# Visualizing Singapore Public Transport Commuters

Guided by: Dr. KAM Tin Seong

Prepared by: Vincent KOH How Han, Sheryl YEO Qin Ying, CHAN Huang Suan

**Abstract** — Singapore's Public Transport System is the main mode of commuting around in Singapore. This study examines the travelling patterns of commuters for both bus and train in February 2019. In particular, the influx and outflux from different areas (planning area/subzones); with the flexibility of choosing the type of day and timing. Furthermore, the team employed spatial statistics to evaluate the probability of commuters travelling to a particular train station and to determine the dominant flow of commuters by bus. The application is developed with R Shiny and Leaflet, allowing the use of interactive map and handling of large data sets. Data used in the application are gathered from sources like LTA DataMall, Singstat, Data.gov and OneMap. Insights gathered from this study were that most populated train stations during peak period were due to it being near an interchange with great transport accessibility or one area that is populated with office buildings. For bus, we inferred that most commuters congregate in bus stops reflecting dominant flows and great level of accessibility (e.g. Interchange), commuters usually also tend to travel shorter trips with bus as their mode of transport. The findings are of great importance to government sectors, service providers and relevant geospatial industries. However, given its limitations, more research can be done to minimise generalisability by using specific transport concession data (e.g. students, senior citizens) to extract out more focused insights.

**Keywords** - Geospatial Analytics, Flow Analysis, Visualization, Traffic Flow, Singapore Public Transport

## 1 Introduction

Singapore's Public Transport System is the number one preferred way to commute around in Singapore, with service improvements being done and as more and more new lines are being introduced. According to the McKinsey Report conducted in 2018, Singapore clinched the top spot for public transport affordability, accessibility, efficiency and safety (Channel News Asia, 2018).

However, there have been cases of breakdowns, long waiting time and overcrowding as ridership reached hit 7.264 million a day (The New Paper, 2018). Transport demand is not fixed and it is difficult for service and government sectors to identify which specific area they should place more focus on. Thus, we developed an application to better understand and gain valuable insights from the commuters' travelling pattern with the past aggregated public transport data provided by LTA DataMall.

With the application, the project aims to effectively identify the commuters' key travelling patterns during various periods of the day, especially during the peak period. Furthermore, we will be able to identify the various hotspots and populated areas where commuters cluster in. Our primary analysis is to conduct spatial statistics to identify the probability of commuters visiting a particular MRT station and dominant flow of passenger commuting by Bus. Ultimately, it enables relevant sectors to better plan and allow for efficient decision making that will impact Singaporeans in the future. We will demonstrate the above mentioned with the usage of R Shiny application to explore and analyse large data sets involving both bus and train.

## 2 Motivation and objectives

Our research and development ideas are motivated by the lack of tools for users like daily commuters and government officials to visualize the day-to-day traffic flows. It aims to provide daily commuters with an analytical tools for them to plan their trips more effectively and efficiently. In addition, government officials can use this application to understand the flows and provide better solutions for commuters. (Example: identifying the major flow of bus commuters and provide alternative bus services to ease traffic flow).

With the help of R, packages like flows and stplanr, will help to calculate the flow amount from origin to destination and provide a statistical calculation of dominant flows from different areas in Singapore. Our team utilised tmap and leaflet to build layers on the map to enhance visualisation. Also, with the help of the 'dplyr' function, it provided the access and capability to process large volumes of data.

## 3 Related Works

As of now, there are no platforms in Singapore specifically that helps to visualize Singapore's Public Transport Flow.

This brings about a possible potential issue as government sectors, businesses and Singaporeans are unable to visualize the actual crowd flow to make insights and plan better.

The team has sourced three related works:

1) Joan Serras - Public Transport Visualization
2) Ogikubo Development - Heavy 4D Tokyo
3) GIScience News Blog - Transport Flow from Uncertain Social Media

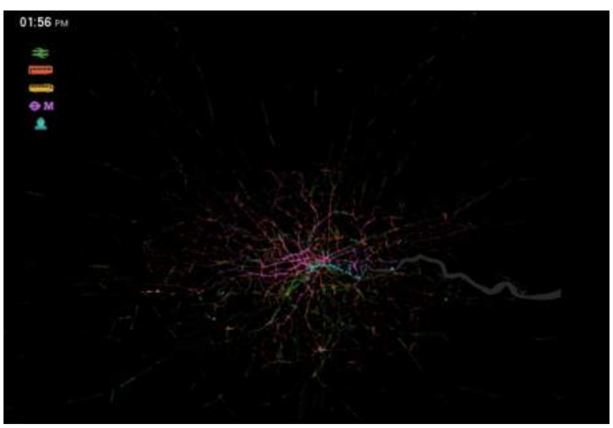
### 3.1 *Joan Serras, Public Transport Utilisation*

Joan Serras' Public Transport Flow helps to visualize public transport flow from a city to country perspective. The visualization of the flow is determined by the transport type and the time at which the transport vehicle departs from one area to another.

Train, coach, metro (tram and tube), ferry and air trips for England, Scotland and Wales over a typical weekday in 2009. Different modes of transport are assigned different colours, and time is represented by the clock at the top left.

The animation clearly highlights the complexity of the networks, the distinct transport geographies of the UK's cities and regions, and the daily peaks of activity.

However, as much as the "X" factor is in the visualization, there are no additional information with regards to the number of passengers or any statistic with regards to flow. The visualization is not customizable or editabled by any means for the user, and serves only as a visual simulation of the various transport mode within a time frame.




*. 1: Joan Serras work on "Public Transport flows, UK"*

### 3.2 Ogikubo Development Co Ltd, Heavy 4D Tokyo


*Fig. 2: Overall traffic information source for integration*

Ogikubo Development Co Ltd is the organisation that pioneered this web application. The project displays the operation of public transportation networks such as railways and buses within Tokyo on a 3D map that can be used on a PC or smartphone.

In Japan, all conventional traffic information are found in the bus stop or the train station. This includes printed timetables, route map and the map of the train station. The project aims to synthesize all the conventional traffic information into a centralised web application where the users can find all the information that they need in one location.

The application is served from the perspective of a overhead drone which projects the map in a 3D format, with real-time data of trains projected on the map itself.


*Fig. 3: Video demo for "Heavy 4D Tokyo" web application*

From the figure above, the simulation and visualization of the train stations and the individual trains are modeled in 3D. The trains are animated to move along the train lines as seen in the green and orange models representing the trains that are departing from the train station.

### 3.3 *Steiger, E. Ellersiek, T. Zipf, A.,* Crowd Analyser

Three PhD undergraduates published the a research paper about analysing public transport flow from uncertain social media sources. In this case, they attempted to analyse content from mobile application that are geotagged such as a photo uploaded on Foursquare or a comment on a local event via twitter.

A visual representation as seen in the Figure 4 below, is the result of clustering numbers of social media posts within the geographical location, along railway networks of London.

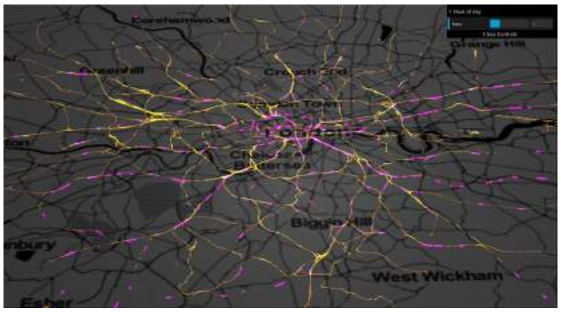



*Fig. 4: WebGL Visualization of media post clustering*

# 4 Methods

## 4.1 Dominant Flows

We leveraged on the nodal regions created by Nyusten and Dacey in 1961 to "Dominant Flows" in our application, using three types of nodes: Dominant, Dominated and Intermediary. This allow the application to highlight a clear hierarchy between locations based on the flows.

Flow between place i and place j is consider dominant when:

1. most important flow from i is emitted to j
2. sum of incoming flows by j more be more than sum of incoming flows by i

Flow selection consist of 3 different methods:

1. k first flows from all origin
2. flows that are greater than threshold k
3. sum of flows is at least equal to k

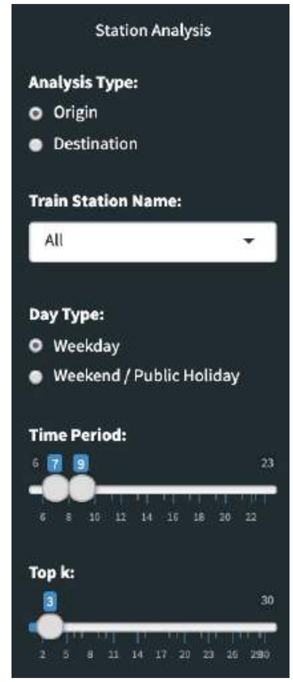
However, there is a potential flaw in the model as the flow intensities are undervalued. Thus, by introducing a filter to select certain percentage of flows that represent k% of the sum of outgoing flows, it will effectively return the type of flow with the ideal number of flows that is required.

## 4.2 User Interface Design

For both our application (Train & Bus Visualization), we allow the user to specify the parameter of key variables so that they are able to view the visualization based on what they want to see.

### 4.2.1 Train Flow Visualisation

For the Train Flow functionality, we provided user with the option of choosing which station they would like to see.




In addition to that, we allow user to specify if they want to view this station as the origin or destination station of trip. This would help when user wish to see train flow from home to work and vice versa.

Day and time parameters are also provide so that user can either visualize the train flow in a specific time or type of day as a whole in a month.

Top k parameter is provided to user so that they are able to filter the view based on the selected k-value popular flows during a specific day and time period.

The difference between the selection of "By Station" and "By Subzone" analysis (found on the side navigation bar) lies within the selection factor of either "Station Name" or "Subzone Name" as a view of the entire application.

### 4.2.2 Bus Flow Visualisation

The Bus Flow functionality make use of Singapore Planning Area to conduct analysis, our team is able to provide the user with the ability to select the "Planning Area" they wish to visualize.

In addition, we also have a parameter "% of flows" which allow user to have an overview visualization of the sum of total outgoing flow towards the dominant planning area. It allows the user to set a threshold which filters the results based on the minimum value set by the parameter.

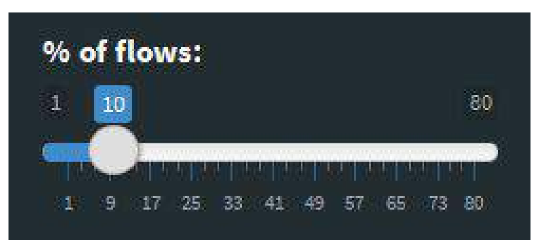



*Fig. 5: % of flows parameter*

### 4.2.3 Similarities Between Two Applications

For both application, the team has provided the visualization aspect for the application, and a tabular format that shows the detailed list of data that was used within the visualization (Fig. 6). This will benefit certain user that prefer numbers over visualization, as they are able to have control over the data that they want to see. These tables have in-built functionality that enables the user to see the results in an ascending or descending order. In addition to that, our team provided the initial data that was used for both application to process. This helps user to understand the raw numbers of the ridership for that month before any processing take place.

*Fig. 6: Result table*

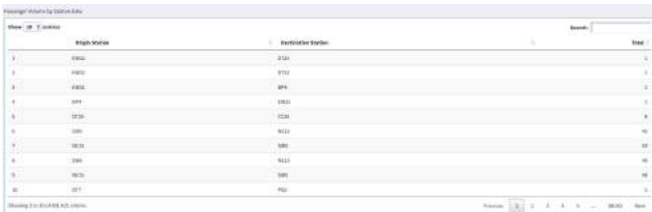


*Fig. 7: Raw data*

*Fig. 8: Split functionality view*

The team made use of a split functionality technique to separate different analysis method and table generation into different view so that user would not be bombarded with maps and numbers.

Using the split functionality view technique, we are able to link maps, result data and raw data into one single application without showing too much or too little to user. This is crucial as by reducing the amount of information in one view, we want our user to focus more on the main analysis which is the map or the generated result that would give them crucial information on Singapore public transport flows. In addition, this would also reduce the waiting time for processing of data.

### 4.3 APPLICATION

#### 4.3.1 SYSTEM ARCHITECTURE

R programming language is the base of our team application. In addition to R, our team also perform extensive research and development in packages for flows analysis as this is our main focus for this project.

As R only provide the basic programming capabilities, our team also look into Shiny and Shiny Dashboard to serve our application on a web instead of a script or R Markdown view.

With the help of Shiny, we are able to fully deploy a workable application that user can access to this application anywhere, anytime without the needs to have any coding knowledge while using the application.

For deployment, our team selected shinyapps as the place for hosting our web application. However due to server constraint and limitation in free tier, we are unable to deploy our bus application. Hence, the bus application is only available through the local host.

#### 4.3.1 DATA VISUALISATION

The visualization on maps for our application are created using tmap, a R library that was written by Martijn Tennekes and Leaflet, written by multiple authors. These mapping packages allow user to manipulate elements on the map itself using data retrieve from different government agencies. By processing the data and adding data as layers on the map itself, we are able to generate more informative map as compare to normal map or even static map image.

A combination between mapping packages and other R packages also played an important role in the system. Packages like “tidyverse” help the system to speed up data processing when user make selection on parameters. “sf” and “sp” help the team in converting data to spatial which play an important role when it comes to spatial mapping and intersecting points with subzone or planning area boundary. This would allow the team to conduct proper calculation when processing data from point to zone analysis. In order for the application to have a seamless user experience, our team also make use of “shiny” reactive function that allow user to make multiple changes, without the needs of refreshing the page.

Unlike the previously open source packages, the Flow Package that the team used did not provide the functionality for users to employ the utility of a dynamic map option. Hence, the team took some effort to conduct research and contacted seniors on their experience with how they implemented the dynamic function of dominant flow through the package. Eventually, the team rewrite the function using leaflet as the base map for the function.

## 5 RESULTS

### 5.1 BUS

In addition to the visualization of the ridership flow between one bus stop to another stop. Our bus application also provide the following:

1) Identify the planning area that is the dominant area. By identifying the dominant, we know where are most people going via bus according to a "% of flow" parameter specified by the user.

We measure the potential of the origin using the origin's population by age group in the area and the destination attractiveness using the number of amenities (e.g. Supermarkets, Hawker Centres, Schools) it has in the specific area.

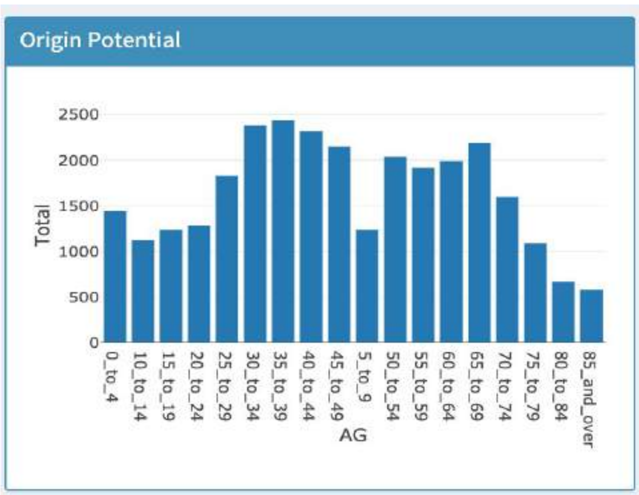



*Fig. 9: Demographic segments within Clementi subzone*

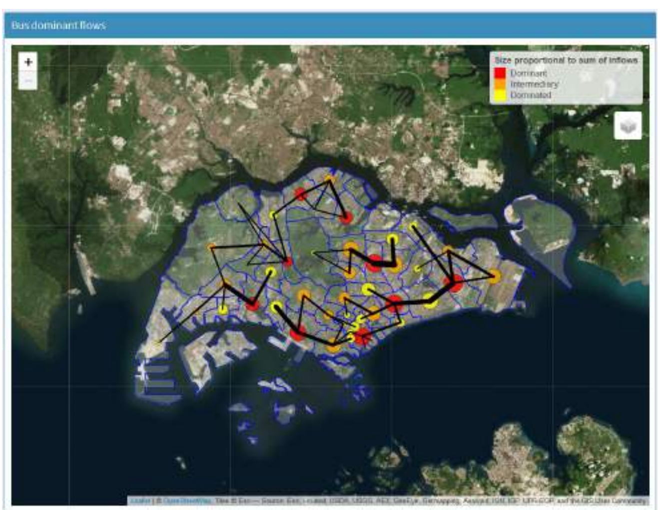



*Fig. 10: Flows above threshold value of 18%*

2) Visualizing flows by planning area. By using this technique, users are able to visualize the travel pattern of people from that planning area. This is important as it give us insight to how people travel and the limitation of bus services from that planning area.

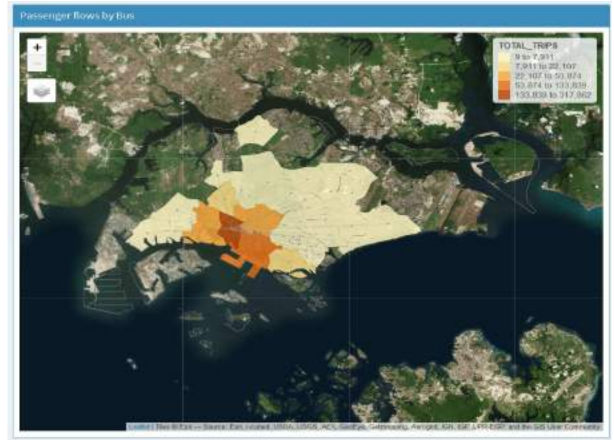



*Fig. 11: Passenger outflow movement (Clementi)*

## 5.2 TRAIN

As Singapore has a comprehensive train network, we have a slightly different approach to analyzing train as compare to bus. Our train application provide the following:

1) Identify the top k route in Singapore, based on the ridership flows from one station to the other. This is enhanced by the flexibility to view the results from one station or a general view of all train stations.

*Fig. 12: Selecting top 10 by all station between 7am to 9am*

*Fig. 13: Selecting top 10 by Dhoby Ghaut between 7am to 9am*

2) Visualizing flows based on subzone. Using this technique, the users can see how people travel from subzone to subzone.

*Fig. 14: Selecting Clementi North as Subzone*

3) By selecting an origin subzone, we allow user to see the distribution of different age group staying in that subzone. This provide user the understanding of the origin potential of trip.

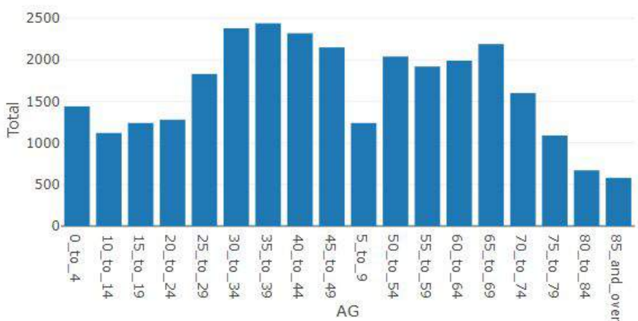



*Fig. 15: Potential of trip from subzone "Clementi North"*

4) By selecting a destination subzone, we allow user to see the number of hawker center, schools and supermarket in that subzone. This represent the attractiveness of a trip at the destination subzone.

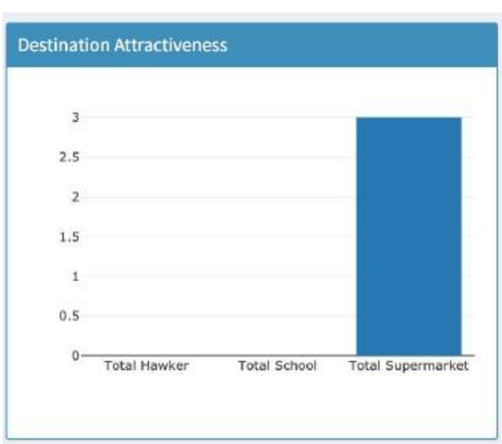



*Fig. 16: Attractiveness of trip from Subzone "One North"*

## 6 Discussion

### 6.1 Learning Outcomes

During our town hall presentation at GeoWorks, we realised that many visitors agree that there is a lack of visualization tool for Singapore public transport. This is crucial as more Singaporeans are taking Public Transport everyday.

Without a proper tool for analysis and visualization, there is a gap between user knowledge and information to be consumed. For daily commuters, they will be unable to have an up-to-date information about the trip that they want to make. This creates the necessity to make plans that would involve a fifteen minutes grace period, to accommodate the scenario that there might be insufficient space on the bus or train.

For the government agencies, they would not be able to do strategic planning for the allocation of bus or train services in an area. This could result in congestion within a bus stop or train station because of the lack of information to know the crowding situation in an area. Due to the surge in breakdowns recently, having no alternative services would bring inconvenience to the commuters and extend to a situation of overcrowding because of the breakdown of a certain line or bus service.

With this system, we are able to allow commuters, marketers, business and government agencies gain a better understanding of the travelling patterns of commuters. By knowing the travelling pattern, government agencies can better plan their transport resources; business and marketers can know where to place their campaign to allow a wider reach of audience; commuters can consider using alternative transport to reach to their destination.

### 6.2 Insights

#### 6.2.1 Train

*Fig. 17: Top 30 trips in Singapore on a weekday between 7 - 9am*

Some insights that our team observed for train analysis were:

1) High volume of passengers could be possibly due to that station being the only area to access the MRT. For example, the highest trip recorded was from Bukit Panjang. Bukit Panjang station itself has both LRT and MRT. Moreover, being the first stop of Downtown Line can mean that passengers from nearby areas such as Bukit Batok, Choa Chu Kang, etc. will most likely transfer via bus or LRT to MRT.

2) One group of passenger trip trend identified is when there is a need for them to switch to another line. For example: Passenger that tap in at Pasir Ris (EW1) and tap out at Tampines (EW2) most probably need to switch to Downtown Line Tampines (DT32). Reason for tapping out at these station could means that the station itself contain different gantry which led to different line platform. Example: Tampines, Newton, etc.

3) Another group of passengers identified is when the train station of a subzone that contain high residential density (Example: Ang Mo Kio, Bedok, Toa Payoh, etc.) and their trip ends at Raffles Place which is the location of Central Business District (CBD).


*Fig. 18: Analyzing train trip by subzone "Tiong Bahru Station"*

For this insight, we will make use of the top 8th trip of origin station during weekday from 7 - 9am, Tiong Bahru, as the main analysis. The reason for our selection on Tiong Bahru is based on a report (StackedHomes, 2018) on expat areas in Singapore, which the report mention that Tiong Bahru is one of the popular expat choice of areas due to its close proximity to CBD and Orchard.

Diving deeper into analysing by subzone, we can make use of this report as our baseline assumption for our analysis on working adults staying in Tiong Bahru travelling pattern. Using our subzone functionality of the train, we can identify the population distribution of Tiong Bahru which is use to represent the potential of passenger taking a trip from Tiong Bahru MRT station.

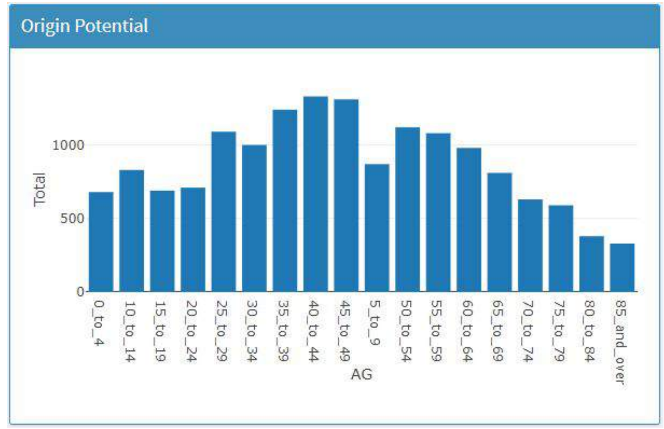



*Fig. 19: Potential of trip from origin subzone "Tiong Bahru Station"*

For subzone Tiong Bahru Station, we can easily identify that it is an area that has high amount of working adults (25 - 64). Using the generated trip data, we are able to identify the top 5 destination subzone for passengers that tap in at MRT station in Tiong Bahru Station.

| | origin_sz.name | dest_sz.name | Total |
|---|---|---|---|
| 10 | TIONG BAHRU STATION | RAFFLES PLACE | 14688 |
| 24 | TIONG BAHRU STATION | TANJONG PAGAR | 12191 |
| 26 | TIONG BAHRU STATION | ONE NORTH | 4077 |
| 15 | TIONG BAHRU STATION | CITY HALL | 3885 |
| 48 | TIONG BAHRU STATION | JURONG GATEWAY | 2978 |

*Fig. 20: Top 5 trip data from subzone Tiong Bahru Station*

A common trait between this 5 subzones is that these subzones have a substantial amount of offices congregated around the area. With offices in the area means a high volume of working adults, thus we can deduce that the top 5 trips data are generated mostly by working adults (probably high percentage of these working adults are expat)

4) Using time to perform analysis. Our team manage to find another pattern of passenger travelling pattern.

   By analysing the Top 7 trip visualization from 6AM to 7AM, our team found out that during this period, people living in the west tend to travel out earlier to work or school.

*Fig. 21: Top 7 train trips at 6 - 7am*

| | ORIGIN_PT_CODE | DESTINATION_PT_CODE | TOTAL_TRIPS | ORIGIN_STN_NAME | DESTINATION_STN_NAME |
|---|---|---|---|---|---|
| 2 | BP1 | EW24-NS1 | 24246 | CHOA CHU KANG (BP1) | JURONG EAST (EW24-NS1) |
| 4 | NS5 | EW24-NS1 | 21955 | YEW TEE (NS5) | JURONG EAST (EW24-NS1) |
| 6 | EW27 | EW29 | 19261 | BOON LAY (EW27) | JOO KOON (EW29) |
| 5 | EW26 | EW29 | 17906 | LAKESIDE (EW26) | JOO KOON (EW29) |
| 3 | NS2 | EW24-NS1 | 17858 | BUKIT BATOK (NS2) | JURONG EAST (EW24-NS1) |
| 1 | DT1 | DT11 | 17640 | BUKIT PANJANG (DT1) | NEWTON (DT11) |
| 7 | EW28 | EW29 | 17445 | PIONEER (EW28) | JOO KOON (EW29) |

*Fig. 22: Top 7 train trip details at 6 - 7am*

Some stations identified are Jurong East and Joo Koon. These areas are more popular because Jurong East has a bus interchange and train interchange whereby passengers can travel via North South Line (red line) or East West Line (green line); for Joo Koon, it could be due to the nature of the area being an industrial area with plentiful of jobs.

| | ORIGIN_PT_CODE | DESTINATION_PT_CODE | TOTAL_TRIPS | ORIGIN_STN_NAME | DESTINATION_STN_NAME |
|---|---|---|---|---|---|
| 1 | DT1 | DT11 | 27387 | BUKIT PANJANG (DT1) | NEWTON (DT11) |
| 5 | BP1 | EW24-NS1 | 24853 | CHOA CHU KANG (BP1) | JURONG EAST (EW24-NS1) |
| 3 | EW1 | EW14-NS26 | 24254 | PASIR RIS (EW1) | RAFFLES PLACE (EW14-NS26) |
| 4 | EW1 | EW2 | 23879 | PASIR RIS (EW1) | TAMPINES (EW2) |
| 7 | NS21 | NS20 | 23617 | NEWTON (NS21) | NOVENA (NS20) |
| 6 | NS5 | EW24-NS1 | 22789 | YEW TEE (NS5) | JURONG EAST (EW24-NS1) |
| 2 | DT11 | DT17 | 22258 | NEWTON (DT11) | DOWNTOWN (DT17) |

*Fig. 23: Top 7 train trip details at 7 - 8am*

In the 7AM to 8AM period, we would see more working adults travelling to the central areas and hence, this explains the top few trips containing destinations like Novena, Raffles Place, Downtown; where there are many offices congregated in those areas. For destination like Newton, Jurong East and Tampines, it could be due to transfer cases either to Downtown line (for Newton and Tampines) or bus interchanges (Jurong East and Tampines) or access to offices in the International Business Park in Jurong East.

| | ORIGIN_PT_CODE | DESTINATION_PT_CODE | TOTAL_TRIPS | ORIGIN_STN_NAME | DESTINATION_STN_NAME |
|---|---|---|---|---|---|
| 2 | DT11 | DT17 | 23519 | NEWTON (DT11) | DOWNTOWN (DT17) |
| 7 | NS21 | NS20 | 22206 | NEWTON (NS21) | NOVENA (NS20) |
| 5 | EW17 | EW14-NS26 | 21063 | TIONG BAHRU (EW17) | RAFFLES PLACE (EW14-NS26) |
| 6 | EW1 | EW2 | 20427 | PASIR RIS (EW1) | TAMPINES (EW2) |
| 3 | DT33 | DT35 | 20093 | TAMPINES EAST (DT33) | EXPO (DT35) |
| 1 | DT1 | DT11 | 20059 | BUKIT PANJANG (DT1) | NEWTON (DT11) |
| 4 | EW1 | EW14-NS26 | 19124 | PASIR RIS (EW1) | RAFFLES PLACE (EW14-NS26) |

*Fig. 24: Top 7 train trip details at 8 - 9am*

In the 8AM to 9AM period , this is the time whereby all working adults are expected to be at work already hence, this explain the destination of trip mostly in prime working locations. Some key areas identified from this destination station are:

- CBD area (Downtown, Raffles Place)
- Changi Business Park (Expo)
- Tampines (Bus interchange and Downtown Line)
- Newton (Office area and North South Line)

After analyzing on the time factor, our team decided to look into one of the initiative by Land Transport Authority (LTA), early travel discount scheme (previously known as Travel Early, Travel Free on the MRT).

For passengers to be able to enjoy this benefit, they must tap in at any MRT or LRT before 7.45am, regardless of the destination stop, will receive up to 50 cents discount.

Using the above conditions stated and the data generated from Fig 22, 23 and 24, we can observe that most people do leverage on the travel discount benefit of travelling early as the figures of total trip tend to drop after 8AM.

However, there might be a limitation to this insight as we do not have data before this scheme was introduced. Hence, limiting the accuracy of this insight as to whether the scheme have indeed shifted the travelling pattern successfully.

### 6.2.1 Bus

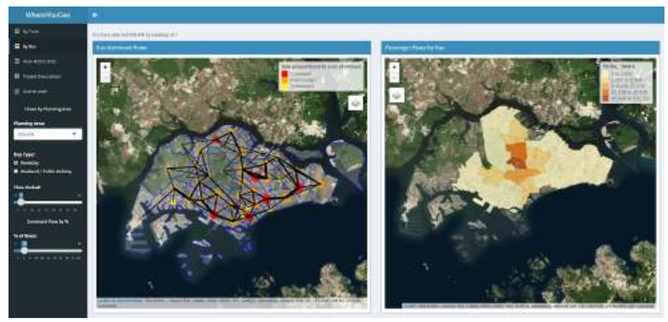


*Fig. 25: WhereYouGeo's bus application*

Some insights that our team observed for bus analysis were:

1) Planning areas that have dominant flow are areas that have bus interchanges or have wide accessibility to other planning areas. For example: Using Fig. 25, we can see some dominant areas like Woodlands, Yishun, Jurong East, Bukit Panjang, etc. These areas have bus services that travel far to other planning areas. One example is Bukit Panjang. Bukit Panjang have bus services that travel to HarbourFront (963), Woodlands (187, 960, 963, 966), Tampines (67), Jurong East and West (176, 187), etc.

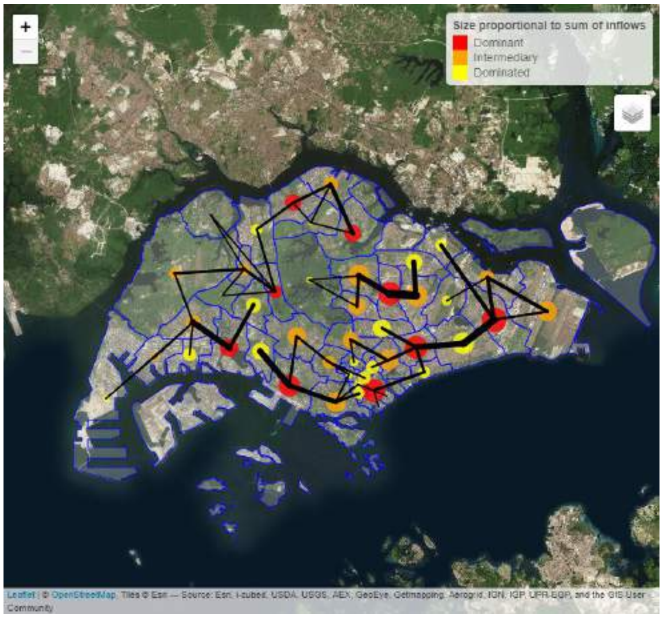



*Fig. 26: Dominant flow analysis (18% threshold)*

2) Passenger movements depend heavily on bus services provided to them in the planning area. As our application data does not include transfer, we will only draw insight based on 1 trip distance. Using Fig. 27, we can see that as distance increase or where areas does not have much facilities or office space, there is lesser passenger travelling.

   The area that is reddest is the location of Bukit Panjang. Using domain knowledge on Bukit Panjang, our team can draw insights that as there are quite a number of elderly in this area, short trips are common and this trip are most probably fulfilled by bus feeder services 920 and 922 and also service like 972 that travel within Bukit Panjang before leaving for Orchard.

   Red areas are Bukit Batok, Bukit Timah, Choa Chu Kang and Woodland. These area consist of schools, MRT station, etc. which most passengers from Bukit Panjang will travel to during weekday 7AM to 8AM.

   Orange areas consist of Jurong East, Novena, Tanglin, Orchard and Downtown Core. Some common traits between these areas is that they are heavy office congregated. Using domain knowledge, 7 - 8am is the time whereby working adult start to travel for the day as some areas like Novena, Tanglin, Orchard and Downtown Core will pass by Pan Island Expressway (PIE) which will start to jam up around 7.30am daily.

   As this data does not include transfer data, one domain knowledge our team has and observed is that when passengers board at Bukit Panjang area, some will alight at Tanglin or Novena area to transfer to MRT line (Downtown or North South line respectively) or transfer to other buses which will ferry them to areas such as Queenstown.

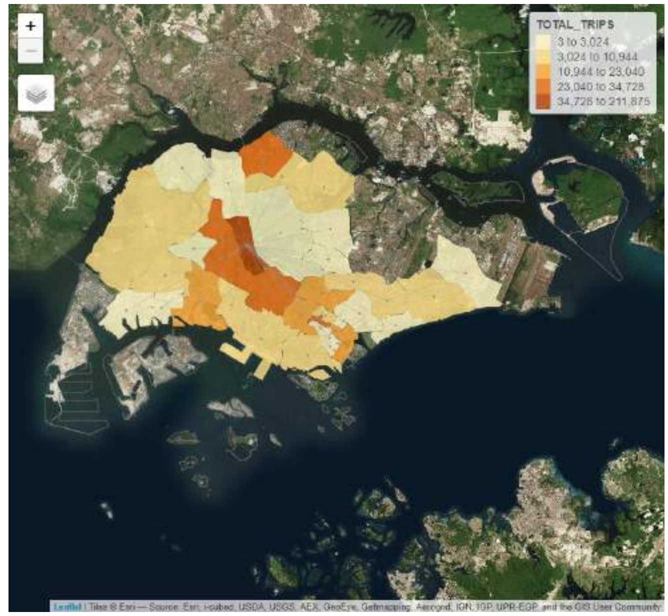



*Fig. 27: Travelling pattern of passenger by bus from Bukit Panjang at 7am*

## 7 Future Works

After implementing the system and going through Town Hall presentation, the team has several ideas on how this application can further improve to make it useable for users on a daily basis.

### 7.1 Usage of Concession Data

One of the issues faced was the dataset availability from the Singapore Government Agencies. As the data that we were able to access is very aggregated, we are only able to come out with visualization in a bird-eye view.

Our initial ideas focuses more on recommending facilities based on commuting patterns of concession pass holders (e.g. Students, Senior Citizens), the lack of concession pass data resulted us being unable to perform higher level techniques and visualizations.

### 7.2 Live Data Processing, MRT Cabin Density and Breakdown Alert

For user to use our application on daily basis, one important factor is the availability of live data. With the capabilities of a live data functionality, the system can be further improve to make real time analysis on flows. This would greatly benefit commuters on the go.

Once the system has go live, another functionality that this application can improve is the ability to retrieve and present user which part of the MRT cabin are full or empty. This help commuters to plan ahead their journey. For example: when the cabin is constantly full, rider may consider taking bus instead of trying their luck to squeeze into MRT. This would definitely reduce the overcrowdedness during peak hours.

Another idea is to integrate the system with live breakdown alert. User of this system can get first hand news when there is a train breakdown. With the help of this, commuters do not need to reach the station before knowing there is a breakdown on the line they are taking.

### 7.3 IMPROVED HUFF ANALYSIS FOR SUBZONE

The Huff Model analysis that the team implemented was a proof of concept that utilises three variables, and that is hawker, school and supermarkets. We foresee the potential to translate the findings to an overlay which could help users to identify the accessibility of a location, or find the correlation as to why people of different age group travel to a location.

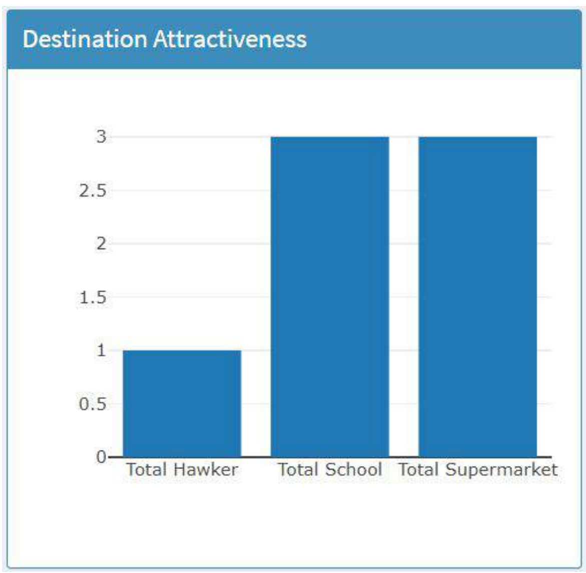



*Fig. 28: Accessibility analysis from Huff Model*

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