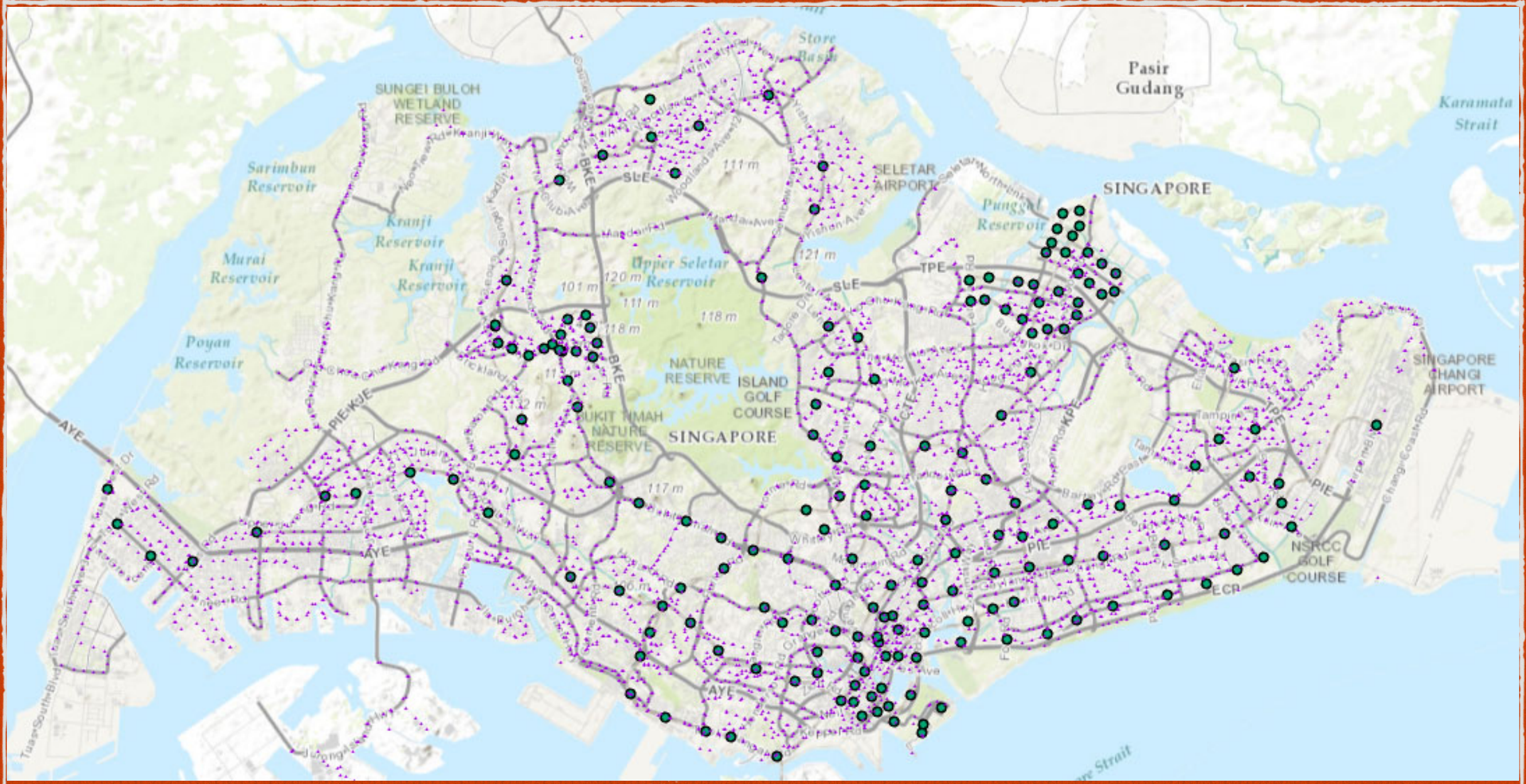


ROBUSTNESS OF SINGAPORE PUBLIC TRANSPORTATION NETWORK

GROUP 8 : THE DAYLIGHT ANALYSTS

CHEW TZE HOONG (A0123694) LIANG NANXING (A0123702) VISHNU GOWTHEM THANGARAJ (A0134525)

Agenda

- ☐ Background
- ☐ Project Objectives and Deliverables
- ☐ Assumptions
- ☐ Data Sources
- ☐ Methodologies Overview
- ☐ Data Transformation
- ☐ Data Preparation

- [ ] **Analysis Measures**
  - Shortest Path Calculation
  - Total Commute Time
- [ ] **Scenario Analysis**
  - Baseline Scenario
  - Proposed Nodes
  - Real-time Breakdown Scenarios
- [ ] **Limitations**
- [ ] **Future Extensions**
- [ ] **Queries & Answers**

“ Transportation is the center of the world!

It is the glue of our daily lives.

When it goes well, we don’t see it.

When it goes wrong, it negatively colours our day, makes us feel angry and impotent, curtails our possibilities ! ”

– Robin Chase, Founder of ZipCar.

Background

- Transportation - one of the real signs of a developed nation.
- 11 media-documented cases of train breakdowns in Singapore in the first three months of 2015.
- Huge impact on the day to day lives of Singapore residents.
- Need for Network Analysis of the current existing Public Transportation Network.
- Need for a Robust, Resilient-to-failures Public Transportation network.

Objectives & Deliverables

- ☐ Network Analysis of current public transportation system.
- ☐ Understand robustness through removing selected edges.
- ☐ Analysis of real-time breakdowns that occurred in Singapore.
- ☐ Proposal of new nodes and edges to improve resilience to failure

Assumptions

- ☐ Train networks by SMRT and SBS Transit form core Singapore Train and Bus Network.
- ☐ Impacts of other public transportation is not considered for the model.
- ☐ Time taken for bus/train to stop at a station, Time taken for passengers to alight/ drop off are not factored into calculation of travelling time.
- ☐ Non-peak hours travelling is not considered ; During peak hours buses travel on an average of 25 km/h
- ☐ Assumption related to distance
  - Commuters prefer to take public transport to reach a station if distance > 400 metres.
  - If distance < 400 metres, assumed that on an average people would walk to the station.
  - Short links between stations are represented by a 4.8 km/h walking speed.

- [ ] **Waiting time due to switching mode of transportation**
  - **Change to Bus : 8 Minutes**
  - **Change to MRT/LRT : 3 Minutes**
  - **Change MRT/LRT at Interchange : 5 Minutes**

- [ ] **MRT/LRT Stations under construction, travelling time between them is 2 mins**

- [ ] **Optimal and uniform traffic conditions exist during the peak timings and the travelling time and waiting time estimations throughout the network.**

Data Sources

For Bus Routes Data

Transit Link Website

SBS Transit

SMRT

Geo-Spatial Information Data

Open Street Map

OpenStreetMap

Subzone Data Population Density Travelling Time Data

WIKIPEDIA
The Free Encyclopedia

DEPARTMENT OF STATISTICS SINGAPORE

Methodologies Overview

Robustness Measure

- Accurate quantification to network's well being.
- Ease of translation to the physical domain.
- Aptness of application to Different Strategies (i.e Spoke-hub network vs point-to-point network)

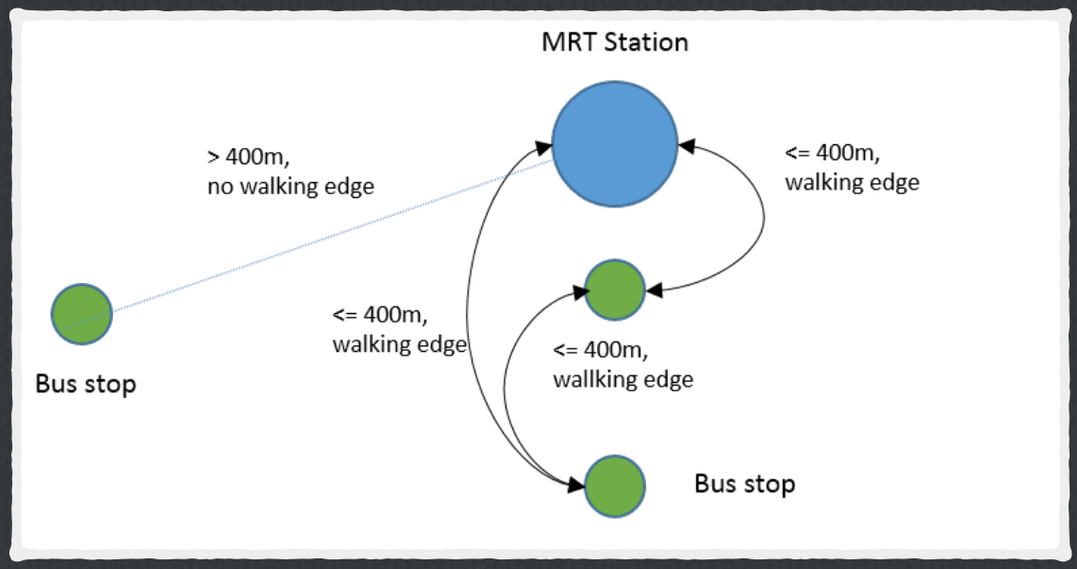
Population Simulation

- Accounting for travel direction & magnitude of commuter flow.
- Commuters between each start,end pair can be calculated.

Data Transformation : Nodes and Edges

- [ ] Convert bus Nodes, Train Nodes, Walking Routes into Nodes & Edges.
  - Ordered the sequence of bus stops for each route and created start and end nodes using lag Value; Edge Weights created using bus speed of 25 km/h

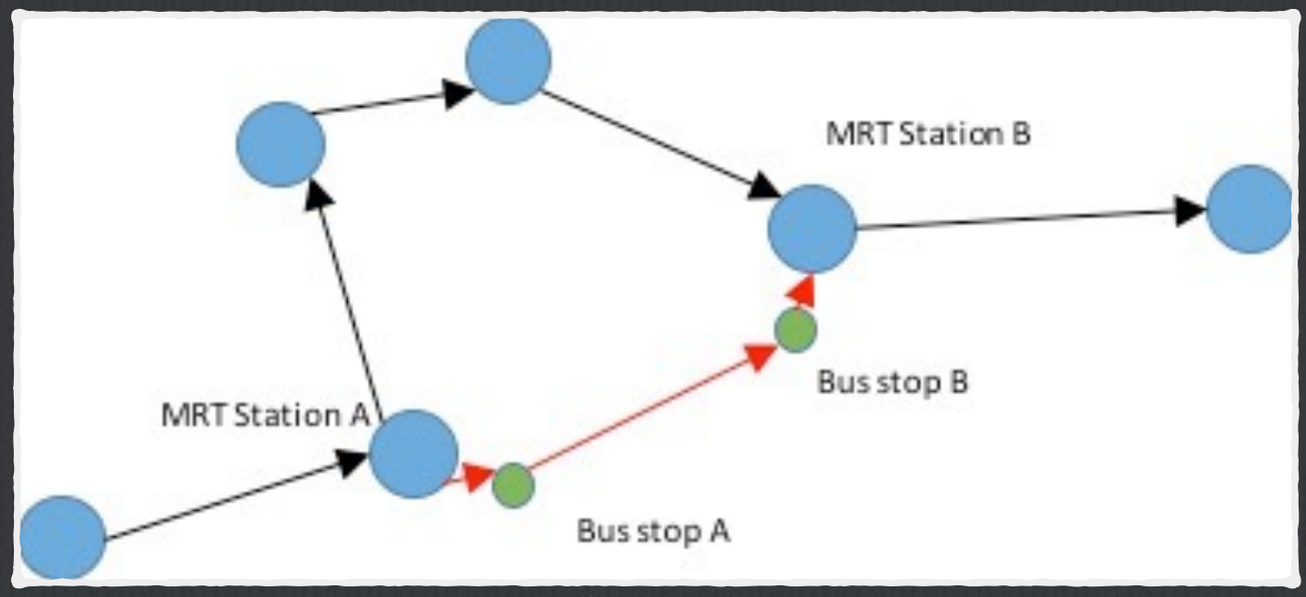
- [ ] Link Trains and Bus Routes using Walking Edges
  - Distance between Nodes calculated using Haversine Distance and filtered for nodes <=400m apart; Edge Weights created using 4.8 km/hr walking speed.

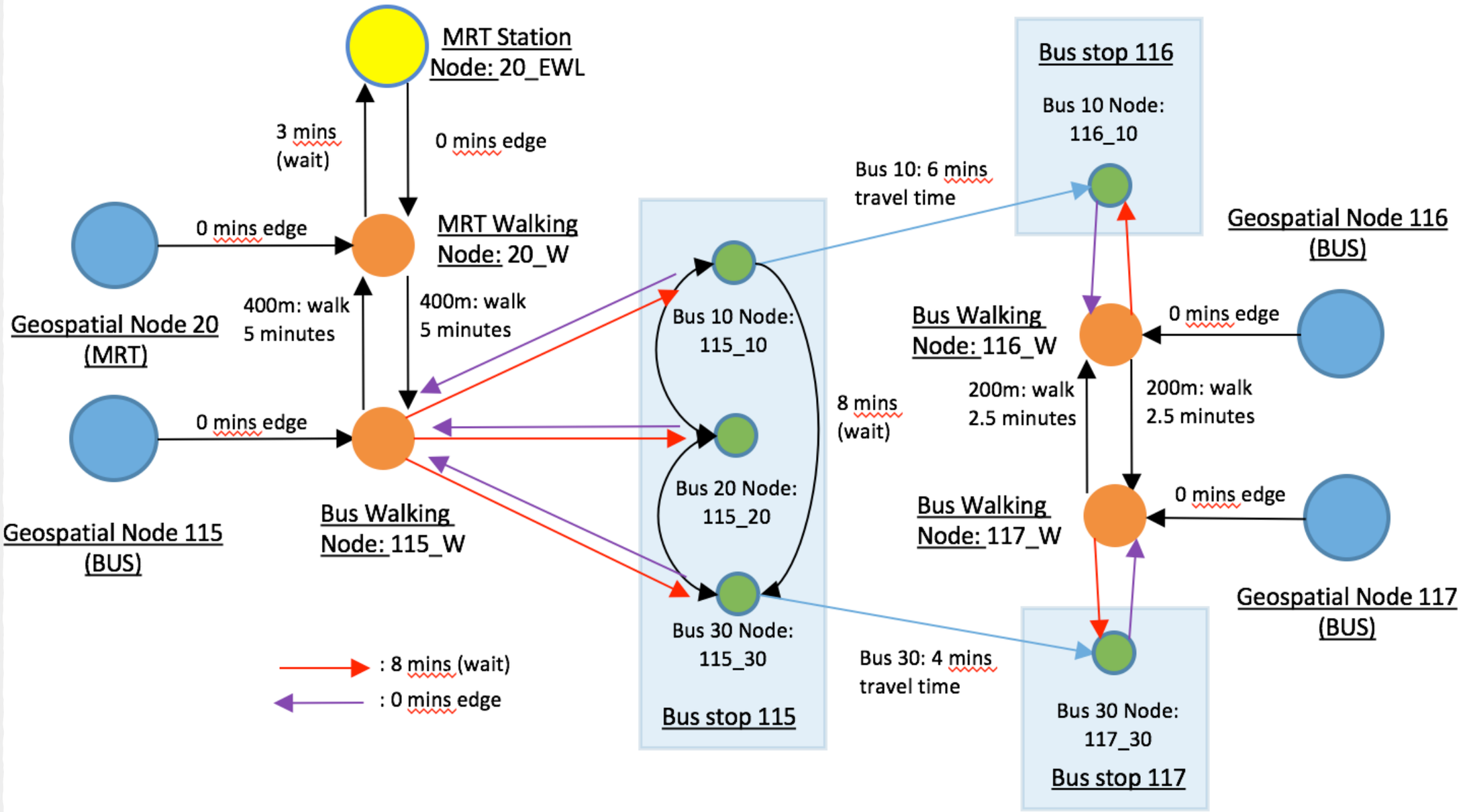


Data Transformation : Why Model Waiting Time?

- ☐ Model Waiting time for each route change to incorporate reality.

- ☐ Bus to MRT, MRT to Bus, MRT Interchange, Bus to Bus (Same Stop), Bus to Bus (Different Stop)





Data Preparation

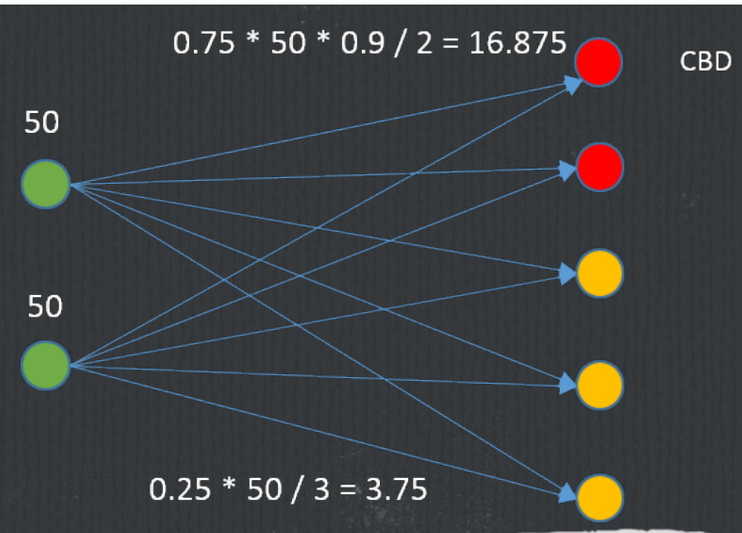
Data Preparation : Modelling Commuter Count

- ☐ Working Population : Age 18 - 65. 75% travels to CBD, 25% to all other nodes

- ☐ Uniformly Distributed across all node pairs.

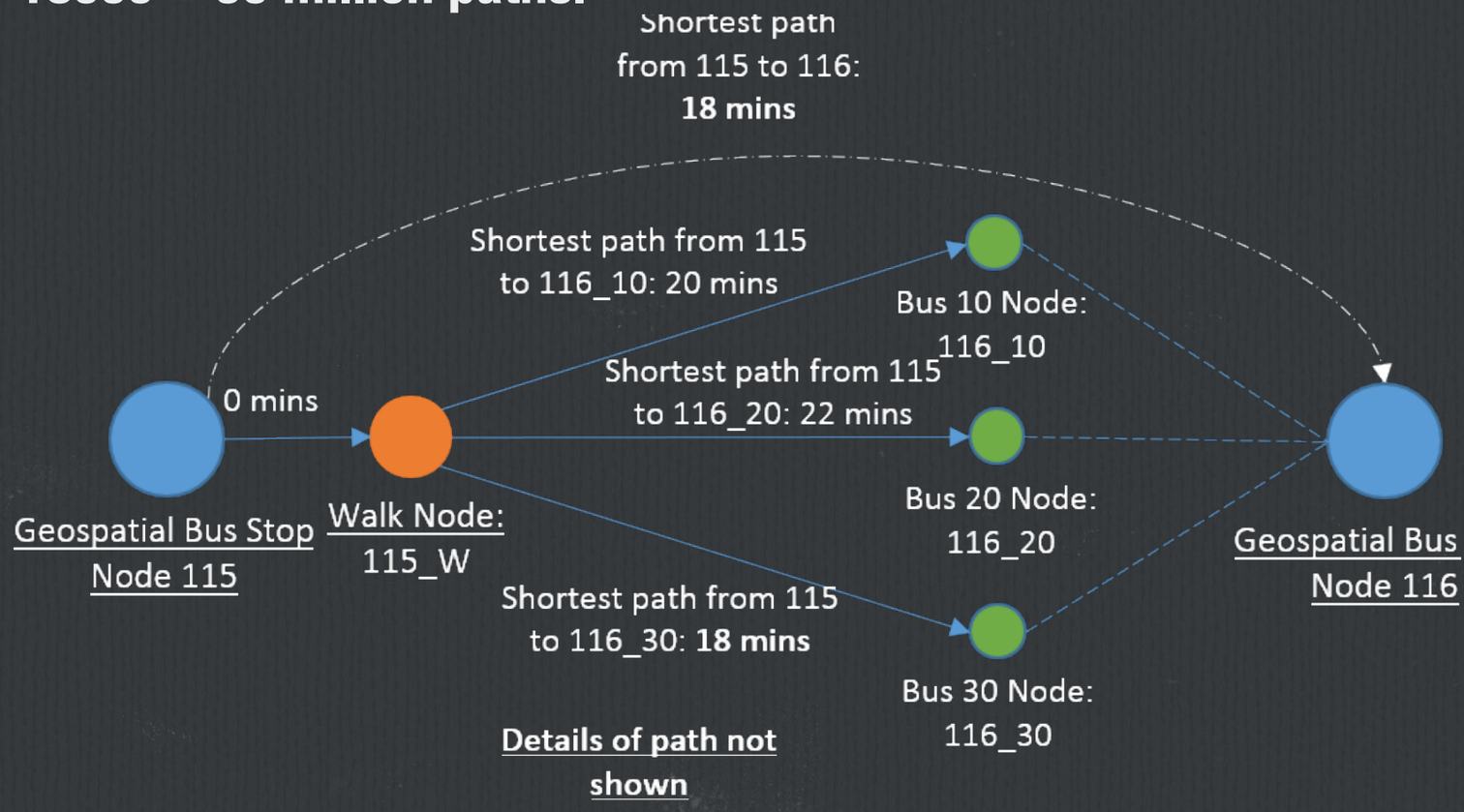
$$commuter\ count_{start=subzone\ i,\ \ end=CBD\ node\ j} = 75\% \times \frac{subzone\ i\ working\ population \times 90\%}{subzone\ i\ node\ count \times total\ CBD\ node\ count}$$

$$commuter\ count_{start=subzone\ i,\ \ end=nonCBD\ node\ j} = 25\% \times \frac{subzone\ i\ working\ population \times 90\%}{subzone\ i\ node\ count \times total\ nonCBD\ node\ count}$$



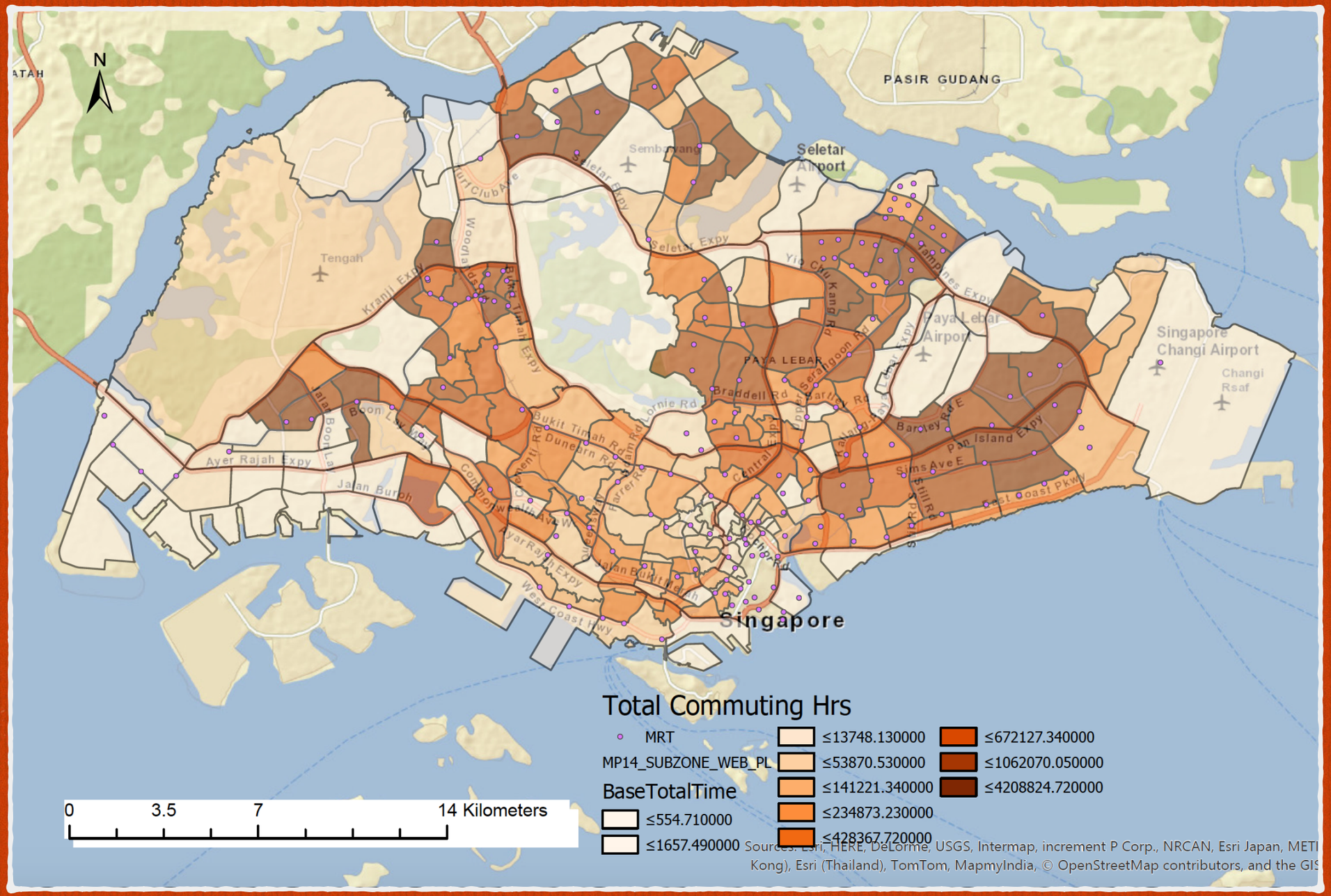
Data Preparation : Shortest Commute Time

- ☐ Only for actual geo-spatial nodes pairs.
- ☐ Djikstra's Algorithm for shortest path (uni-directional, weighted)
- ☐ Intermediate nodes as end nodes to derive geo-spatial end nodes (no incoming edges). 5000 * 18000 = 90 million paths.



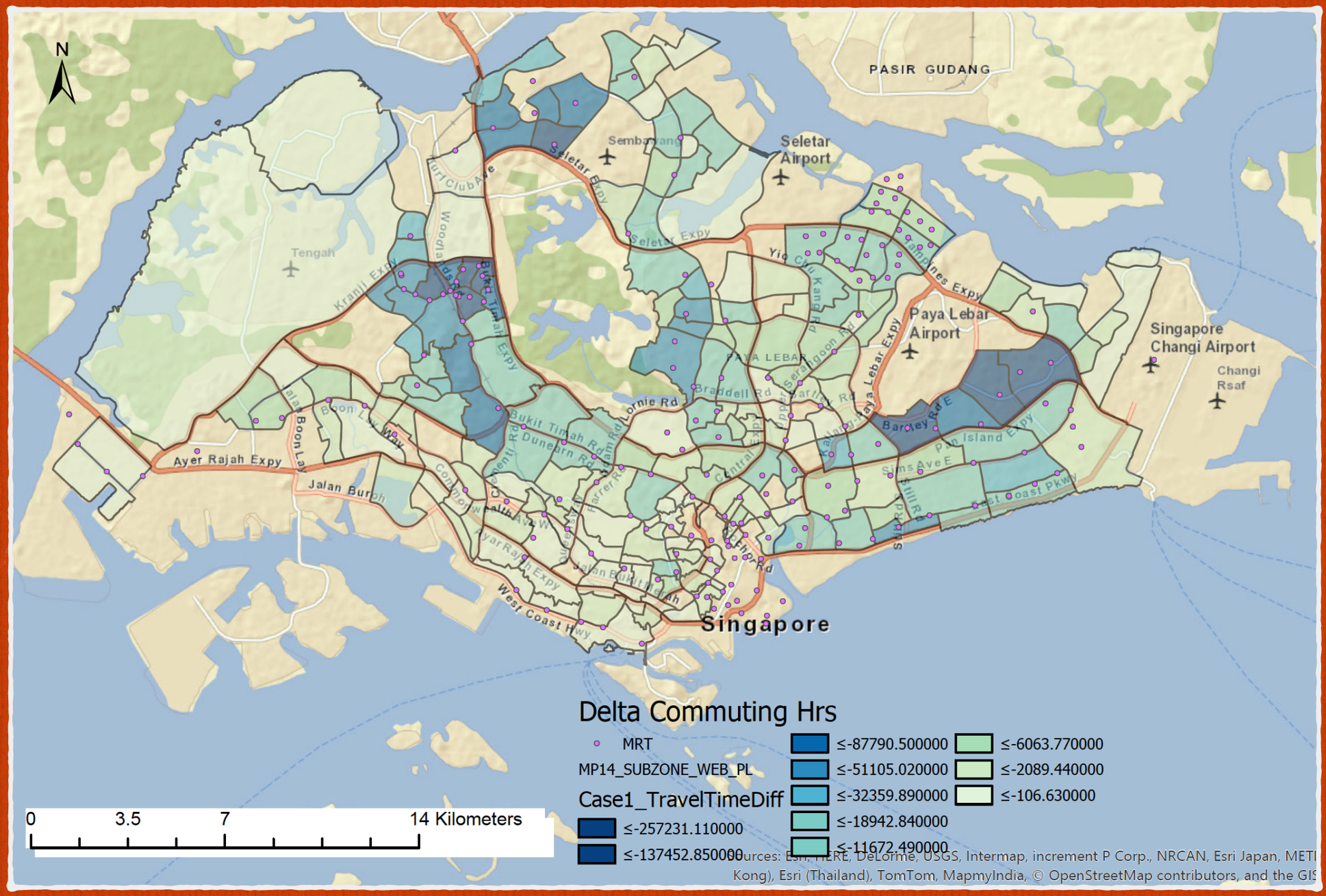
Data Preparation : Total Commute Time

- ☐ Merged commuter count distribution and shortest commute time using start and end geospatial nodes.
- ☐ Total Commute Time is the summation of the product of commuter count and shortest commute time of all the node pairs combination.



- Slightly Correlated to Subzone Population
- Nearer to CBD, Less Commute Time
- ArcGis and ArcMap
- Tampines East, Tampines West & Woodlands ⇧CT

Baseline Commute Time

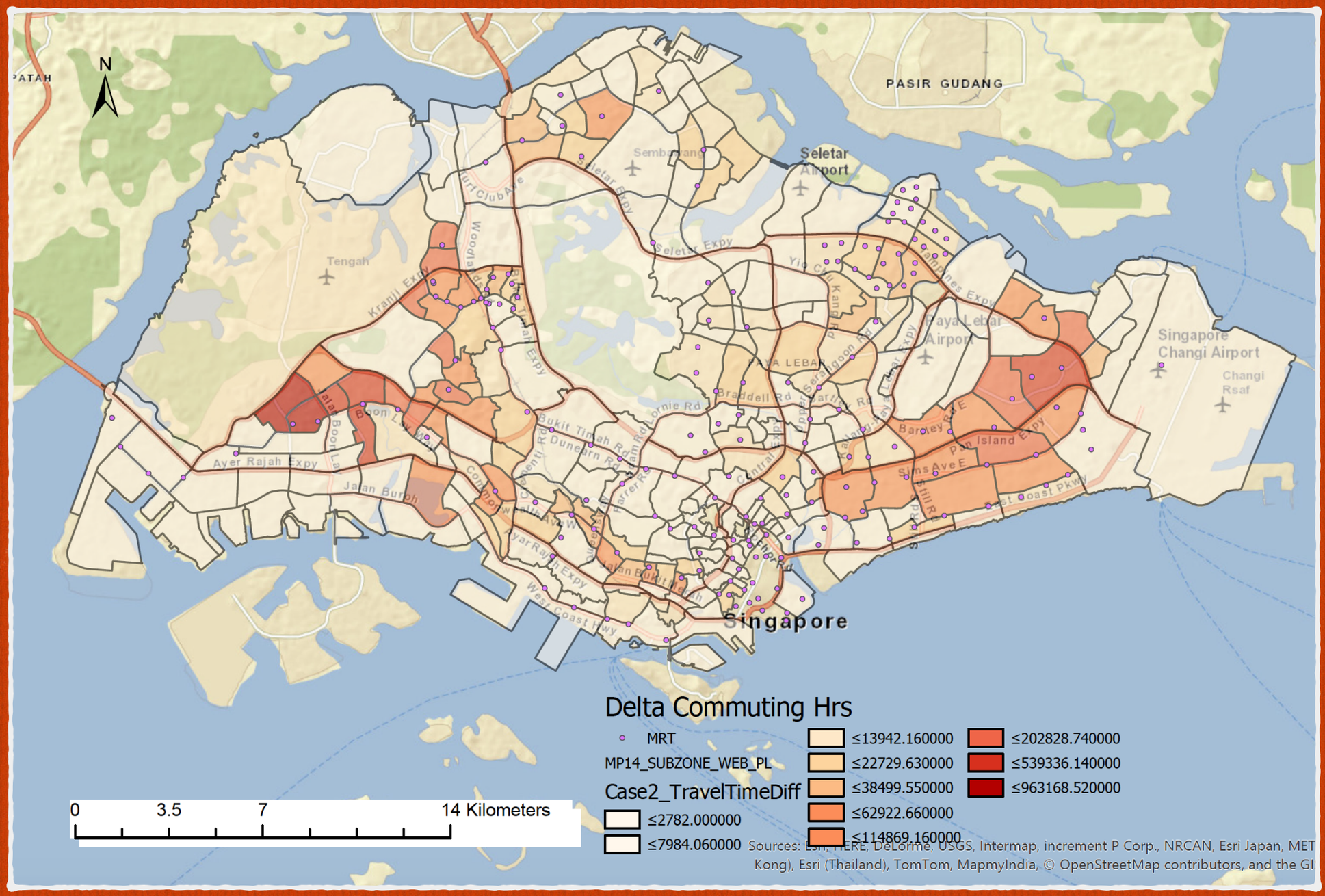


- Proposal had Improved Subzones Inline with Baseline Scenario needs
- Usage of Delta Commuting Hrs
- Thomson East Coast Line and Downtown Line
- Jelebu, Tampines East, Tampines West, Woodlands South have improved Commute Time ⬇

Proposed Nodes Analysis

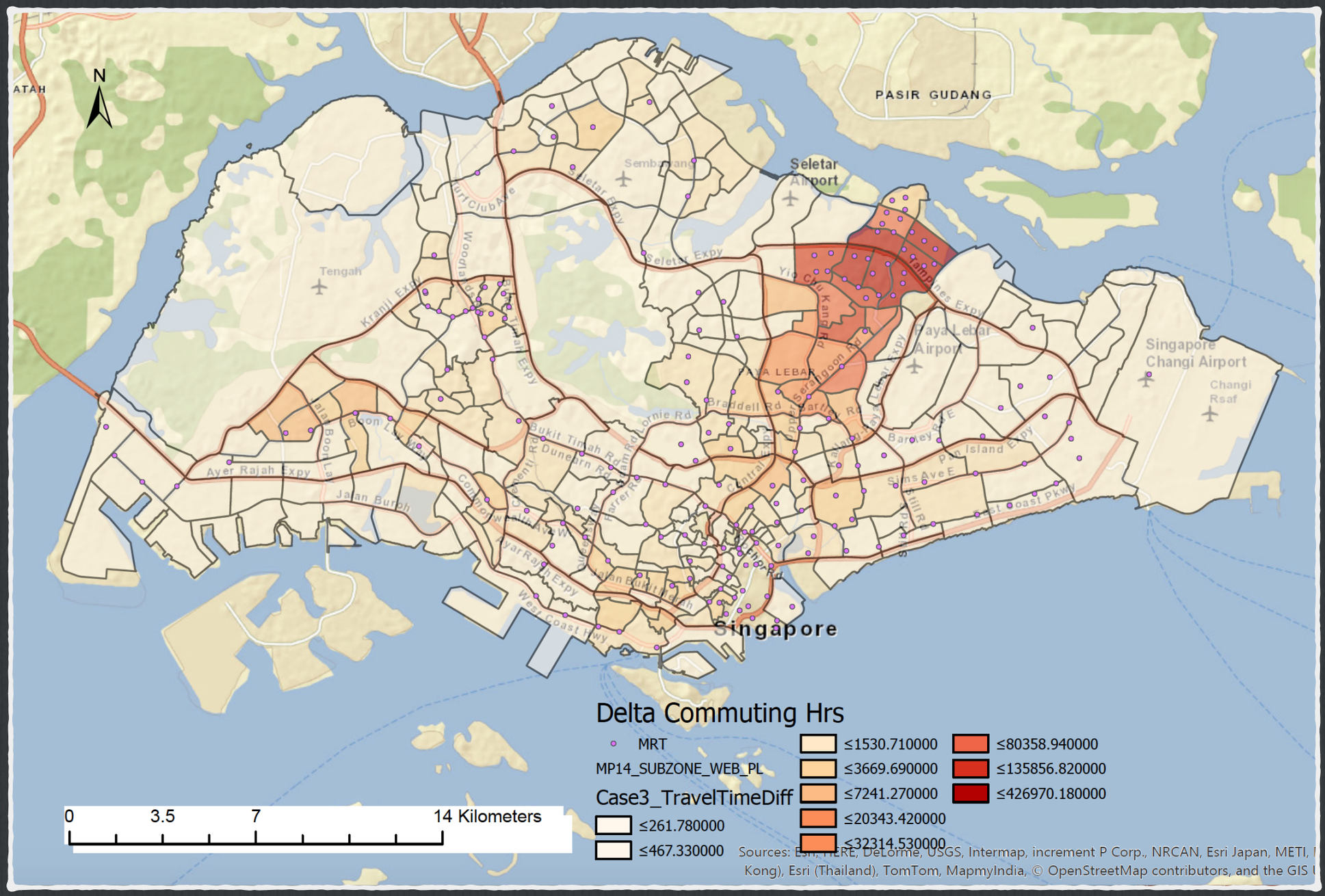
MRT Breakdowns Analysis

AFFECTED NODES		DATE OF OCCURENCE (DD/MM/YY)	AFFECTED HOURS	MRT LINE
FROM	To			
Jurong East	Bugis	03/03/15	1.50	East West Line
Woodleigh	Punggol	19/06/13	2.50	North East Line
Bishan	Marina Bay	15/12/11	5.58	North South Line



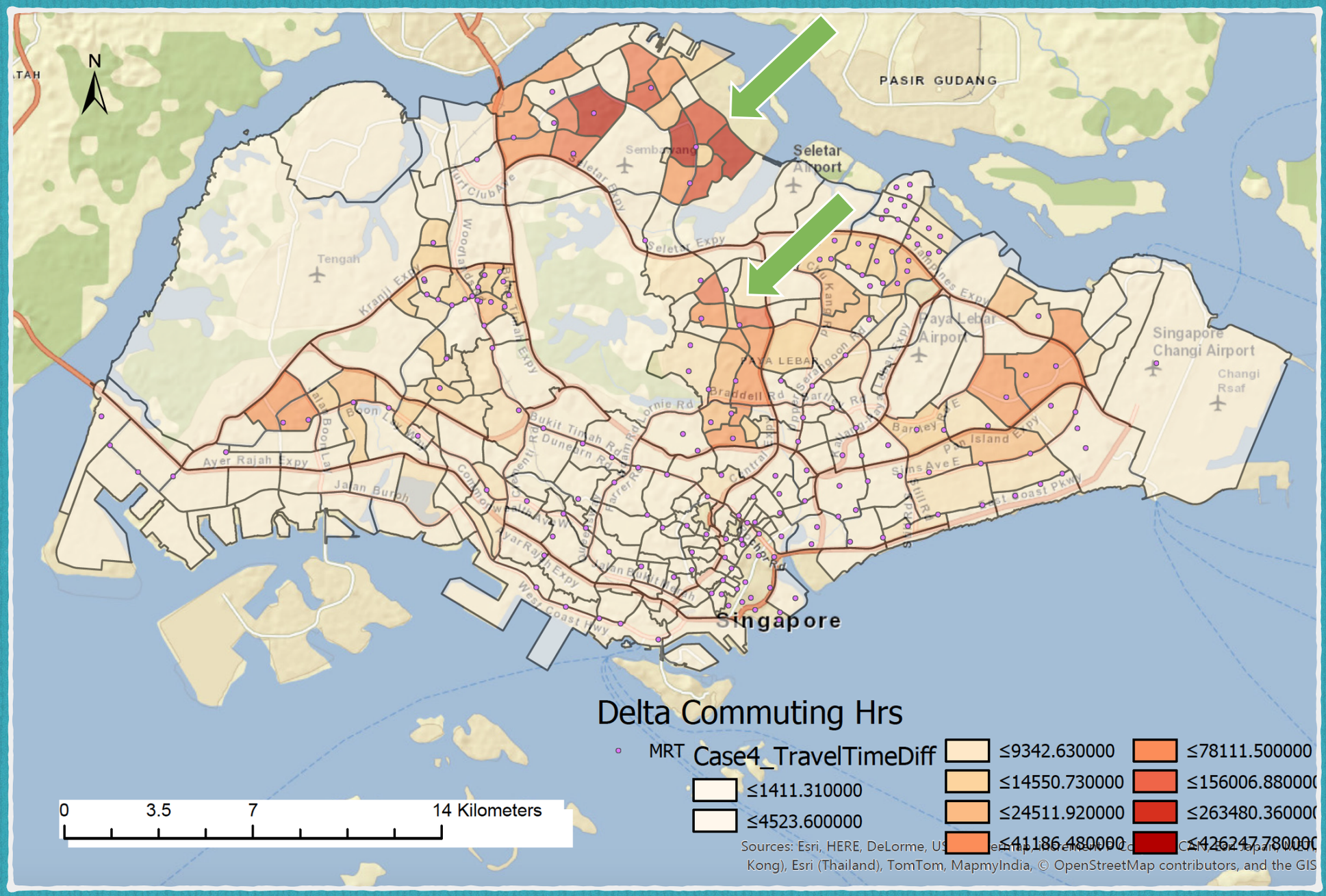
Jurong East - Bugis Breakdown Analysis

- MRT Stations from Jurong East to Bugis were affected recently due to track fault
- Vitality of East-West Line
- Subzones East and West of the Island most affected.
- Jurong West Central had the highest impact of the breakdown of about 46%



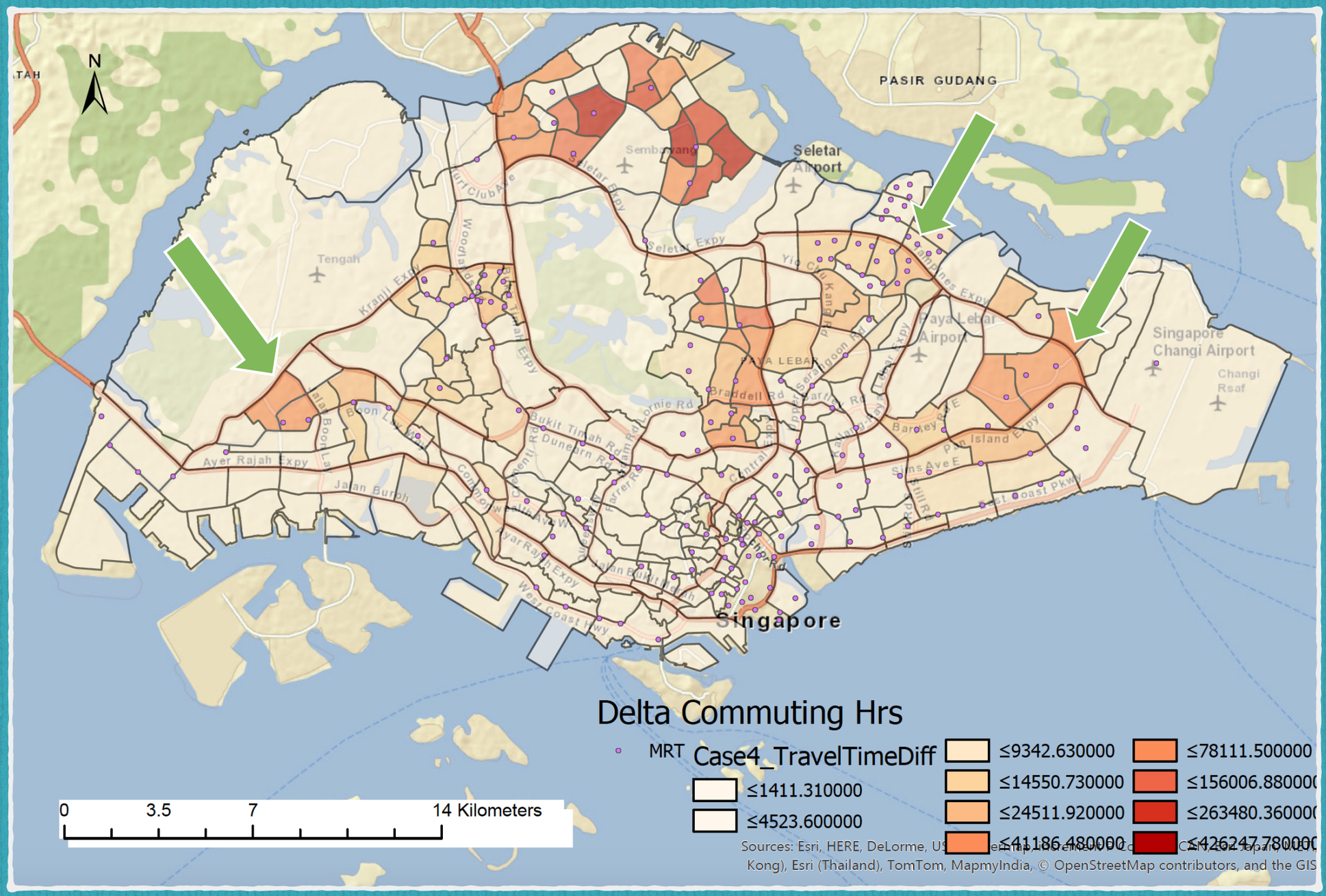
Woodleigh - Punggol Breakdown Analysis

- Increase in total commuting time only in the North Ease subzones
- A total increase of 20-40% of commuting time



Bishan - Marina Bay Breakdown Analysis

- Darker shades indicates heavier impact on total commuting time
- Heavy impacts north of Bishan, where there is large population and they intuitively take train to CBD
- Heavy impacts in vicinity of Bishan



Bishan - Marina Bay Breakdown Analysis

- Heavily populated subzones at extreme east/west are impacted at the ‘last mile’: commuters change to bus at the city hall/raffles place train inter-changes
- Circle Line commuters who change to NS line at Bishan to take bus totally

Limitations

- ☐ ‘Response Reactions’ not factored
  - New bus services mirroring train services not factored (but it takes time for these services to be up)
  - Over-estimate impact
- ☐ Transportation capacities not factored
  - Bus services typically have lower capacities compared to train
  - Under-estimate impact
- ☐ Human behaviours not modelled
  - Typical commuter more likely to stay and wait till fault is corrected
  - Under-estimate impact
- ☐ Assumes commuters have full transportation information and can arrive at shortest path
  - Scaling effect on total commuting hours

Future Extensions

- ☐ Permute Train Nodes Breakdown
  - ☐ Calculate at impact on total commuting hrs for all breakdown scenarios
  - ☐ Propose critical edges for transportation companies and security agencies to focus on
- ☐ Proposal of New Transportation Nodes/Edges
  - ☐ Framework developed by project can be a base to evaluate efficacy of new nodes/edges
  - ☐ Stratify island into grids, identify grids with high Population : Transportation node ratio, randomly generate nodes/edges, assess impact
  - ☐ Transportation planner to zoom into grids with high potential
- ☐ Higher Resolution Starting and Destination Node Pairs
  - ☐ Government may have address and workplace information of residents, and also whether they drive (own a car)
  - ☐ Use this information for calculation of total commuting time for better accuracy

Thank You !

Questions ?