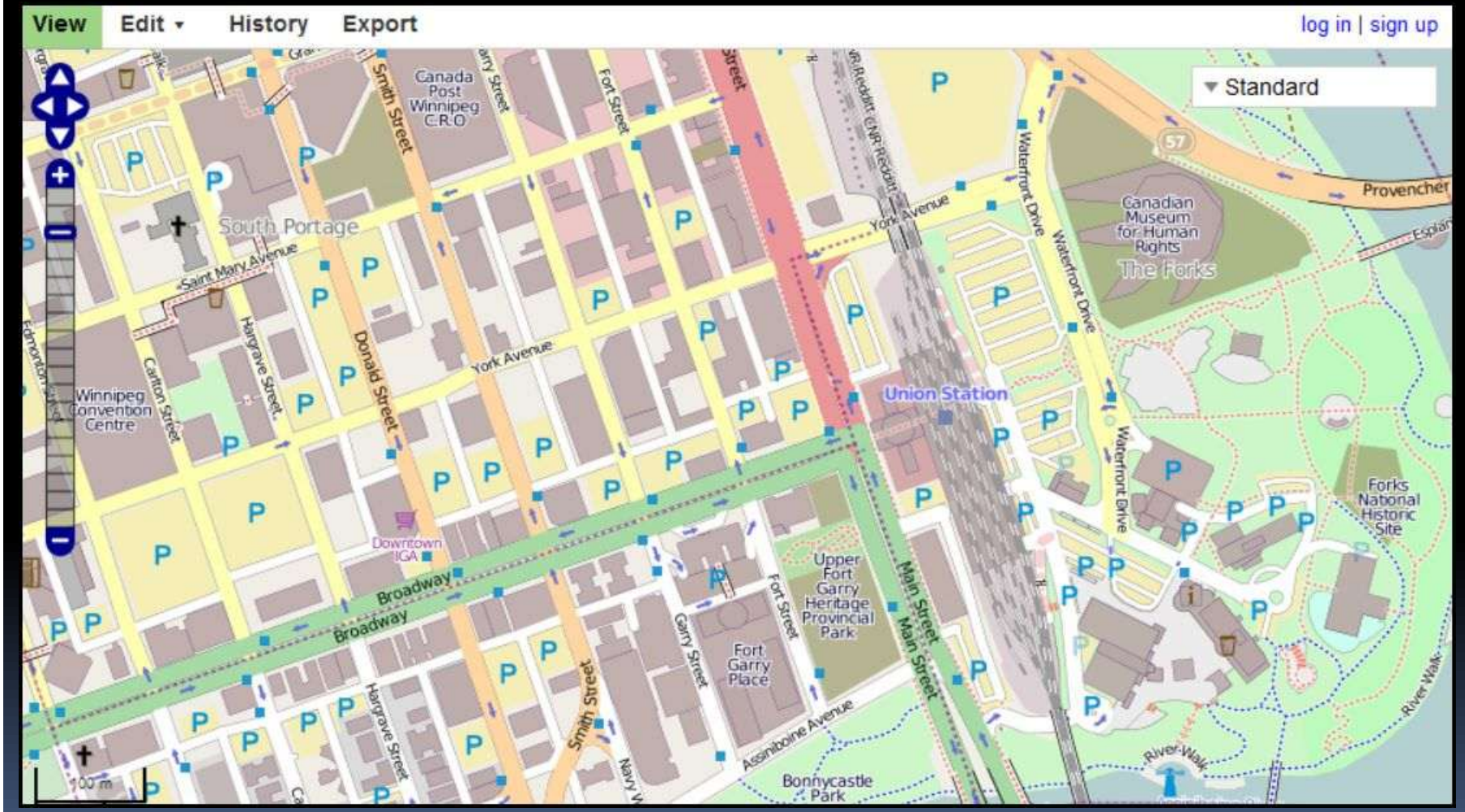
Unity

- Created by Unity Technologies
- Game engine and authoring tool
- Multiplatform
  - Mac OS X/Windows/Web
  - iOS/Android
  - Xbox 360/Wii/PlayStation 3

Unity

- Engine code is closed source C++
- User code written using the MONO Framework
  - C#
  - Boo (Python variant)
  - UnityScript (JavaScript variant)

Sim Construction: OSM



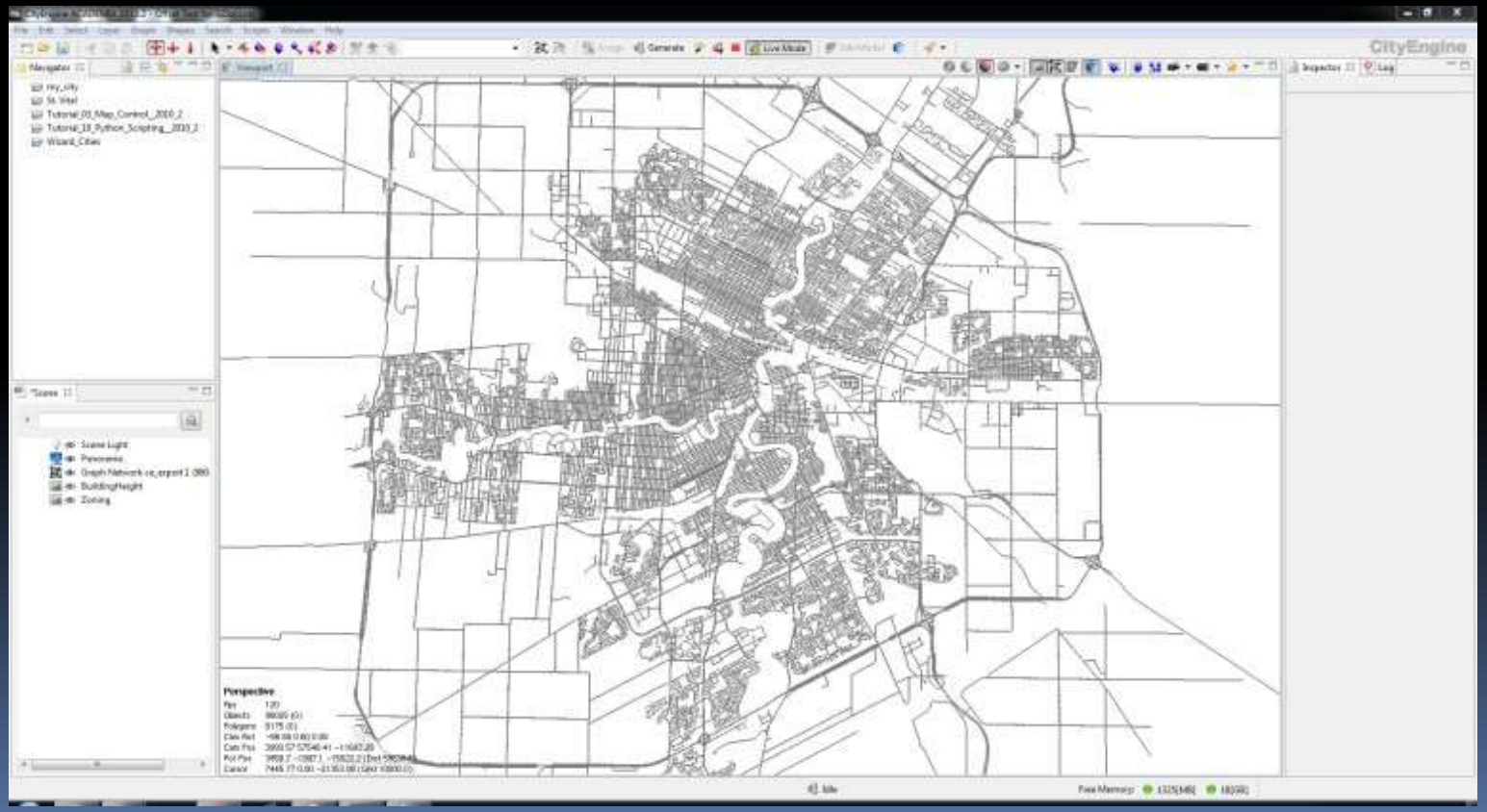
Sim Construction: OSM

- Data is available in several formats
- We use XML
- Human readable/editable
- Too much info, needs to be filtered

```
2791  <node id="1692779787" lat="49.8905379" lon="-97.1361865" uid="396642" visible="true" version="1"
2792   <tag k="amenity" v="bank"/>
2793   <tag k="name" v="Assiniboine Credit Union"/>
2794   <tag k="source" v="Bing"/>
2795  </node>
```

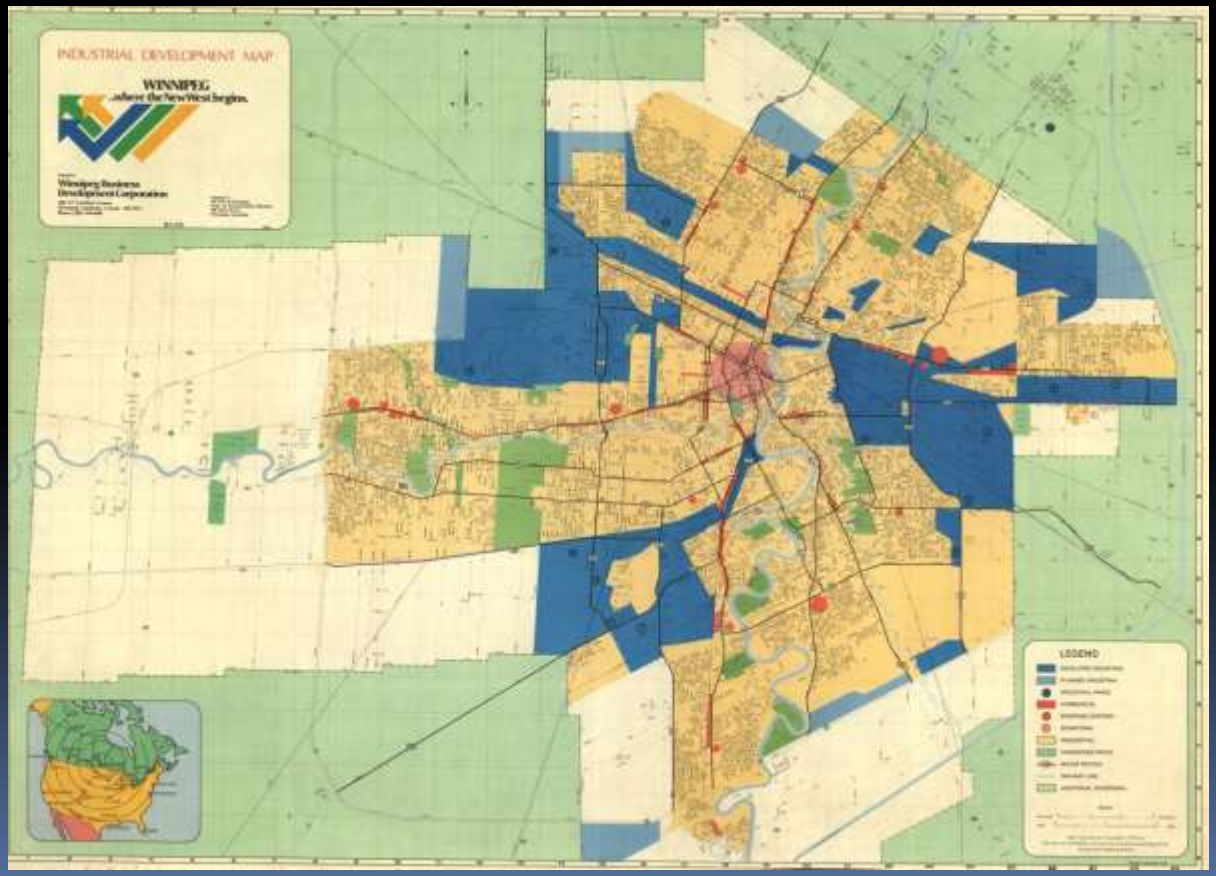
Sim Construction: CityEngine

- OSM data loaded into CE creating the street network



Sim Construction: CityEngine

- Zoning maps used to guide building construction



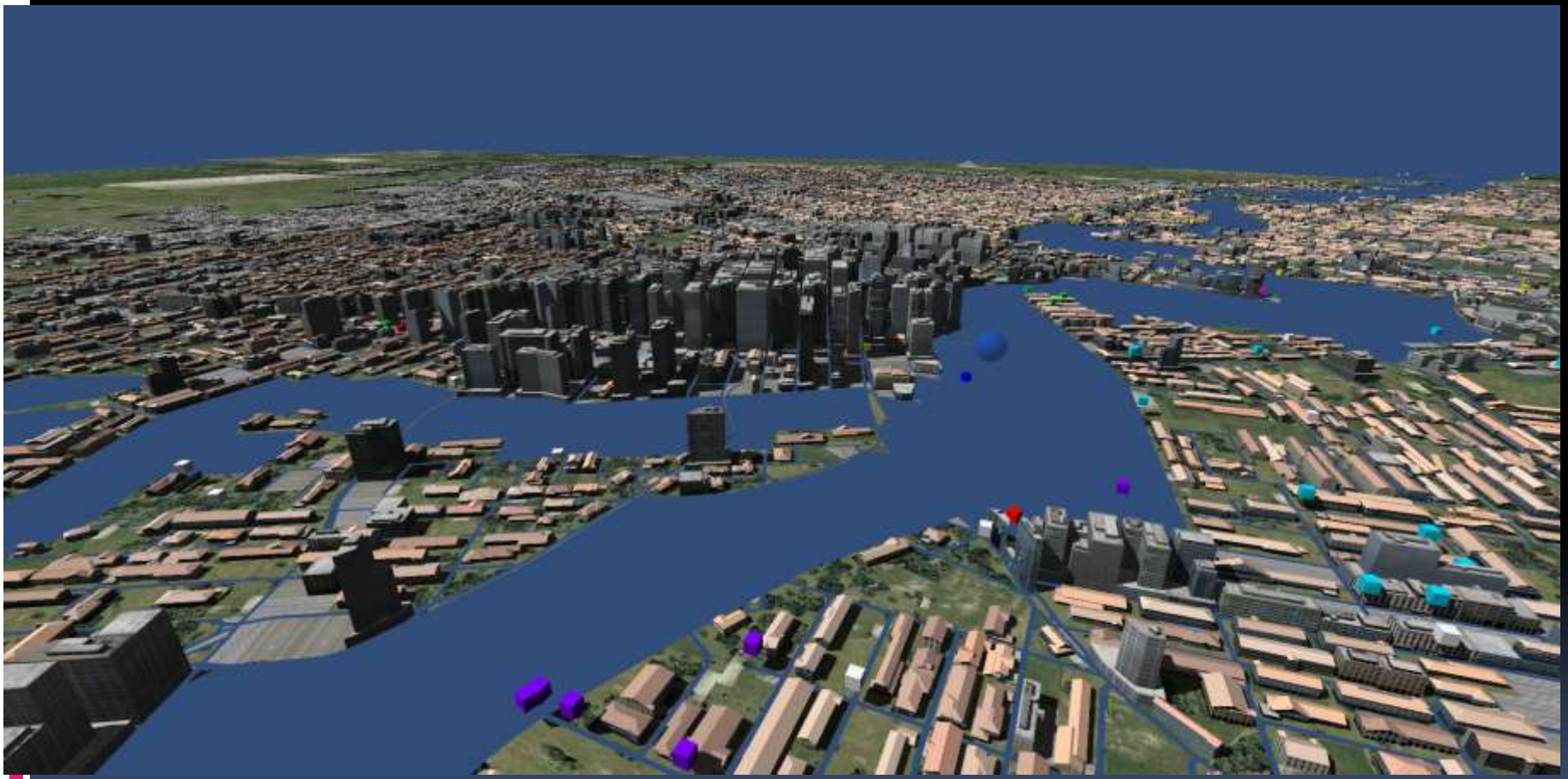
Sim Construction: CityEngine

- Generated 3D model exported along with street network

Sim Construction: Unity

- Assets from CityEngine imported into Unity Project
  - 3D models – default importer
  - Street network – custom importer

Sim Construction: Unity

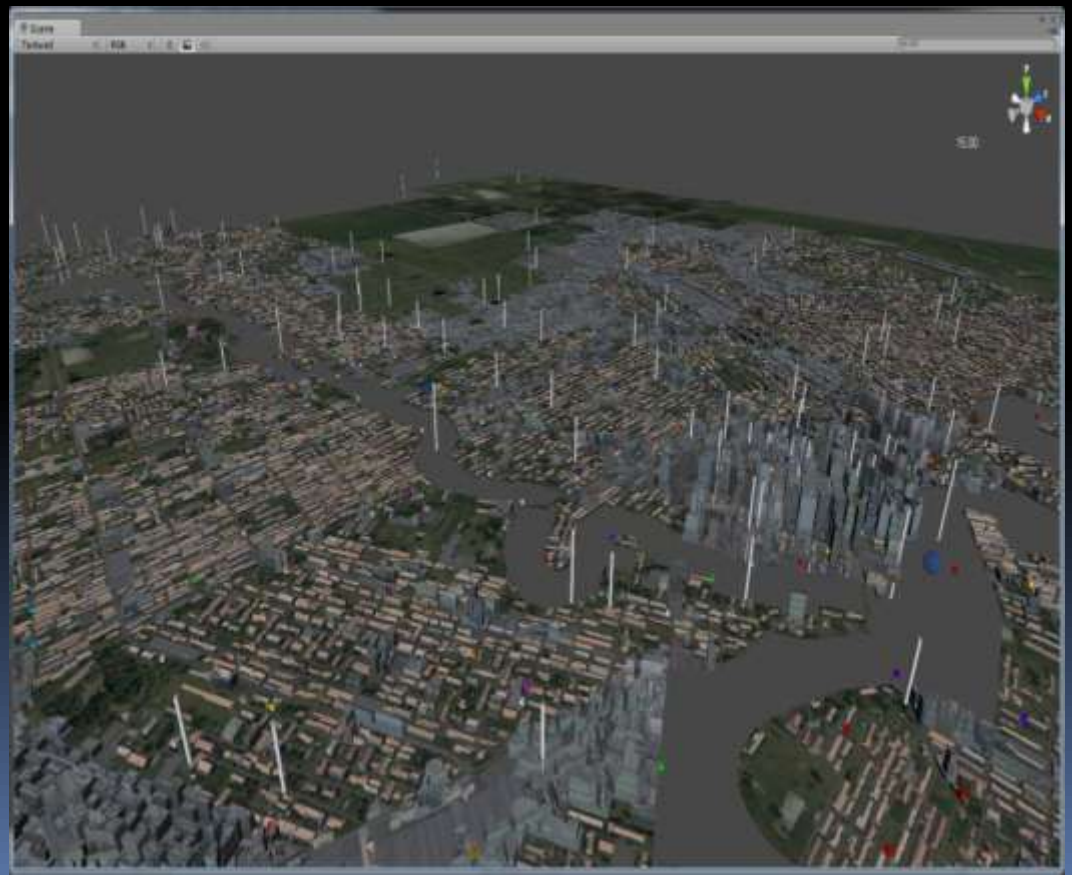


Simulation Environment

- Environment
  - Street network treated as a graph
    - Vertex – intersection
    - Edge – street
      - Streets are weighted up or down to mimic throughput and capacity
        - main thoroughfares have low weight, residential streets have higher weights

Simulation Environment

- Environment
  - Cell Tower Sectors
    - Act as containers for intersections
    - Intersections owned by nearest tower



Agent Behaviour

- Agents
  - Travel on the street network
    - A* – dynamic
    - Pre-computed – static

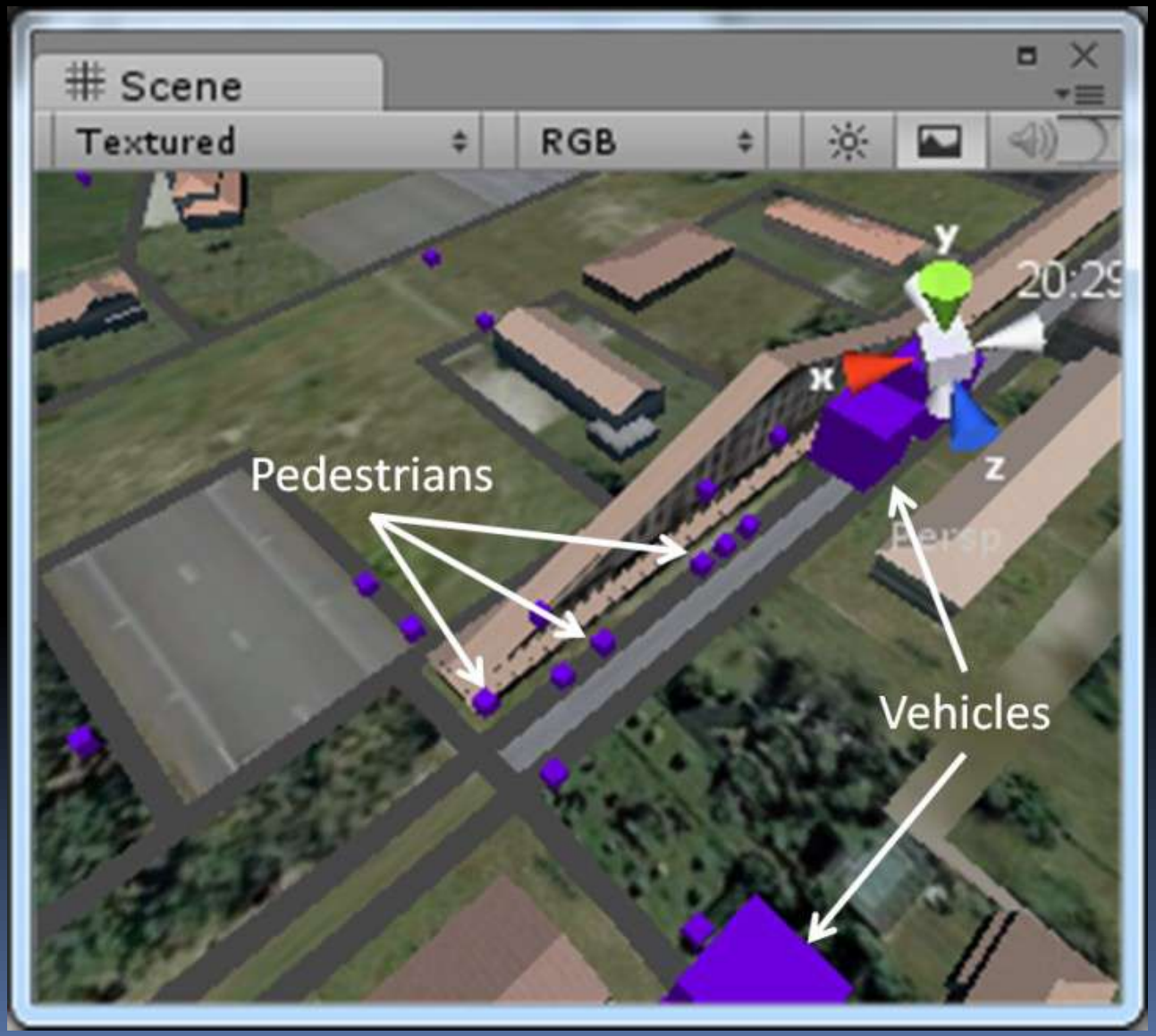
Agent Behaviour

- Movement governed by cellular data
  - Cellular data contains a sector and timestamp per entry
  - Choose random intersection within a sector
  - Leave early enough to arrive on time

Agent Behaviour

- Two modes
  - Vehicular
    - Used when target destination is above a threshold distance
  - Pedestrian
    - Used when not in Vehicular mode
    - Traverse the street graph while remaining in the given sector
    - In Pedestrian mode, agents may enter any institution they pass

Agent Behaviour

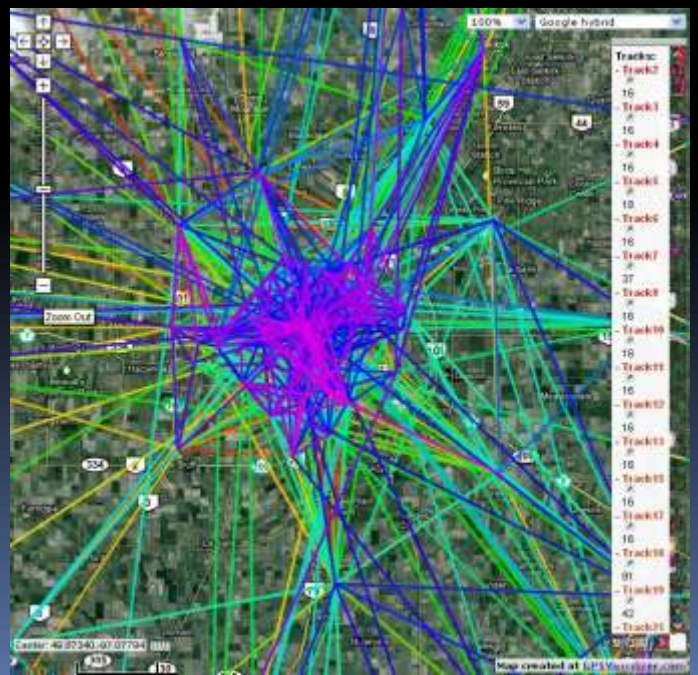


Shortcomings

- No Pedestrian/Vehicle interaction
- Missing Data
  - No speed limit/capacity data
  - No traffic control system data
  - Holes in cellular data
    - Phone is off
    - Phone is unable to reach a tower
- Only Winnipeg (one provider)

Simulation Validation

- Baseline Simulations
  - Seed ~25000 agents with cellular data in a 1-1 pairing
    - Data collected over five week days in Fall 2010

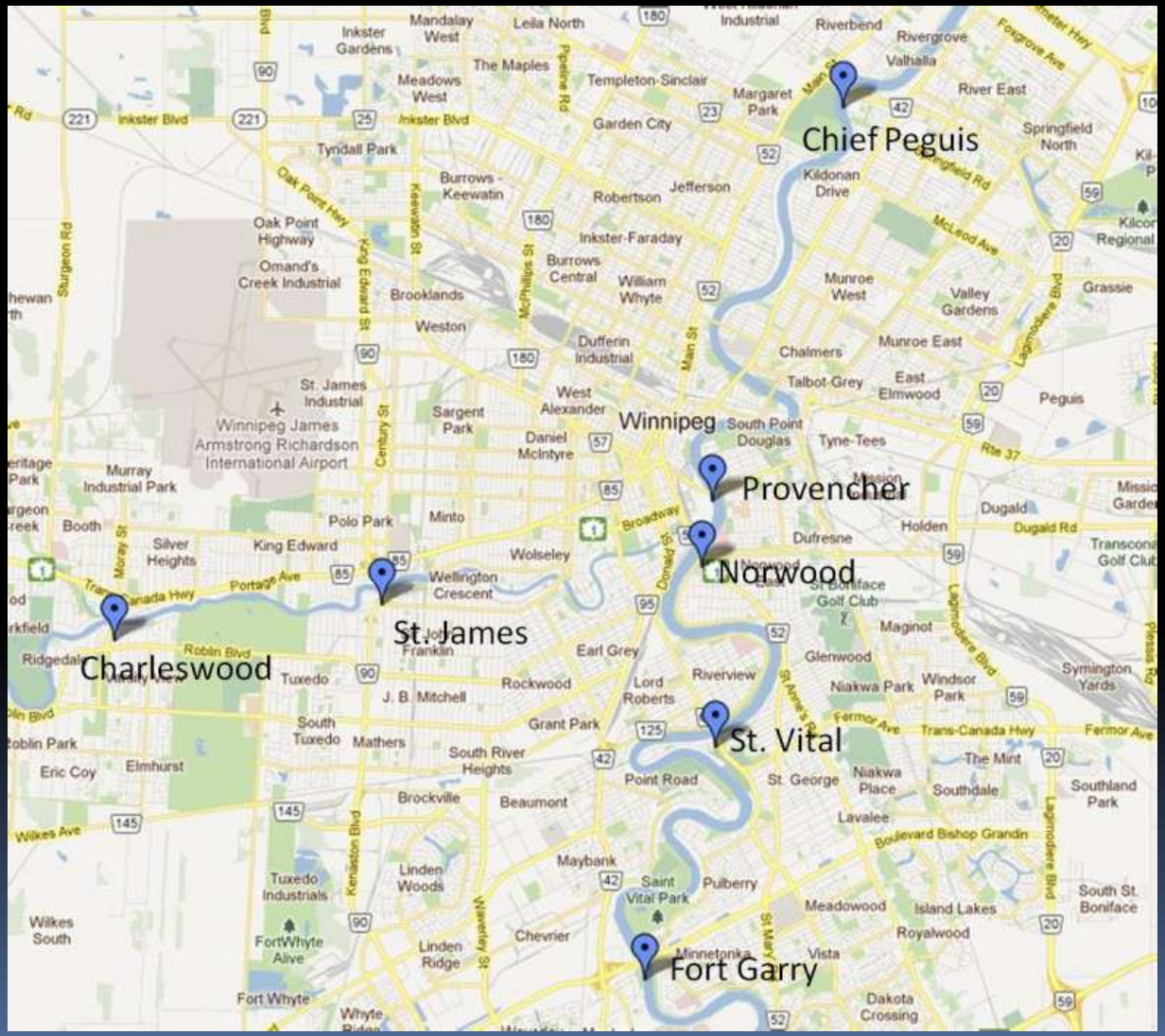


Raw Trajectories: Sample

Simulation Validation

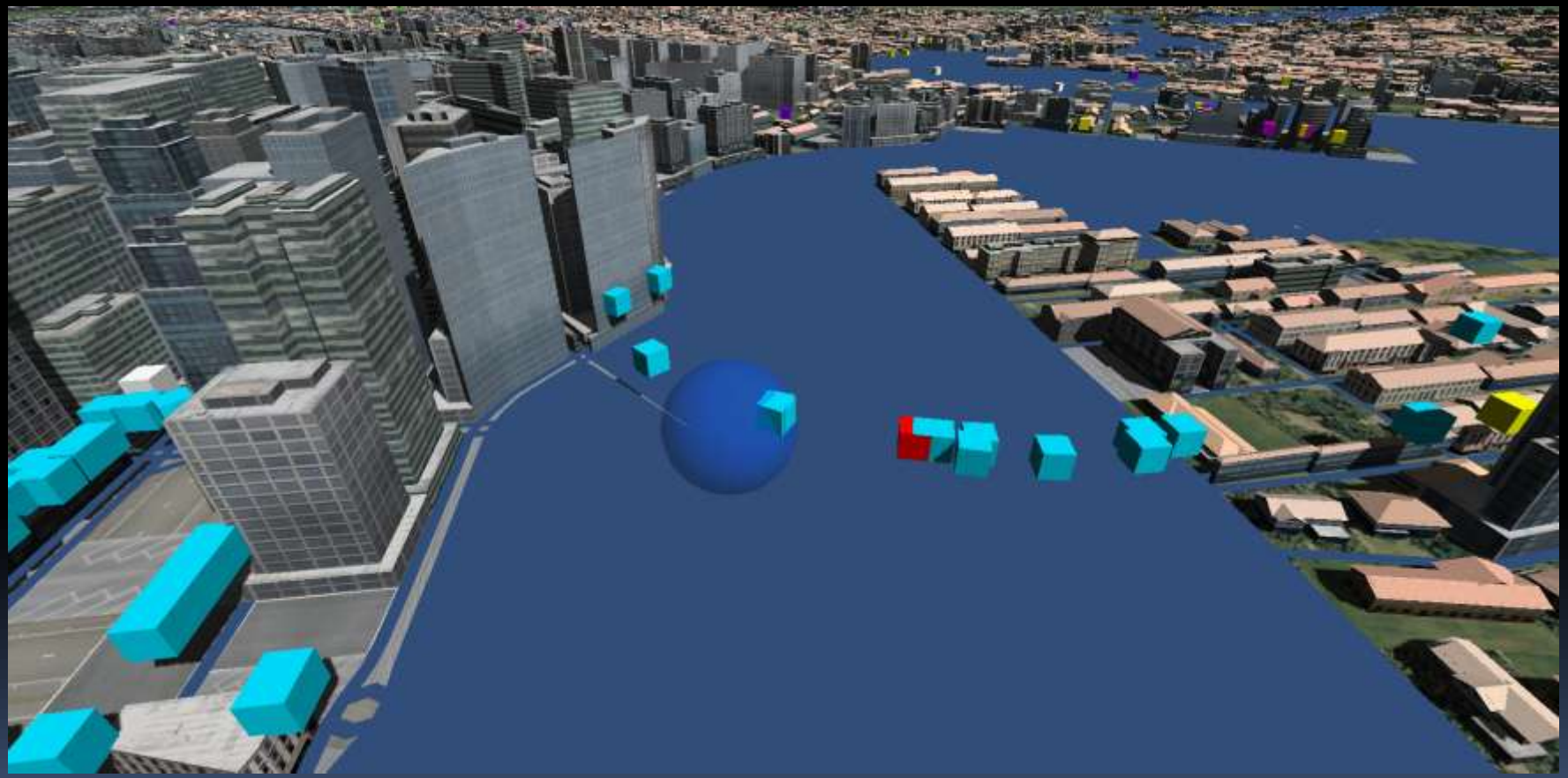
- Global Validation
  - Compare data with the Winnipeg Area Travel Survey from 2009
- Local Validation
  - Compare data with traffic counts collected at seven Winnipeg bridges (2011)

Simulation Validation



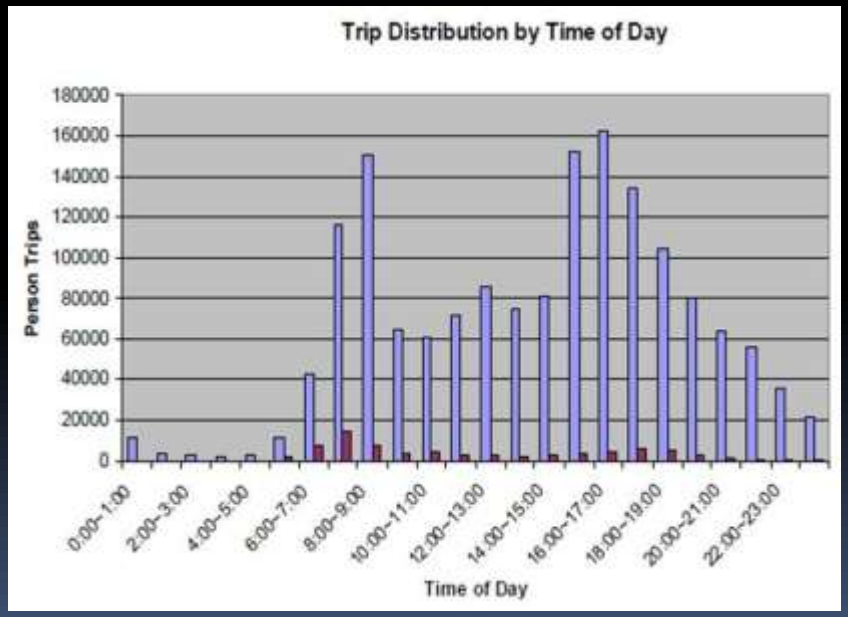
Good ingress/egress

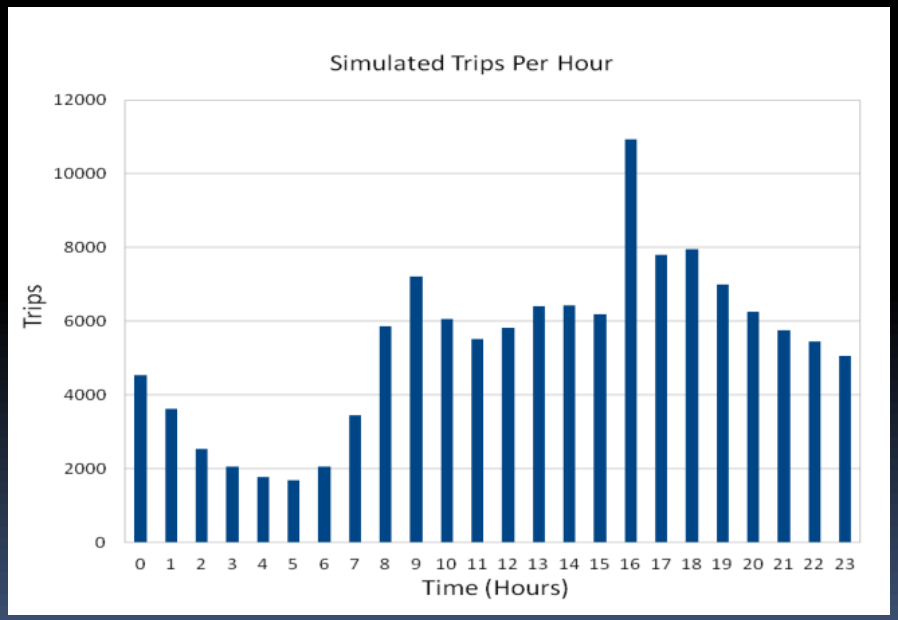
Simulation Validation



Global Results

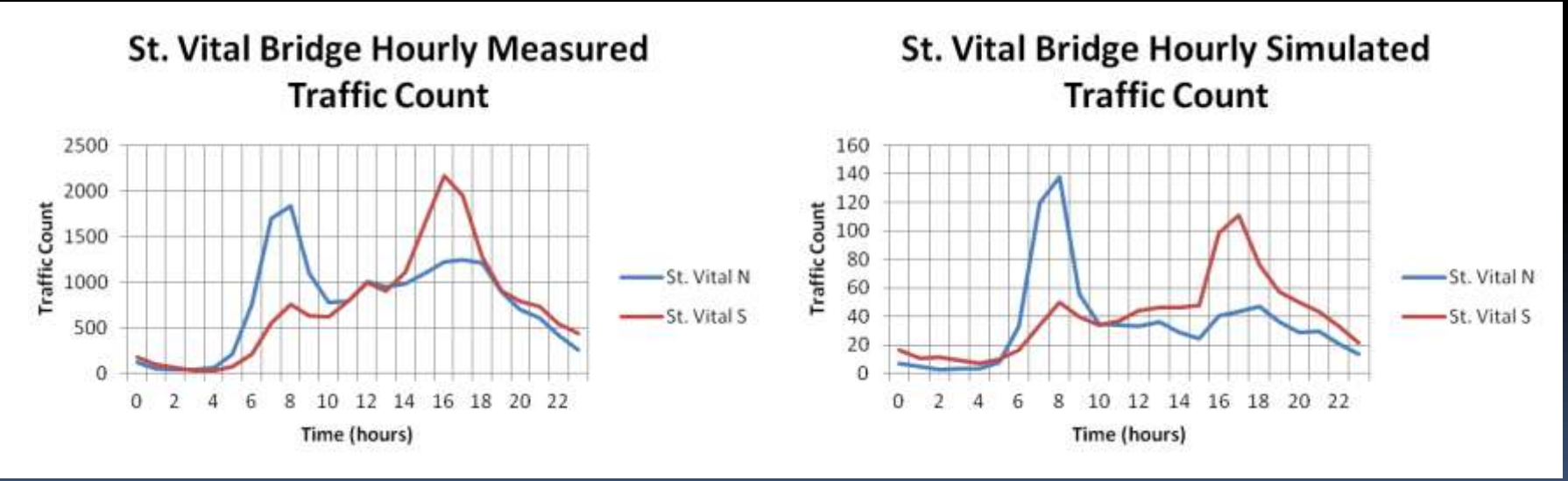
- Absolute numbers off
- Similar features (both are estimates)



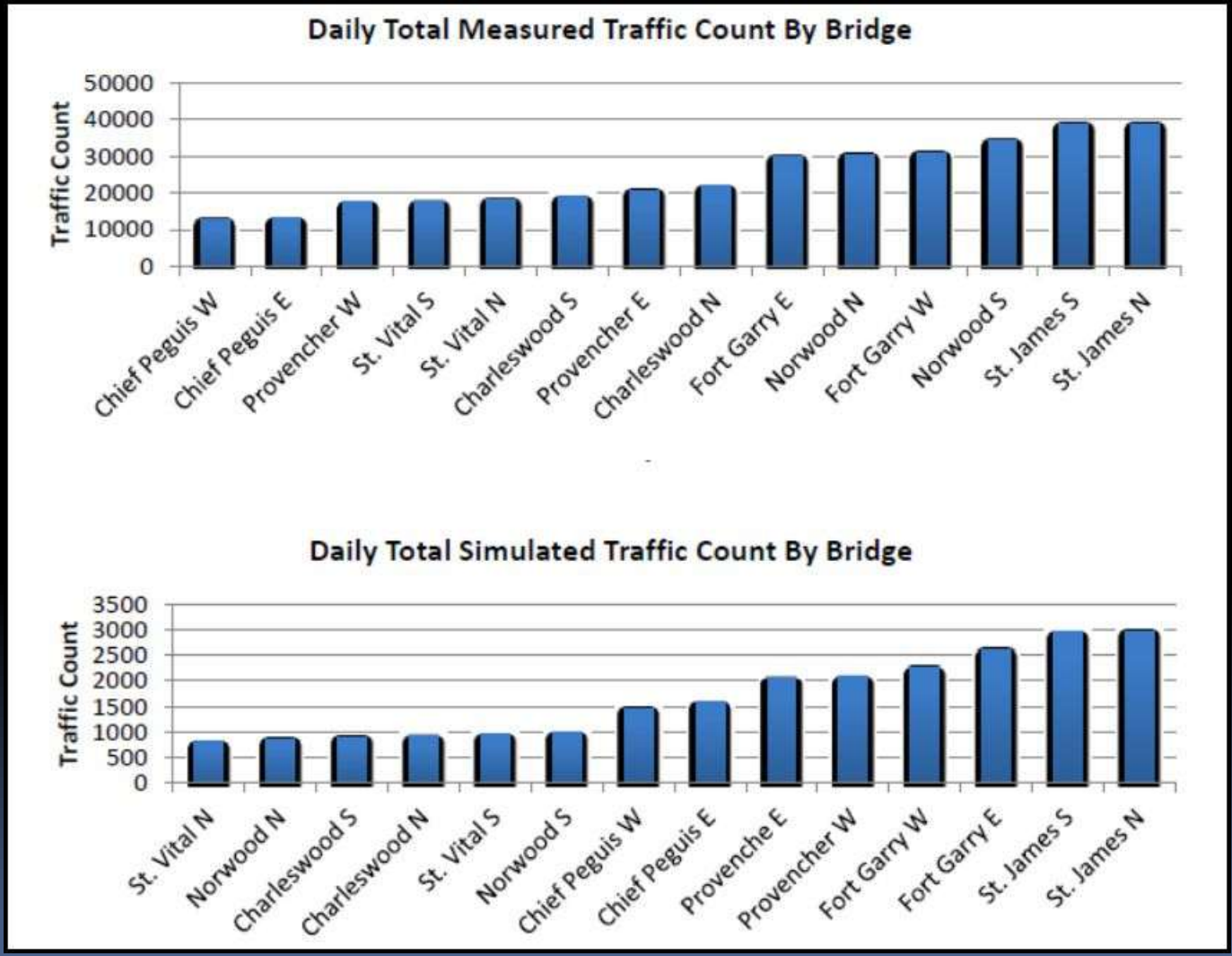


Local Results

- Numbers off again
- Similar Features
- Directionality Preserved



Local Results

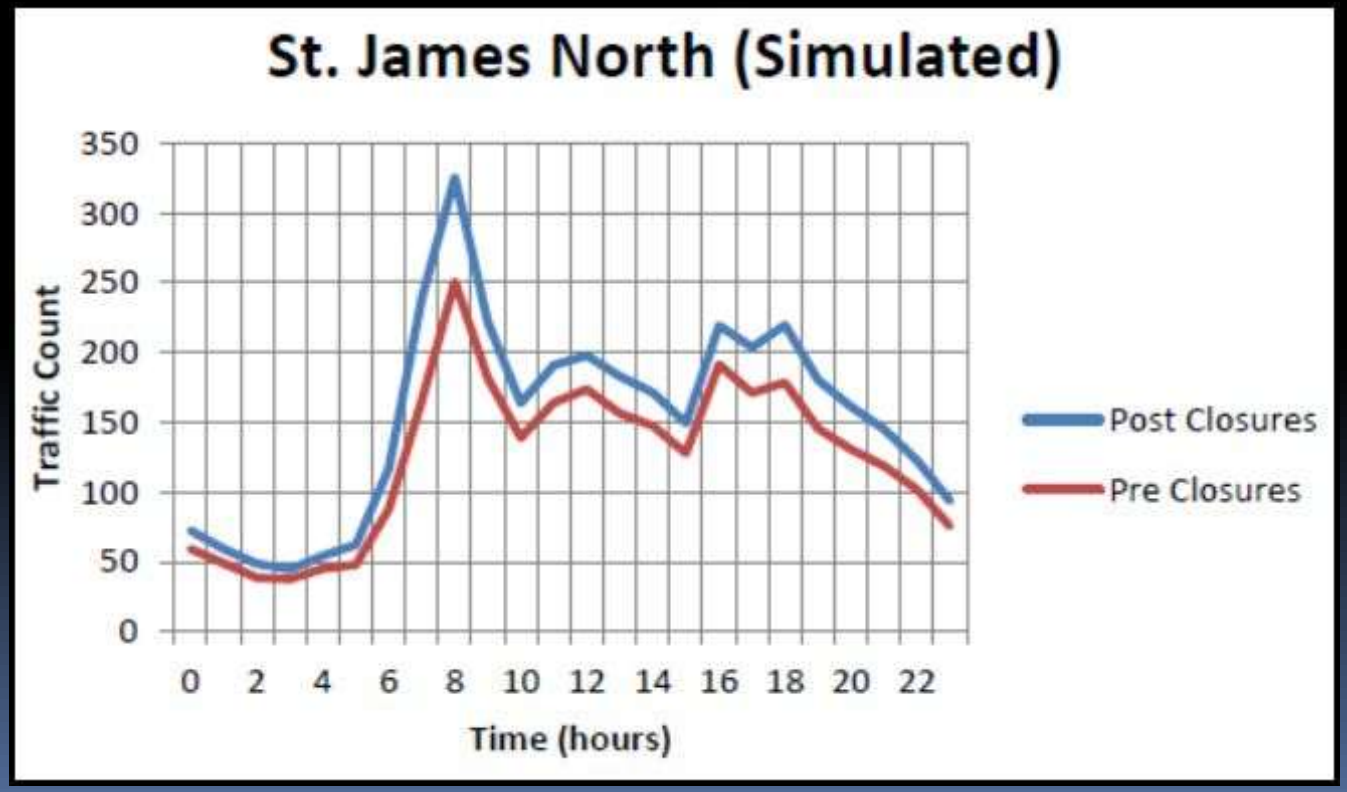


Modeling Scenario

- Would like to investigate the simulator's use as a planning tool
- Two bridge closures
  - Chief Peguis Bridge
  - Charleswood Bridge

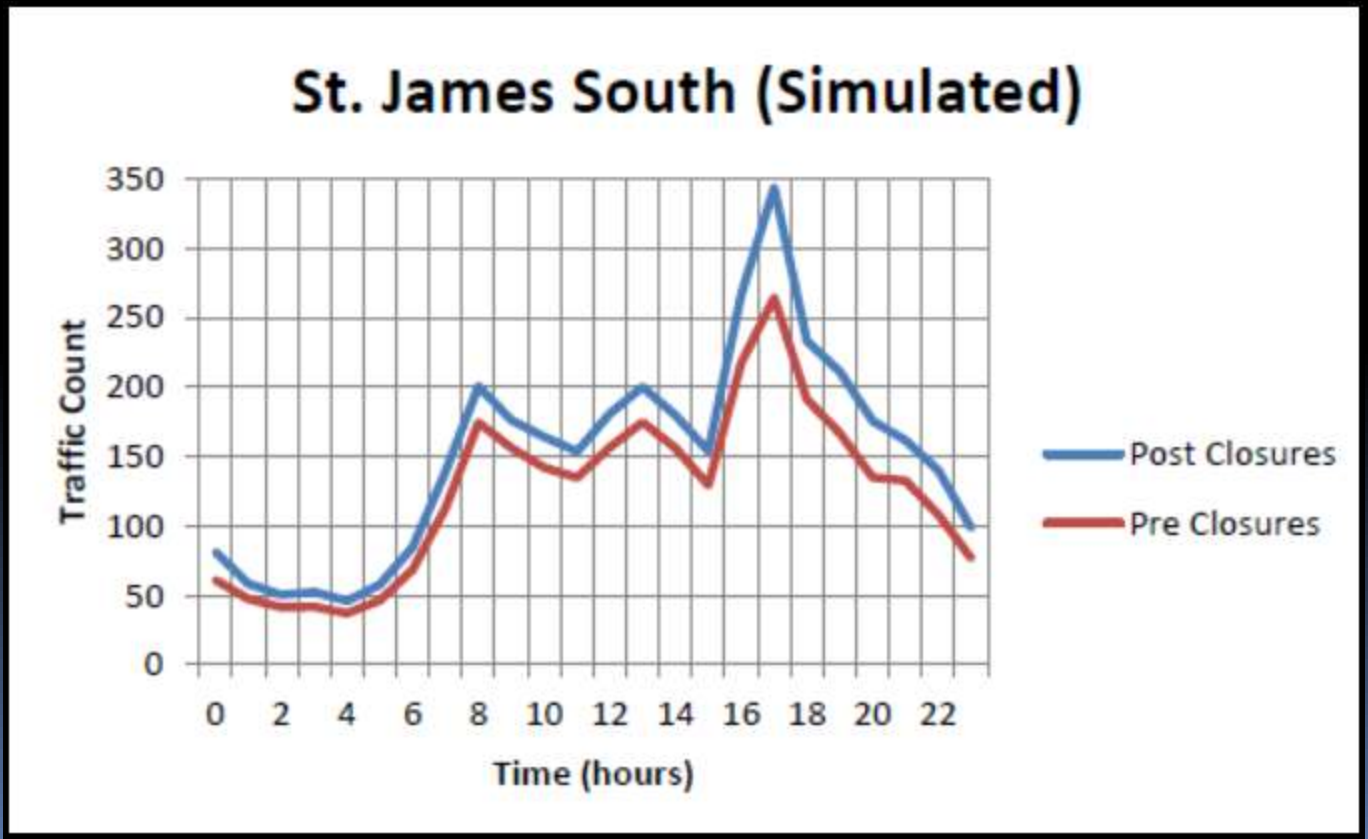
Modeling Scenario

- Only St. James Bridge had significant changes.



Modeling Scenario

- Only St. James Bridge had significant changes.



Part 1: Conclusions

- Initial results promising
  - Cellular Data
    - Ease of collection/use
    - Data interpretation needs work
      - Bus or car?
  - Simulation
    - Shows similar features to surveyed/field collected data
    - Developed very quickly
    - Data driven systems very extensible

Future Work

- Fill in the gaps
  - "Wayness"
  - Speed limits/Capacity
  - Traffic Control
- Add more game-centric features to allow users to better interact with the simulation in real time

Part II

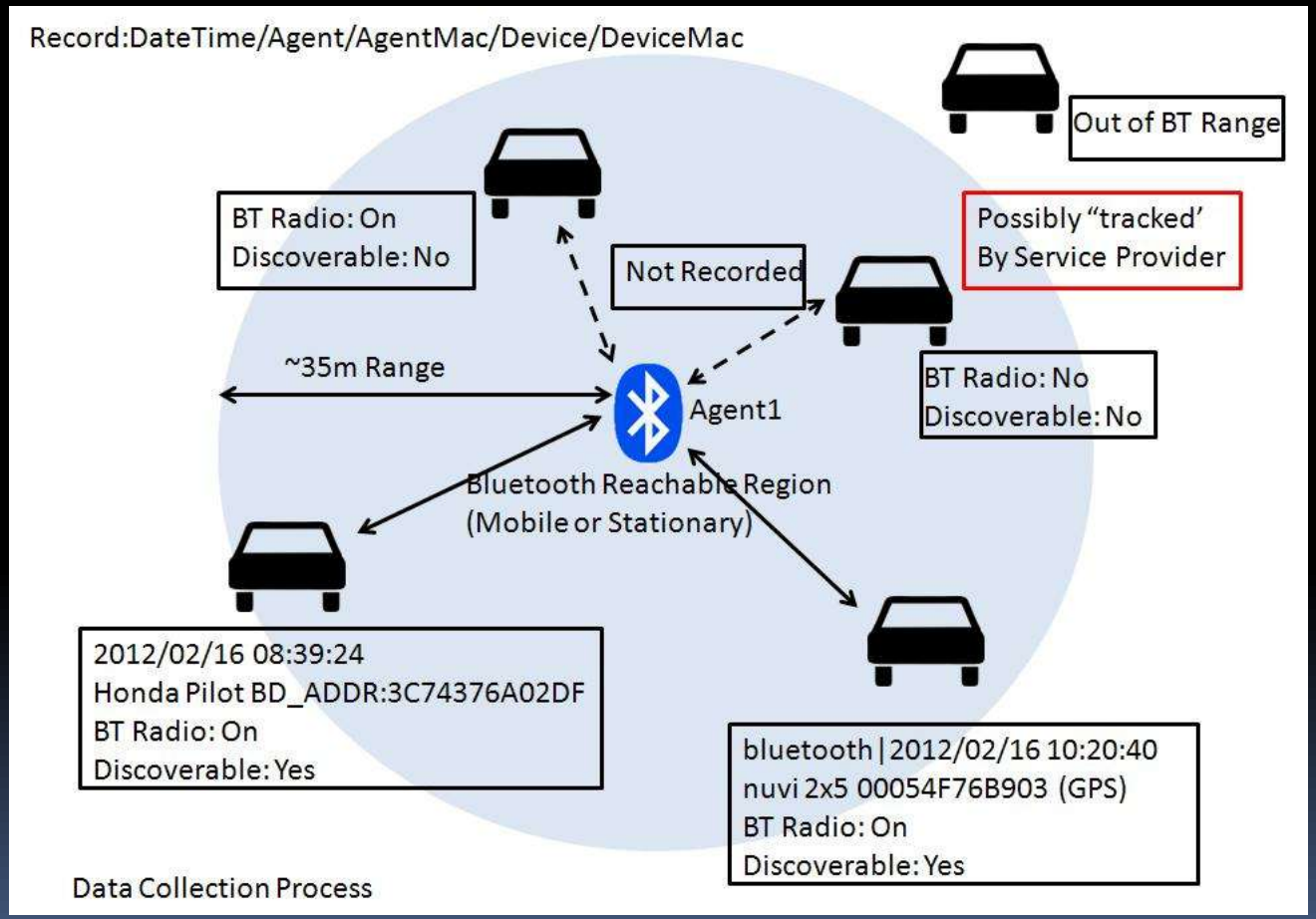
AUGMENTING TRAFFIC MODELING USING BLUETOOTH DATA

B. Demianyk, J. Benevides, M.Sc.

M. Friesen, R. Jacob, B.Sc.

- Follow-on to increasing fidelity of data from a cellular service provider
- Developed a mobile app to collect proximate data over BT from “agents” or “probes”
- Similar to the Blue Translucent Sphere mentioned in Part I.

Bluetooth Probes (Agent Tracker)

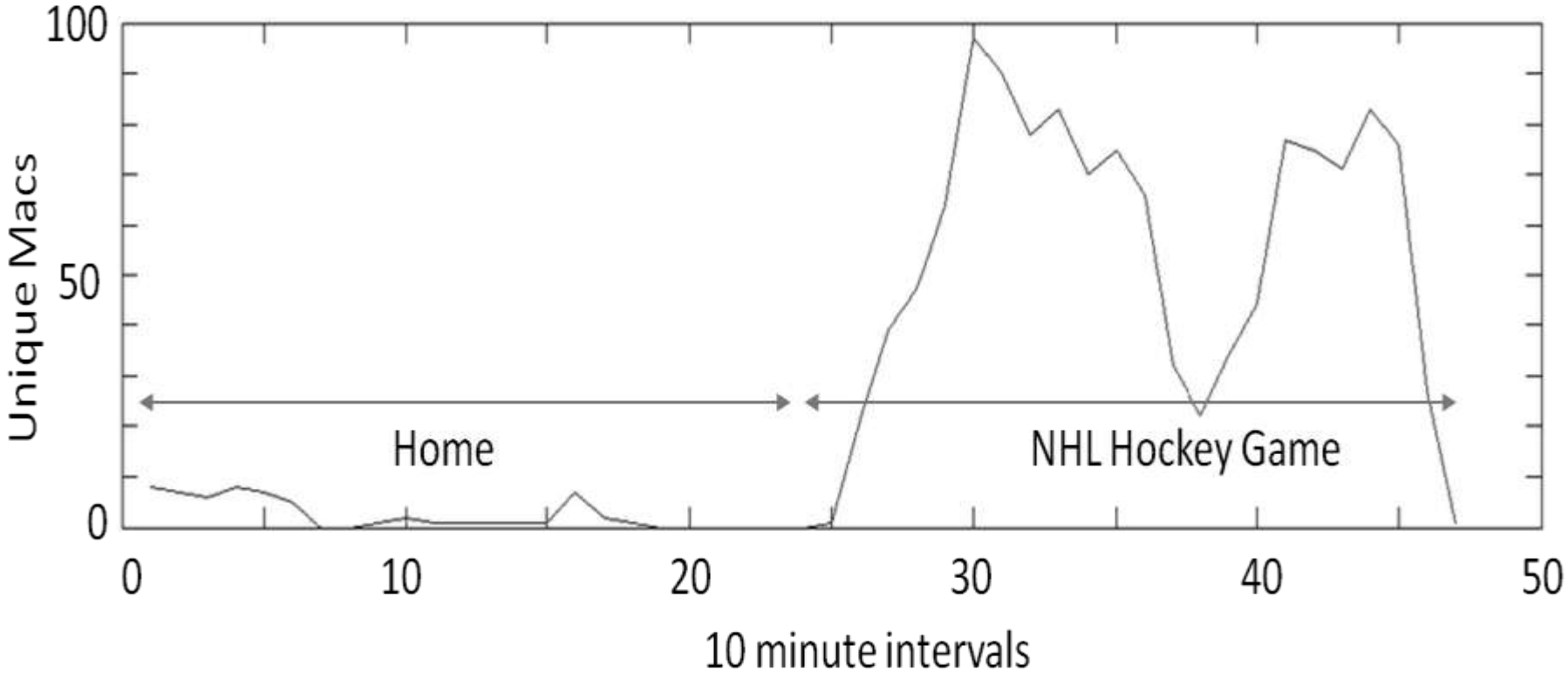


Use Case data collection from probes

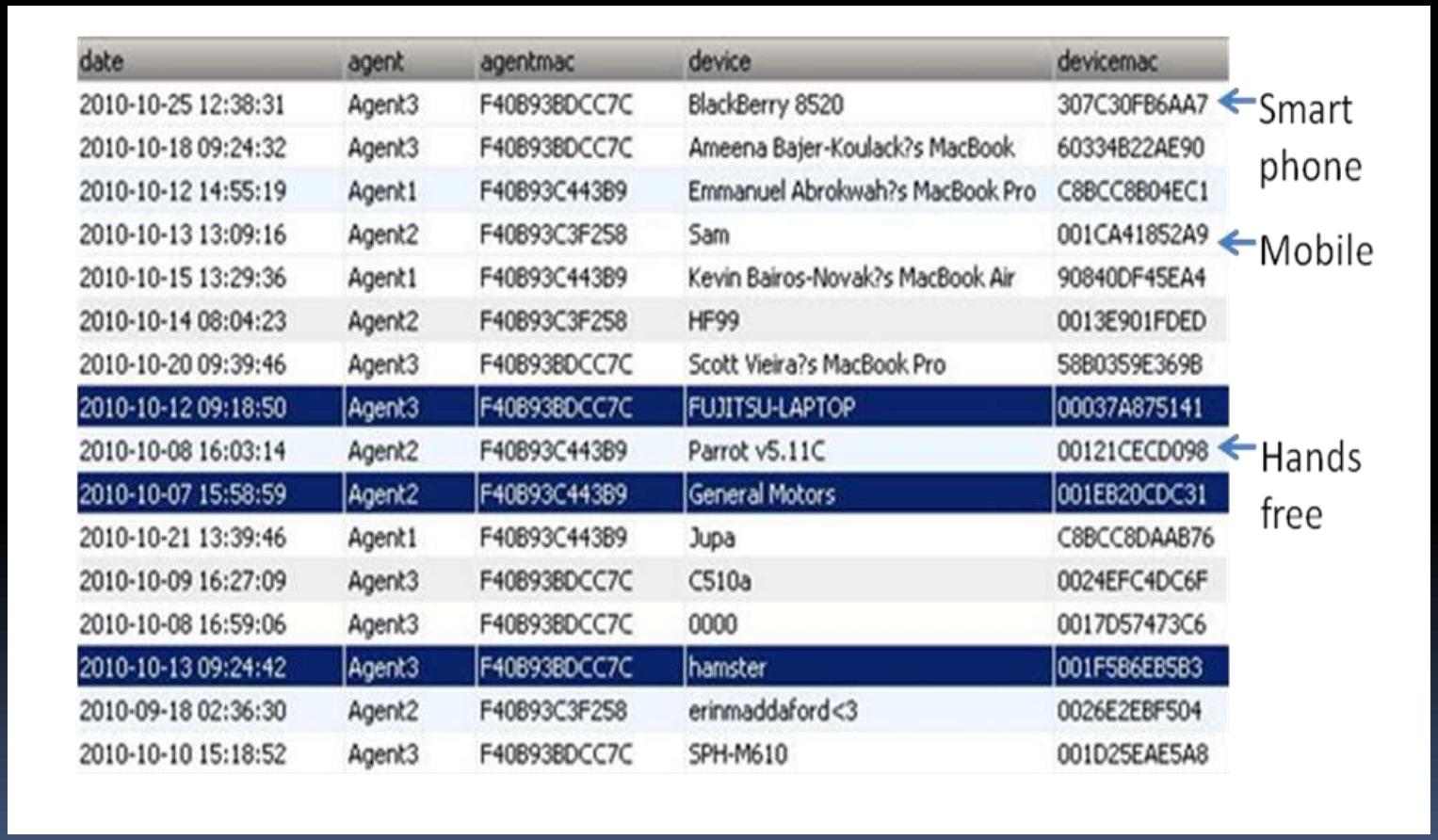
Potential to collect lots of data.

- Good(Excellent) proxy for people/vehicles
- As mentioned Health Canada reports that there were 28 million cell phone users Q1 of 2012, representing approximately 80% of Canada's population
- Not to mention other BT devices
- Not limited to service provider

Data collection example: fun



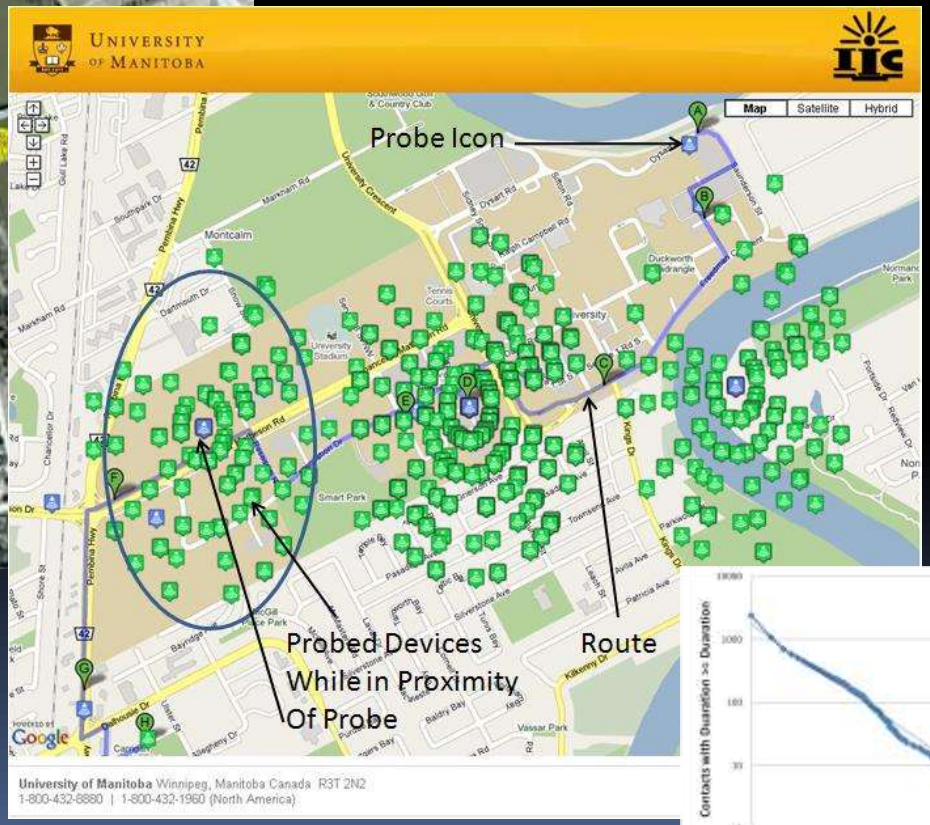
Look-ups for Devices and Class of Device



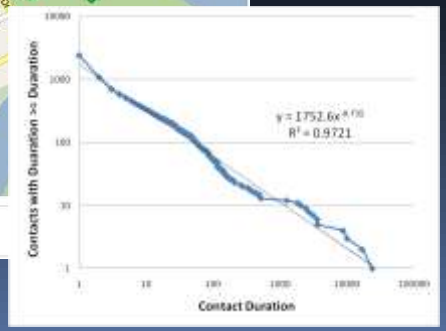
date	agent	agentmac	device	devicemac
2010-10-25 12:38:31	Agent3	F40B93BDCC7C	BlackBerry 8520	307C30FB6AA7
2010-10-18 09:24:32	Agent3	F40B93BDCC7C	Ameena Bajer-Koulack?s MacBook	60334B22AE90
2010-10-12 14:55:19	Agent1	F40B93C443B9	Emmanuel Abrokwah?s MacBook Pro	C8BCC8B04EC1
2010-10-13 13:09:16	Agent2	F40B93C3F258	Sam	001CA41852A9
2010-10-15 13:29:36	Agent1	F40B93C443B9	Kevin Bairos-Novak?s MacBook Air	90840DF45EA4
2010-10-14 08:04:23	Agent2	F40B93C3F258	HF99	0013E901FDED
2010-10-20 09:39:46	Agent3	F40B93BDCC7C	Scott Vieira?s MacBook Pro	58B0359E369B
2010-10-12 09:18:50	Agent3	F40B93BDCC7C	FUJITSU-LAPTOP	00037A875141
2010-10-08 16:03:14	Agent2	F40B93C443B9	Parrot v5.11C	00121CECD098
2010-10-07 15:58:59	Agent2	F40B93C443B9	General Motors	001EB20CDC31
2010-10-21 13:39:46	Agent1	F40B93C443B9	Jupa	C8BCC8DAAB76
2010-10-09 16:27:09	Agent3	F40B93BDCC7C	C510a	0024EFC4DC6F
2010-10-08 16:59:06	Agent3	F40B93BDCC7C	0000	0017D57473C6
2010-10-13 09:24:42	Agent3	F40B93BDCC7C	hamster	001F5B6EB5B3
2010-09-18 02:36:30	Agent2	F40B93C3F258	erinmaddaford<3	0026E2EBF504
2010-10-10 15:18:52	Agent3	F40B93BDCC7C	SPH-M610	001D25EAE5A8

Mac and CoD lookup

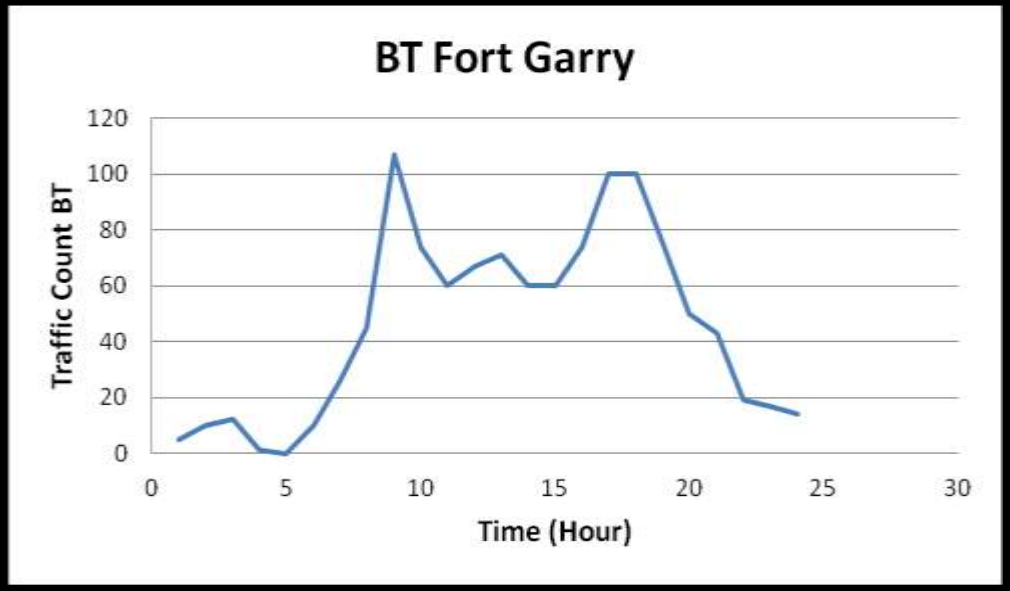
BT augmenting more traditional probes



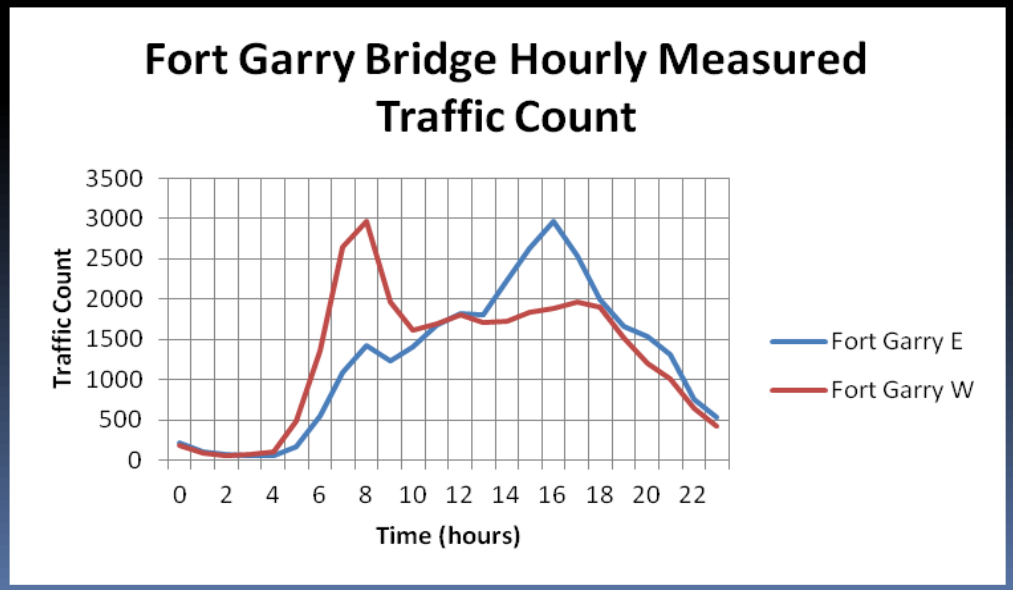
SNA?



Experiment at FG Bridge



Stationary Probe



Mechanical Counter

Part 2: Summary

- There is some opportunity to improve the data collection of probes for proximity data collection. (augment other sources)
  - Generate trajectories
- Challenges are having enough probes.
  - Probe uptake
  - Perceived benefit to participation

Opportunities

- Incredible modeling potential with combined service provider data.
- VSNs ???
- Commercialization opportunities, public works and city planning.
- Other opportunities outside of auto information sector.

Youtube: For fun/reference

- Real crazy
- www.youtube.com/watch?v=RjrEQaG5jPM

- Game Engine (Early stage)
- www.youtube.com/watch?v=mUee-tFv1uE

Thanks for your time/attention