CSE3021 : SOCIAL AND INFORMATION NETWORKS

ANALYSIS OF SINGAPORE METRO STATIONS NETWORK

Team Members:

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1. Introduction:

With increasing population, traffic demand is coupled with increasing number of vehicles on the road. As a result, we are facing many problems like traffic congestion, road accidents and environmental pollution. This can be reduced only when the number of vehicles on the roads is decreased. We can achieve this by increasing public transportation. One of the most accepted methods to improve public transportation is „**Mass Rapid Transit** „system. This has already been used in many of the developed countries and in developing countries including India. setting up metro stations involves the study of geographic and community factors in that particular surroundings. We have to understand the population around that particular metro rail station and then we have to construct the station. This will help the people to identify the station easily and use the station easily and hence they can effectively make use of the metro system.

If a particular station is located in populated community that station will be more important and if a station is more important that it may considered as located in populated community vice versa. Applications of social network analysis include identifying the most influential person(s) in social network, key infrastructure nodes in the internet or urban networks, rumour spreaders and disease spreaders. In the same way we could identify the important stations in MRT network using centrality measures. In this paper we used network analysis to find the most important stations in Singapore metro networks. Here stations are considered as nodes. We used different centrality measures like degree centrality, betweenness centrality, Eigen vector centrality to achieve this. In graph theory and network analysis indicators of centrality identify the most important vertices in graph. We generated the different graph attributes like degree centrality, Betweenness centrality, closeness centrality to identify the tightly interlinked groups with in a network.

2.Literature Review Summary Table:

Authors and Year (Reference)	*Title (Study)*	*Concept / Theoretical model/ Framework*	*Methodology used/ Implementation*	*Dataset details/ Analysis*	*Relevant Finding*	*Limitations / Future Research/ Gaps identified*
1.Niraj sharma 2.rajni dhyani 2013	*Critical issues related to metro rail projects India*	*Issues while constructing metro projects in India*	*Identifying different problems while constructing metro networks and proposing a solution to them*	*Daily passengers who uses metro*	*What are the environmental issues related To the metro construction*	*Theoritical analysis .Experimental results are required*
c.prem Shankar R.vidya raj V.midhun raj K.sateesh kumar.	**analysis of road network of buffer area of kochi metro rail using tools of social network analysis.**	**how road networks influence metro systems**	**used the tools of social network analysis to study the road network of kochi.**	**Kochi road networks**	**how road networks influence metro systems**	**Some other parts in kochi should be included.**
Yew-Yih Cheng, Roy Ka-Wei Lee, Ee-Peng Lim and Feida Zhu	**Measuring Centralities for Transportation Networks Beyond Structures**	**How people are effected by the network disturbances in their lives**	Network centrality Visual analytics Transportation network	**Singapore subway networks.**	**Use of centrality measures to find the critical nodes**	**can be used for other most used subways.**

3. Objective of the project:

The main objective of this project is to analyse the Singapore metro networks and to find the most important station. This can be applied to any metro networks to find the important station during construction itself.

4. Innovation component in the project:

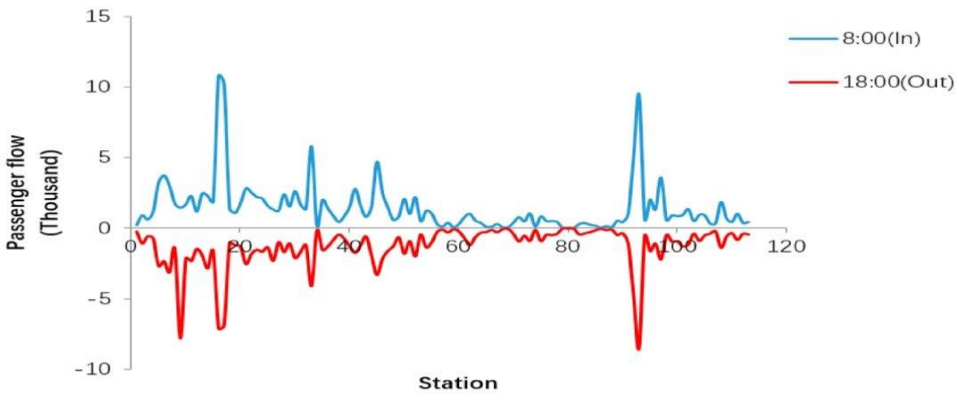
In this project we used the stations which are to be announced also. So, we can know the important stations even before announcing any trains to that particular station.

5.Data Collected:

We are working on the Singapore metro stations. We tried to apply the concept of network analysis on a network of connected railway stations, attempting to identify the important stations (nodes) in this network. The first step we implement is to collect the data from the Wikipedia page on "List of Singapore metro stations". We take the data from the table "MRT Stations" mentioned in this Wikipedia page, which has all the details of stations involved in the mass rapid transit across Singapore. We used data scraping techniques and later we applied the data cleaning techniques to sort the required data in a proper way.

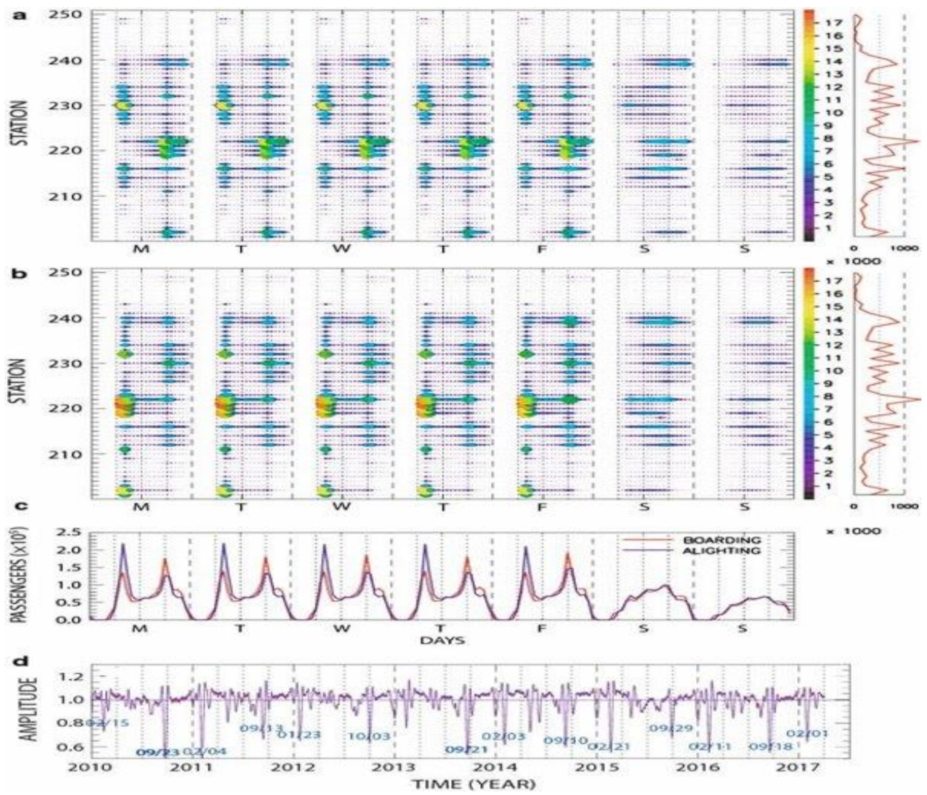
Passenger Flow Vs Station

—shows the statistics of daily passenger flow of metro in five working days. As can be seen from the figure, the passenger flow from Monday to Friday ranges from 1.20 million to 1.32 million. Passenger flow from Monday to Friday is increasing gradually, but the increase is not large, about 0.12 million. At the end of 2020, the permanent population of station was 8.27 million, which can be used to calculate the proportion of pedestrians to the permanent population in about one seventh.

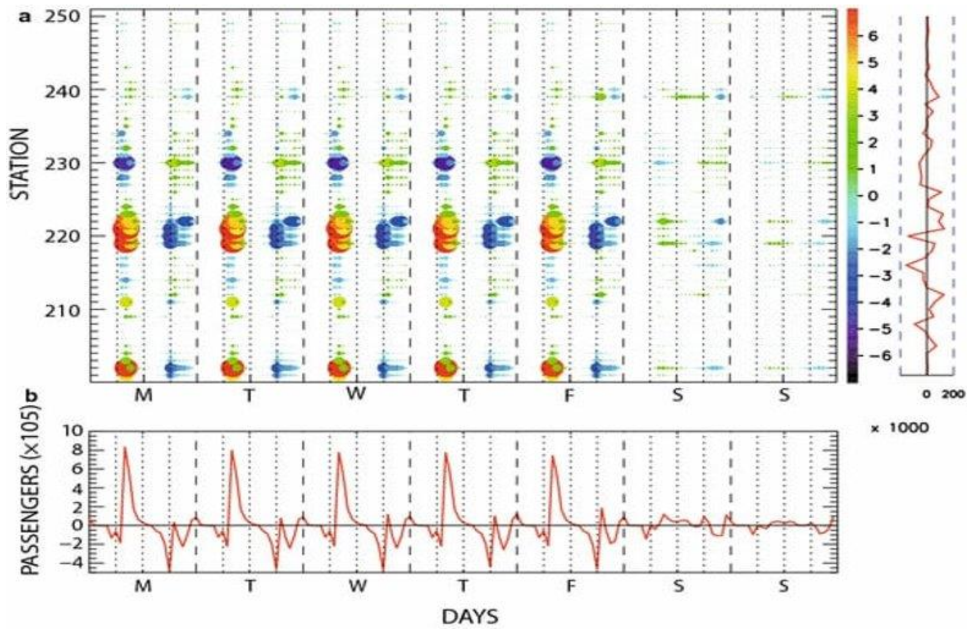


The below graphs show you the relations of different stations in week days…

The overall amplitude which means the no of trains arriving per weak to the total time (year)



Overall Stations Vs Days in a Week:

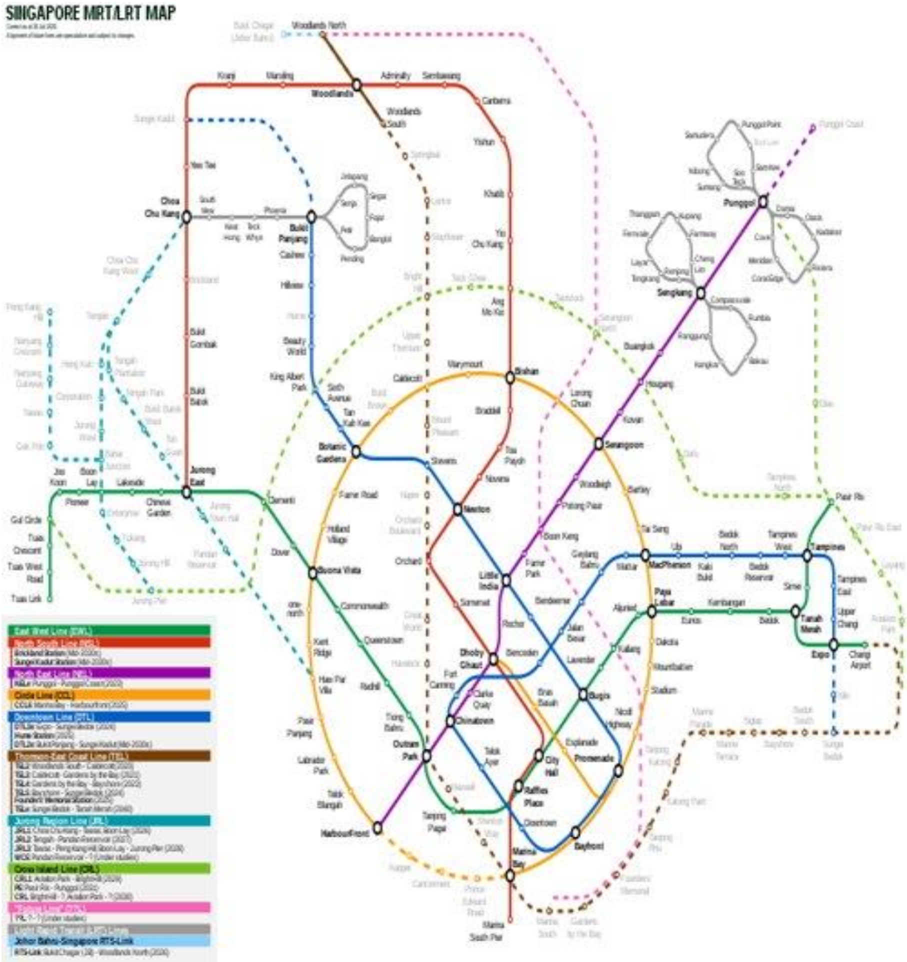


The Number of Stations and all their Networks:

This is a list of all mass rapid transit (mrt) stations in Singapore by their locations. for urban planning purpose, Singapore is officially divided into 55 planning areas by the urban redevelopment authority. this list includes operational, non-operational and confirmed future stations on the mrt network.

Some stations, such as bukit panjang and tai seng, are located on the boundaries of two or more planning areas, hence these stations will appear more than once in the list below. this takes into account the entire area of the station, both underground and above-ground sections, and not simply its above-ground features like exits (e.g., the underground segment of mountbatten station stretches across geylang and kallang planning areas, hence it will be stated as such in the list below, even when both its above-ground exits are located wholly within geylang planning area).

Downtown core has a total number of 14 stations located within and along its boundaries, making it the planning area with the greatest number of mrt stations. bedok and kallang rank second with 11 total stations.Clementi, marina east, and newton each have one station.Currently, 10 planning areas have no operational or planned mrt station - central water catchment, Changi bay, lim chu kang, mandai, north-eastern islands, paya lebar, seletar, simpang, southern islands, and western islands. however, this could change when the route of the future cross island line is fully confirmed. there will be additional mrt lines that will be announced for completion after 2031 but they are under planning.[1] the exact location of the new brickland mrt station is not yet known.If a station is partially completed, i.e. an existing station is slated to become an interchange with a future line, such a station will be listed under "operational stations". "future stations" strictly refer to those that are under construction, in various stages of planning, or completed stations that are not in service.



6. Work done and implementation

Methodology adapted:

We are working on the Singapore metro stations. We tried to apply the concept of network analysis on a network of connected railway stations, attempting to identify the important stations (nodes) in this network.

The first step we implement is to collect the data from the Wikipedia page on "List of Singapore metro stations". We take the data from the table "MRT Stations" mentioned in this Wikipedia page, which has all the details of stations involved in the mass rapid transit across Singapore. We used data scraping techniques and later we applied the data cleaning techniques to sort the required data in a proper way.

Codes Walkthrough

Installing the rvest package to scrape the list of MRT stations from wikipedia

```
install.packages("rvest")
library(rvest)

```

```
> library(rvest)
Loading required package: xml2
```

Before we can scrape the MRT stations data, we would need to ascertain the correct [XPath](#) to use.

1. navigate to the [wikipedia page](#) and fire up the developer tool
2. copy the table XPath

Now we are ready to do some real and dirty work, scraping and cleaning the data!

Data Scraping

```
> url <- "https://en.wikipedia.org/wiki/List_of_Singapore_MRT_stations"
> mrt_stn <-  url %>%
+     read_html() %>%
+     #paste the copied xpath: html_nodes(xpath here)
+     html_nodes(xpath='//*[@id="mw-content-text"]/div[1]/table[2]') %>%
+     html_table(fill = TRUE)
>
> mrt <- mrt_stn[[1]]
```

Data Cleaning

```
> mrt <- mrt[,c(1:3,6,8:9)]
> names(mrt) <- c("Code","Name","Opening","Status","Location")
>
> mrt <- subset(mrt,Code != Name)
>
> mrt <- mrt[2:nrow(mrt),]
>
> mrt$Code <- substr(mrt$Code, 1, 4)
> mrt$Code <- iconv(mrt$Code, "ASCII", "UTF-8", sub="")
> mrt$Name <- gsub('\\[.\\]',"",mrt$Name)
> mrt <- mrt[mrt$Name != 'Reserved Station',]
> mrt <- mrt[mrt$Name != 'Punggol Coast',]
> mrt <- mrt[mrt$Status != 'TBA',]
```

Generating the MRT network's edge list

After, these data cleaning techniques are applied, we get the readable data. Now, we exclude the data that is not required for our study and collect the data that is required for our analysis.

There are different lines in the Singapore metro station network:

- North-south line (NSL line)
- East-West line (ESL line)

 Changi-Airport Branch line (CAL line)

 North-east line (NAL line) Circle line (CCL line)

 Downtown line (DTL line)

We collect only the required data i.e., the source, target and network line name from the cleaned data that we generated. So, the mrt edge list is ready. Similarly, we create another node list, which has details regarding each node. This node list has the following details regarding each node:

 Code – This indicates which line it belongs to.

 Id – This column has the names of the stations(nodes).

 It has other values like opening, status, location and label.

i. preparing the North-South Line (NSL) edge list

```
> ns_df <- mrt[substr(mrt$Code,1,2) == 'NS',]
>
> sourceList <- ""
> targetList <- ""
> for (i in 1:nrow(ns_df)-1) {
+     sourceList[i] <- ns_df$Name[i]
+     targetList[i] <- ns_df$Name[i+1]
+ }
>
> ns_edgelist <- data.frame(sourceList, targetList, "NSL")
> names(ns_edgelist) <- c("source", "target", "network")
```

ii. preparing the East-West Line (EWL) edge list

```
> ew_df <- mrt[substr(mrt$Code,1,2) == 'EW',]
>
> sourceList <- ""
> targetList <- ""
> for (i in 1:nrow(ew_df)-1) {
+     sourceList[i] <- ew_df$Name[i]
+     targetList[i] <- ew_df$Name[i+1]
+ }
>
> ew_edgelist <- data.frame(sourceList, targetList, "EWL")
> names(ew_edgelist) <- c("source", "target", "network")
```

iii. preparing the Changi Airport Branch Line (CAL) edge list

```
> cg_df <- mrt[substr(mrt$Code,1,2) == 'CG',]
>
> sourceList <- ""
> targetList <- ""
> for (i in 1:nrow(cg_df)-1) {
+     sourceList[i] <- cg_df$Name[i]
+     targetList[i] <- cg_df$Name[i+1]
+ }
>
> cg_edgelist <- data.frame(sourceList, targetList, "CAL")
> names(cg_edgelist) <- c("source", "target", "network")
>
```

iv. preparing the North-East Line (NEL) edge list

```
> ne_df <- mrt[substr(mrt$Code,1,2) == 'NE',]
>
> sourceList <- ""
> targetList <- ""
> for (i in 1:nrow(ne_df)-1) {
+     sourceList[i] <- ne_df$Name[i]
+     targetList[i] <- ne_df$Name[i+1]
+ }
>
> ne_edgelist <- data.frame(sourceList, targetList, "NEL")
> names(ne_edgelist) <- c("source", "target", "network")
>
```

v. preparing the Circle Line (CCL) edge list

```
> cc_df <- mrt[substr(mrt$Code,1,2) == 'CC',]
>
> sourceList <- ""
> targetList <- ""
> for (i in 1:nrow(cc_df)-1) {
+     sourceList[i] <- cc_df$Name[i]
+     targetList[i] <- cc_df$Name[i+1]
+ }
>
> cc_edgelist <- data.frame(sourceList, targetList, "CCL")
> names(cc_edgelist) <- c("source", "target", "network")
> dt_df <- mrt[substr(mrt$Code,1,2) == 'DT',]
```

vi. preparing the Downtown Line (DTL) edge list

```
> dt_df <- mrt[substr(mrt$Code,1,2) == 'DT',]
>
> sourceList <- ""
> targetList <- ""
> for (i in 1:nrow(dt_df)-1) {
+     sourceList[i] <- dt_df$Name[i]
+     targetList[i] <- dt_df$Name[i+1]
+ }
>
> dt_edgelist <- data.frame(sourceList, targetList, "DTL")
> names(dt_edgelist) <- c("source", "target", "network")
> mrt_edgelist <- rbind(ns_edgelist,ew_edgelist,cg_edgelist,ne_edgelist,cc_edgelist,dt
_edgelist)
> mrt_edgelist
```

Console | Terminal | Jobs

~/

```
                          source                          target network
1                    Jurong East                     Bukit Batok     NSL
2                    Bukit Batok                    Bukit Gombak     NSL
3                   Bukit Gombak                   Choa Chu Kang     NSL
4                  Choa Chu Kang                        Yew Tee     NSL
5                        Yew Tee                         Kranji     NSL
6                         Kranji                      Marsiling     NSL
7                      Marsiling                      Woodlands     NSL
8                      Woodlands                      Admiralty     NSL
9                      Admiralty                      Sembawang     NSL
10                     Sembawang                       Canberra     NSL
11                      Canberra                         Yishun     NSL
12                        Yishun                         Khatib     NSL
13                        Khatib                   Yio Chu Kang     NSL
14                  Yio Chu Kang                     Ang Mo Kio     NSL
15                    Ang Mo Kio                         Bishan     NSL
16                        Bishan                       Braddell     NSL
17                      Braddell                      Toa Payoh     NSL
18                     Toa Payoh                         Novena     NSL
19                        Novena                         Newton     NSL
20                        Newton                        Orchard     NSL
```

21	Orchard	Somerset	NSL
22	Somerset	Dhoby Ghaut	NSL
23	Dhoby Ghaut	City Hall	NSL
24	City Hall	Raffles Place	NSL
25	Raffles Place	Marina Bay	NSL
26	Marina Bay	Marina South Pier	NSL
27	Marina South Pier	Orchard	NSL
28	Orchard	Marina Bay	NSL
29	Marina Bay	Choa Chu Kang	NSL
30	Choa Chu Kang	Jurong East	NSL
31	Jurong East	Ang Mo Kio	NSL
32	Pasir Ris	Tampines	EWL
33	Tampines	Simei	EWL
34	Simei	Tanah Merah	EWL
35	Tanah Merah	Bedok	EWL
36	Bedok	Kembangan	EWL
37	Kembangan	Eunos	EWL
38	Eunos	Paya Lebar	EWL
39	Paya Lebar	Aljunied	EWL
40	Aljunied	Kallang	EWL
41	Kallang	Lavender	EWL
42	Lavender	Bugis	EWL
43	Bugis	City Hall	EWL
44	City Hall	Raffles Place	EWL
45	Raffles Place	Tanjong Pagar	EWL
46	Tanjong Pagar	Outram Park	EWL
47	Outram Park	Tiong Bahru	EWL
48	Tiong Bahru	Redhill	EWL
49	Redhill	Queenstown	EWL
50	Queenstown	Commonwealth	EWL
51	Commonwealth	Buona Vista	EWL
52	Buona Vista	Dover	EWL
53	Dover	Clementi	EWL
54	Clementi	Jurong East	EWL
55	Jurong East	Chinese Garden	EWL
56	Chinese Garden	Lakeside	EWL
57	Lakeside	Boon Lay	EWL
58	Boon Lay	Pioneer	EWL
59	Pioneer	Joo Koon	EWL
60	Joo Koon	Gul Circle	EWL
61	Gul Circle	Tuas Crescent	EWL
62	Tuas Crescent	Tuas West Road	EWL
63	Tuas West Road	Tuas Link	EWL
64	Tuas Link	Outram Park	EWL
65	Outram Park	Tanah Merah	EWL
66	Tanah Merah	Boon Lay	EWL
67	Boon Lay	Pasir Ris	EWL
68	Expo	Changi Airport	CAL
69	Changi Airport	Changi Airport	CAL
70	Changi Airport	Expo	CAL
71	HarbourFront	Outram Park	NEL
72	Outram Park	Chinatown	NEL
73	Chinatown	Clarke Quay	NEL
74	Clarke Quay	Dhoby Ghaut	NEL
75	Dhoby Ghaut	Little India	NEL
76	Little India	Farrer Park	NEL
77	Farrer Park	Boon Keng	NEL
78	Boon Keng	Potong Pasir	NEL
79	Potong Pasir	Woodleigh	NEL
80	Woodleigh	Serangoon	NEL

81	Serangoon	Kovan	NEL
82	Kovan	Hougang	NEL
83	Hougang	Buangkok	NEL
84	Buangkok	Sengkang	NEL
85	Sengkang	Punggol	NEL
86	Punggol	Hougang	NEL
87	Hougang	Punggol	NEL
88	Dhoby Ghaut	Bras Basah	CCL
89	Bras Basah	Esplanade	CCL
90	Esplanade	Promenade	CCL
91	Promenade	Nicoll Highway	CCL
92	Nicoll Highway	Stadium	CCL
93	Stadium	Mountbatten	CCL
94	Mountbatten	Dakota	CCL
95	Dakota	Paya Lebar	CCL
96	Paya Lebar	MacPherson	CCL
97	MacPherson	Tai Seng	CCL
98	Tai Seng	Bartley	CCL
99	Bartley	Serangoon	CCL
100	Serangoon	Lorong Chuan	CCL
101	Lorong Chuan	Bishan	CCL
102	Bishan	Marymount	CCL
103	Marymount	Caldecott	CCL
104	Caldecott	Botanic Gardens • Kebun Bunga	CCL
105	Botanic Gardens • Kebun Bunga	Farrer Road	CCL
106	Farrer Road	Holland Village	CCL
107	Holland Village	Buona Vista	CCL
108	Buona Vista	one-north	CCL
109	one-north	Kent Ridge	CCL
110	Kent Ridge	Haw Par Villa	CCL
111	Haw Par Villa	Pasir Panjang	CCL
112	Pasir Panjang	Labrador Park	CCL
113	Labrador Park	Telok Blangah	CCL
114	Telok Blangah	HarbourFront	CCL
115	HarbourFront	Caldecott	CCL
116	Bukit Panjang	Cashew	DTL
117	Cashew	Hillview	DTL
118	Hillview	Beauty World	DTL
119	Beauty World	King Albert Park	DTL
120	King Albert Park	Sixth Avenue	DTL
121	Sixth Avenue	Tan Kah Kee	DTL
122	Tan Kah Kee	Botanic Gardens • Kebun Bunga	DTL
123	Botanic Gardens • Kebun Bunga	Stevens	DTL
124	Stevens	Newton	DTL
125	Newton	Little India	DTL
126	Little India	Rochor	DTL
127	Rochor	Bugis	DTL
128	Bugis	Promenade	DTL
129	Promenade	Bayfront	DTL
130	Bayfront	Downtown	DTL
131	Downtown	Telok Ayer	DTL
132	Telok Ayer	Chinatown	DTL
133	Chinatown	Fort Canning	DTL
134	Fort Canning	Bencoolen	DTL
135	Bencoolen	Jalan Besar	DTL
136	Jalan Besar	Bendemeer	DTL
137	Bendemeer	Geylang Bahru	DTL
138	Geylang Bahru	Mattar	DTL
139	Mattar	MacPherson	DTL
140	MacPherson	Ubi	DTL

```
141                     Ubi          Kaki Bukit     DTL
142              Kaki Bukit         Bedok North     DTL
143             Bedok North     Bedok Reservoir     DTL
144         Bedok Reservoir       Tampines West     DTL
145           Tampines West            Tampines     DTL
146                Tampines       Tampines East     DTL
147           Tampines East        Upper Changi     DTL
148            Upper Changi                Expo     DTL
149                    Expo             Stevens     DTL
> |
```

Closing the loop for the graph network

```
> mrt_edgelist$target <- as.character(mrt_edgelist$target)
> mrt_edgelist$source <- as.character(mrt_edgelist$source)
> mrt_edgelist$network <- as.character(mrt_edgelist$network)
> mrt_edgelist[nrow(mrt_edgelist)+1,] <- c("Bayfront","Marina Bay","CEL")
> mrt_edgelist[nrow(mrt_edgelist)+1,] <- c("Bayfront","Promenade","CCL")
> mrt_edgelist[nrow(mrt_edgelist)+1,] <- c("Tanah Merah","Expo","CAL")
```

Specifying this network to be an undirected graph network

```
> mrt_edgelist$type <- "undirected"
```

Exporting the mrt edge list to csv

```
> write.csv(mrt_edgelist, file="mrt_edgelist1.csv", row.names=F)
```

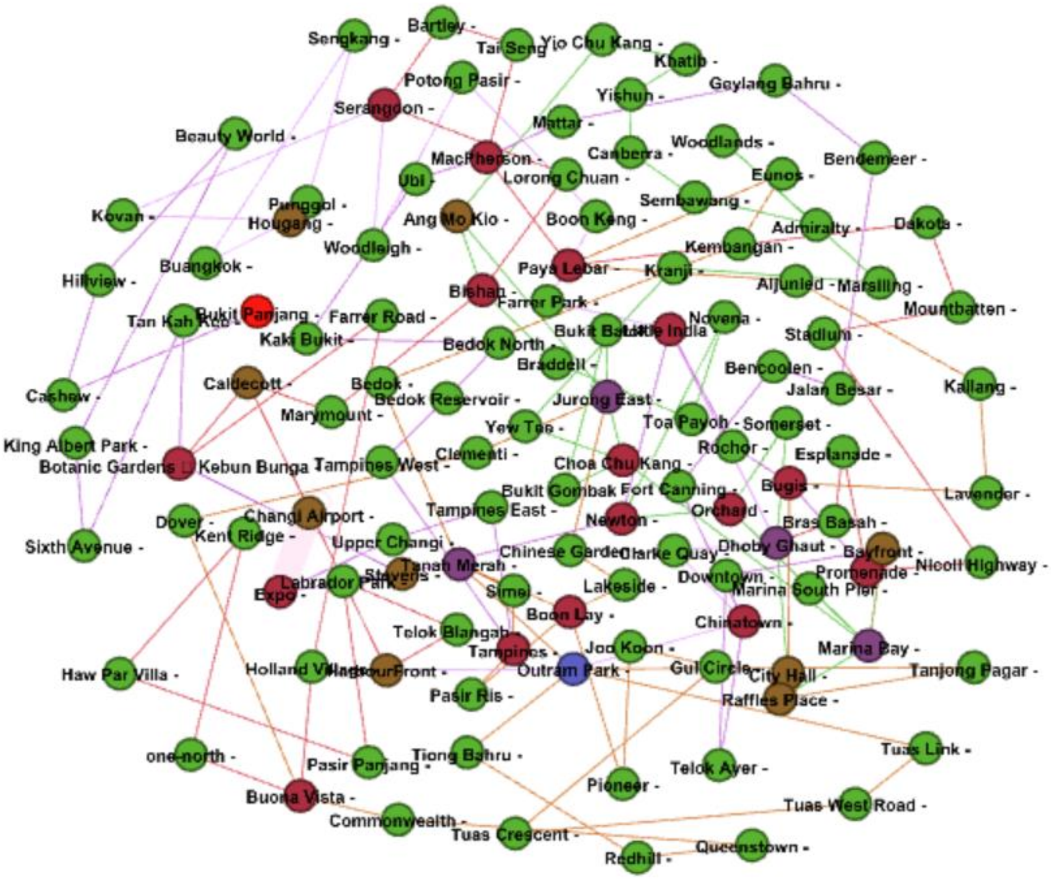
Generating the MRT network's node list

```
> mrt_node <- mrt[substr(mrt$Code,1,2) != 'TE',]
> names(mrt_node)[2] <- "id"
> mrt_node$label <- mrt_node$id
> # removing duplicated mrt names/nodes (nodes in a network should be unique)
> mrt_nodes <- unique(mrt_node)
> mrt_nodes <- mrt_nodes[!duplicated(mrt_nodes$id),]
> mrt_nodes$Code <- substr(mrt_nodes$Code, 1, 2)
```

Exporting the mrt nodes to csv

```
> write.csv(mrt_nodes, file="mrt_nodes1.csv", row.names=F)
```

Visualisation of the MRT network using Gephi



Visualisation of the MRT network using R igraph package

```
> install.packages("igraph")
WARNING: Rtools is required to build R packages but is not currently installed. Please
 download and install the appropriate version of Rtools before proceeding:

https://cran.rstudio.com/bin/windows/Rtools/
Installing package into 'C:/Users/Vyshnavi/Documents/R/win-library/4.0'
(as 'lib' is unspecified)
trying URL 'https://cran.rstudio.com/bin/windows/contrib/4.0/igraph_1.2.6.zip'
Content type 'application/zip' length 9345285 bytes (8.9 MB)
downloaded 8.9 MB

package 'igraph' successfully unpacked and MD5 sums checked

The downloaded binary packages are in
        C:\Users\Vyshnavi\AppData\Local\Temp\Rtmp44oev8\downloaded_packages
> library(igraph)

Attaching package: 'igraph'

The following objects are masked from 'package:stats':

    decompose, spectrum

The following object is masked from 'package:base':

    union
```

```
> # renaming for igraph edgelist format
> names(mrt_edgelist) <- c("from","to","network","type")
> # rearranging for igraph nodelist format
> mrt_nodes <- mrt_nodes[c(2,6,1,3,4,5)]
```

Setting up the graph network

```
> g = graph.data.frame(mrt_edgelist, mrt_nodes, directed=F)
> # Removing self loops
> g = simplify(g, remove.loops = T)
```

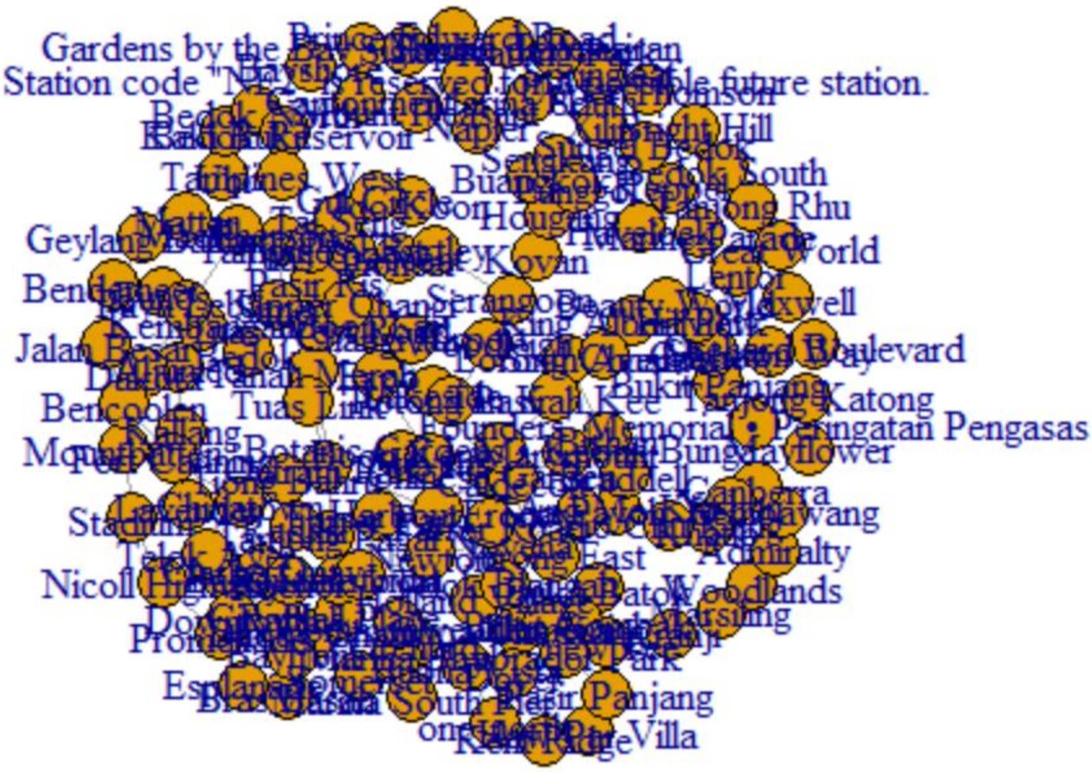
Checking if multiple edges exists in the graph network

```
> any_multiple(g)
[1] FALSE
```

```
> which_multiple(g)
  [1] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
 [14] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
 [27] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
 [40] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
 [53] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
 [66] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
 [79] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
 [92] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
[105] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
[118] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
[131] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
[144] FALSE FALSE FALSE FALSE
> count_multiple(g)
  [1] 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
 [41] 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
 [81] 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
[121] 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
> which_multiple(simplify(g))
  [1] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
 [14] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
 [27] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
 [40] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
 [53] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
 [66] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
 [79] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
 [92] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
[105] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
[118] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
[131] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE
[144] FALSE FALSE FALSE FALSE
> all(count_multiple(simplify(g)) == 1)
[1] TRUE
> simple_g <- g
> any_multiple(simple_g)
[1] FALSE
```

Displaying descriptive statistics of the graph network

```
> V(simple_g)
+ 149/149 vertices, named, from 42d64e0:
  [1] Jurong East
  [2] Bukit Batok
  [3] Bukit Gombak
  [4] Choa Chu Kang
  [5] Yew Tee
  [6] Kranji
  [7] Marsiling
  [8] Woodlands
  [9] Admiralty
 [10] Sembawang
+ ... omitted several vertices
> E(simple_g)
+ 147/147 edges from 42d64e0 (vertex names):
 [1] Jurong East  --Bukit Batok    Jurong East  --Choa Chu Kang
 [3] Jurong East  --Ang Mo Kio     Jurong East  --Clementi
 [5] Jurong East  --Chinese Garden Bukit Batok  --Bukit Gombak
 [7] Bukit Gombak --Choa Chu Kang  Choa Chu Kang--Yew Tee
 [9] Choa Chu Kang--Marina Bay     Yew Tee      --Kranji
[11] Kranji       --Marsiling      Marsiling    --Woodlands
[13] Woodlands    --Admiralty      Admiralty    --Sembawang
[15] Sembawang    --Canberra       Canberra     --Yishun
[17] Yishun       --Khatib         Khatib       --Yio Chu Kang
[19] Yio Chu Kang --Ang Mo Kio     Ang Mo Kio   --Bishan
+ ... omitted several edges
> plot(simple_g)
```




```
> # Network Density
> graph.density(simple_g,loop=FALSE)
[1] 0.01333212
> # greatest distance between any pair of vertices
> diameter(simple_g)
[1] 17
> # Average Path Length
> mean_distance(simple_g, directed=F)
[1] 6.776751
```

HTML Report

Graph Distance Report

Parameters:

Network Interpretation: undirected

Results:

Diameter: 17
Radius: 9
Average Path length: 6.776750700280112

Degree centrality

```
> #Degree Centrality
> V(simple_g)$degree=degree(simple_g, mode="all")
```

Betweenness centrality

```
> #Betweeness Centrality
> V(simple_g)$betweenness=betweenness(simple_g,normalized=T)
```

Closeness centrality

```
> #Closeness Centrality
> V(simple_g)$closeness=closeness(simple_g, normalized=T)
```

Eigen vector centrality

```
> #Eigenvector Centrality
> V(simple_g)$eigen=evcent(simple_g)$vector
```

Maximum Degree Centrality

Degree centrality measures how connected an entity is by counting the number of direct links each entity has to others in the network.

```
> #Degree
> V(simple_g)$name[degree(simple_g)==max(degree(simple_g))]
[1] "Outram Park"
```

Maximum Closeness Centrality

Closeness centrality measures the proximity of an entity to the other entities in the social network.

```
> #Closeness
> V(simple_g)$name[closeness(simple_g)==max(closeness(simple_g))]
[1] "Outram Park"
```

Maximum Eigenvector centrality

Eigenvector measures how connected an entity is and how much direct influence it might have over other connected entities in the network.

```
> #EigenVector
> V(simple_g)$name[which.max(V(simple_g)$eigen)]
[1] "Marina Bay"
```

Maximum Betweenness Centrality

Betweenness centrality measures the number of paths that pass through each entity.

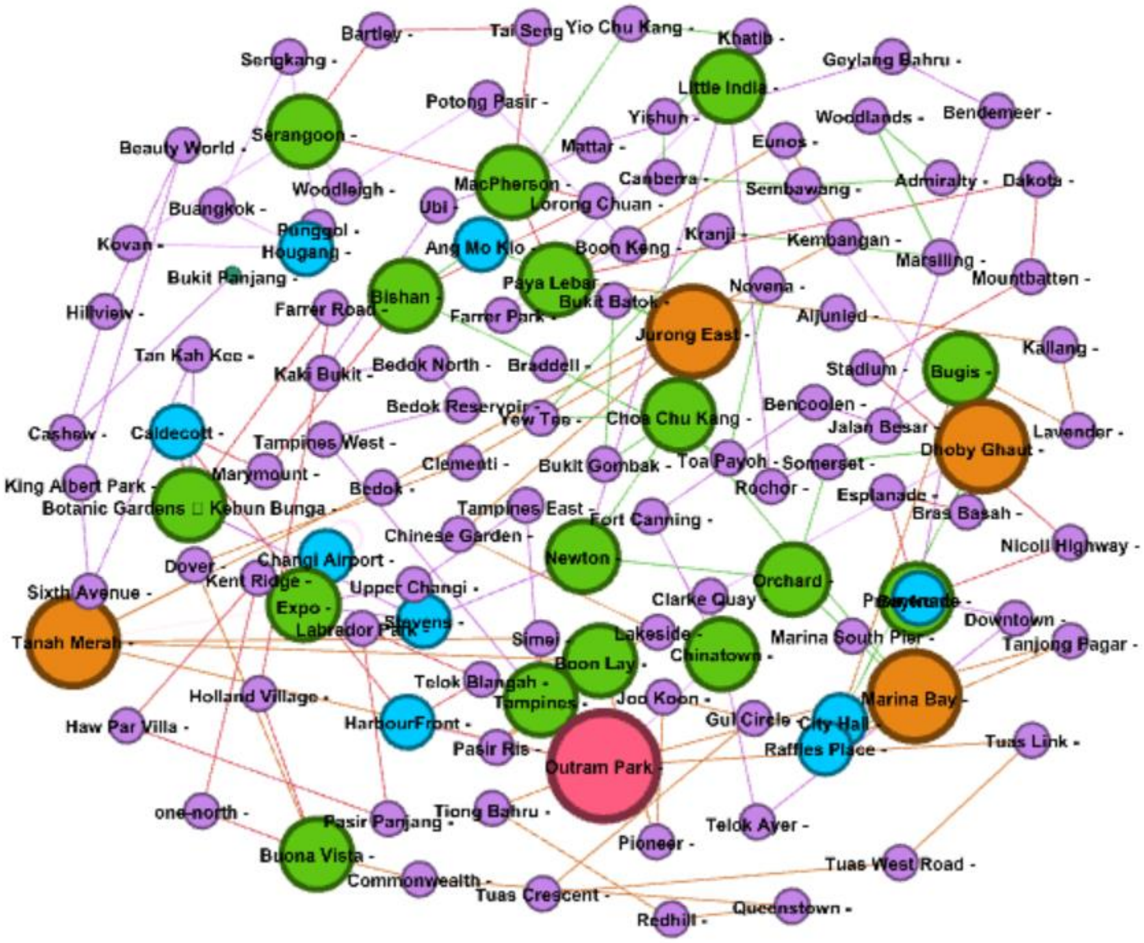
```
> #Betweeness
> V(simple_g)$name[betweenness(simple_g)==max(betweenness(simple_g))]
[1] "Outram Park"
```

Attributes Dataframes

```
> attr = data.frame(row.names=V(simple_g)$name,degree=V(simple_g)$degree,
+                  betweenness=V(simple_g)$betweenness,
+                  closeness=V(simple_g)$closeness,eigen=V(simple_g)$eigen)

> table(attr$degree)

 0  1  2  3  4  5  6 
29  2 89  8 16  4  1 
```



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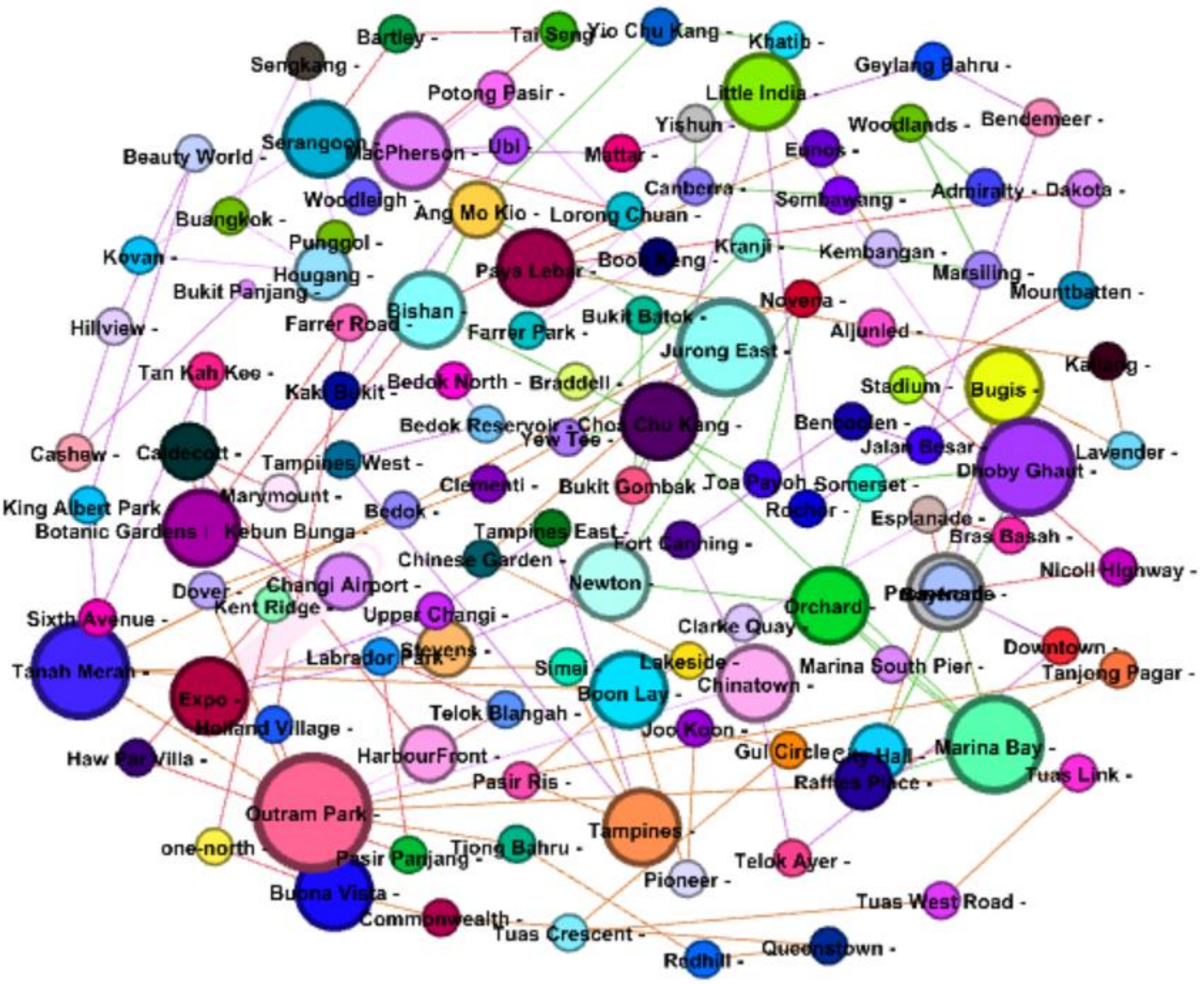
Pasir Panjang
Pioneer
Buona Vista
Tuas West Road
Commonwealth
Tuas Crescent
Queenstown
Redhill

```
> table(attr$betweenness)

                  0 4.59643316786174e-05   0.0016700373843231  0.00192437335294478 
                 32                    1                    1                    1 
 0.00235184163755592  0.00238248452534167  0.00375703692030223  0.00389930747073604 
                   1                    1                    1                    1 
  0.0045045045045045  0.00517864803579089  0.00521695164552307  0.00537782680639824 
                   1                    1                    1                    2 
 0.00555402341116627  0.00577312005883435  0.00664184592756021  0.00720720720720721 
                   1                    1                    1                    1 
 0.00720873935159649  0.00896304467733039  0.00961880247594533  0.00971160665038216 
                   1                    1                    1                    1 
  0.0100287605389646   0.0102546423974995   0.0104461604461604   0.0106100998958142 
                   1                    1                    1                    1 
  0.0106621928050499   0.0108475822761537   0.0112980327266042   0.0114276083663839 
                   1                    1                    1                    1 
  0.0114650364650365   0.0117423545994975   0.0117745296316725   0.0118204939633511 
                   1                    1                    1                    1 
  0.0118826552500022   0.0119430655144941    0.012156033584605   0.0121621621621622 
                   1                    1                    1                    1 
  0.0130011206541819   0.0136590672304958   0.0139333210761782   0.0143025678739964 
                   1                    1                    1                    1 
  0.0145343594323186   0.0148342219770791   0.0149664241500976   0.0150741120128875 
                   1                    1                    1                    1 
  0.0155681191395477   0.0158347122632837   0.0161610590182019   0.0162070233498805 
                   1                    1                    1                    1 
  0.0162845060804244   0.0171508242936814    0.017306446388079   0.0174128209842496 
                   1                    1                    1                    1 
  0.0198846076397097   0.0204464668750383   0.0205077526506098   0.0215113072255929 
                   1                    1                    1                    1 
  0.0216568609425752   0.0220567506281792    0.022119568548814   0.0226711405282834 
                   1                    1                    1                    1 
  0.0228114411787881   0.0229799770616097   0.0230344776263144    0.023447937733652 
                   1                    1                    1                    1 
  0.0245066495066495   0.0249555678127107   0.0265459336887908   0.0301142979714408 
                   1                    1                    1                    1 
  0.0302828338542624   0.0307326276714032   0.0314932279217993   0.0319467426610284 
                   1                    1                    1                    1 
  0.0319911748483177   0.0320371391799963    0.032123814776876   0.0333777655206227 
                   1                    1                    1                    1 
  0.0336489550775265   0.0355242998100141   0.0356851749708893   0.0358000858000858 
                   1                    1                    1                    1 
  0.0362835867937909   0.0375775921694289   0.0379588772445915   0.0382458260009281 
                   1                    1                    1                    1 
  0.0384767420481706   0.0396628406832489   0.0401192008334866   0.0409894588466017 
                   1                    1                    1                    1 

  0.0412363529710469   0.0413295949010235   0.0421516998047611    0.042287185144328 
                   1                    1                    1                    2 
  0.0430832435934477   0.0523993381136238   0.0549019865346396   0.0563507384935956 
                   1                    1                    1                    1 
   0.057635551002898   0.0612603857501817   0.0623276337562052   0.0634935956364527 
                   1                    1                    1                    1 
  0.0647232509477407   0.0715995149668619   0.0772353986639701   0.0781640970416481 
                   1                    1                    1                    1 
  0.0801909051909052   0.0804100018385733   0.0917135065094249    0.091764723907581 
                   1                    1                    1                    1 
  0.0940119419711256   0.0971685971685972   0.0973478580621437    0.107047864190721 
                   1                    1                    1                    1 
   0.108566219280505    0.113032420175277    0.120084224165857    0.155558619844334 
                   1                    1                    1                    1 
```



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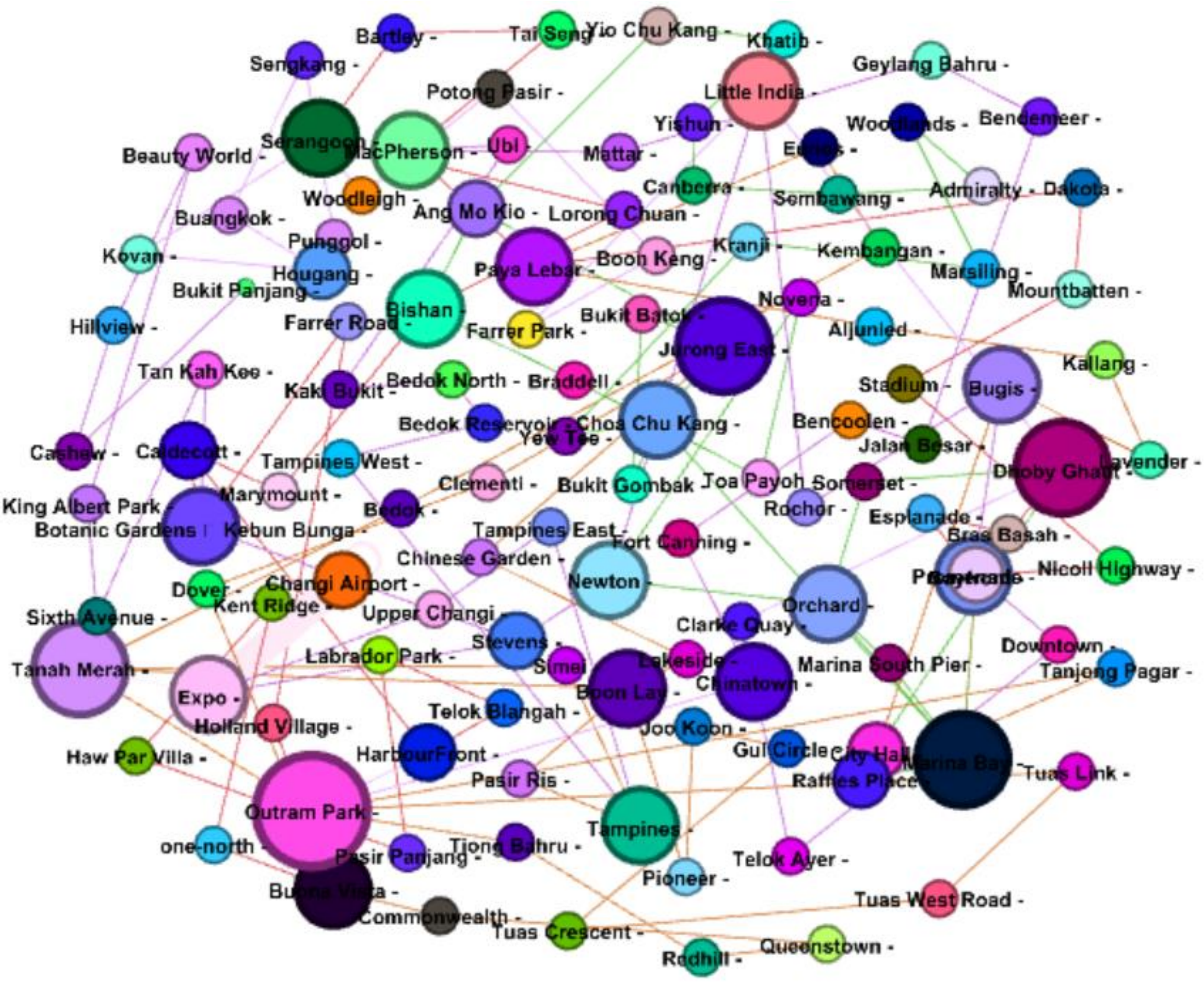
```
> table(attr$closeness)

4.53473607836024e-05 0.000174520069808028 0.000178189593727726 0.000181225081551287
                  29                    1                    1                    1
0.000181950509461427 0.000182315405651778  0.00018254837531946 0.000185048112509252
                   1                    1                    1                    1
0.000185116623472788 0.000185459940652819 0.000185804533630621  0.00018828845791753
                   2                    1                    1                    2
0.000188572506128606 0.000188786105342647 0.000189035916824197 0.000189178963299281
                   1                    1                    1                    1
0.000189214758751183 0.000189250567751703 0.000189753320683112 0.000189933523266857
                   1                    1                    1                    1
0.000189969604863222 0.000190585096245474 0.000190621425848265 0.000190912562046583
                   1                    1                    1                    1
 0.00019105846388995 0.000191204588910134 0.000191314329443275 0.000191681042744873
                   1                    1                    1                    1
0.000191901746305891  0.00019208605455244 0.000192566917003659 0.000192678227360308
                   1                    1                    1                    1
0.000192752505782575 0.000193124758594052 0.000193274062620796 0.000193423597678917
                   1                    1                    1                    2
0.000193685841564982 0.000193760899050572 0.000193798449612403  0.00019387359441644
                   2                    1                    1                    1
0.000194024058983314 0.000194325689856199 0.000194363459669582 0.000194552529182879
                   1                    1                    1                    1
0.000195236235845373 0.000195427008012507  0.00019546520719312 0.000195618153364632
                   1                    1                    1                    2
0.000195771339075959  0.00019588638589618 0.000196001568012544 0.000196425063838146
                   1                    1                    1                    2
0.000196734212079481 0.000196850393700787 0.000196966712625566 0.000197199763360284
                   2                    1                    1                    1
 0.00019723865877712 0.000197316495659037 0.000197355437142293  0.00019739439399921
                   1                    1                    1                    1
0.000197472353870458 0.000197511356903022 0.000197667523225934 0.000197706603400554
                   1                    1                    1                    1
0.000197863078749505 0.000197941409342835 0.000198059021588433 0.000198176773682124
                   1                    1                    1                    1
0.000198216055500496 0.000198333994446648 0.000198412698412698 0.000198609731876862
                   2                    1                    1                    1
0.000198925800676348 0.000198965380023876 0.000199084212621939 0.000199163513244374
                   1                    2                    1                    1
0.000199322304165836 0.000199760287654814 0.000199840127897682 0.000199920031987205
                   2                    1                    1                    1
  0.0001999600079984 0.000200280392549569 0.000200601805416249 0.000200803212851406
                   2                    2                    1                    1
 0.00020096463022508 0.000201005025125628 0.000201207243460765  0.00020124773596297
                   1                    1                    1                    1
 0.00020096463022508 0.000201005025125628 0.000201207243460765  0.00020124773596297
                   1                    1                    1                    1
0.000201369311316955 0.000201450443190975 0.000201572263656521  0.00020185708518369
                   1                    1                    1                    2
0.000202061022428773 0.000202183582693085 0.000202224469160768 0.000202388180530257
                   1                    1                    1                    1
0.000202470135654991 0.000202511138112596  0.00020259319286872 0.000202963263649279
                   1                    1                    1                    1
0.000203086921202275 0.000203541624262162 0.000204498977505112
                   1                    1                    1
```



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Promenade -
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Pioneer -
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Commonwealth -
Tuas Crescent -
Redhill -
Queenstown -

```
> table(attr$eigen)

7.30604920606494e-18 0.000154881507965341 0.000494614475258369   0.0010401857695776
                  29                    1                    1                    1
  0.0014246710309335   0.0016609179021745 6 0.0016609179021745 7   0.0021338046210212 5
                   1                    1                    1                    1
 0.00331085798972081  0.00350345229686652  0.00405507595349635  0.00426395962146019
                   1                    1                    1                    1
 0.00458357598805216  0.00480230027724479  0.00653352324436609  0.00660201365342882
                   1                    1                    1                    1
 0.00734282818803907  0.00762510297197871  0.00810413790653631  0.00843942848313553
                   1                    1                    1                    1
 0.00873414405104212  0.00876318223778098  0.00905447887499985   0.0102951296965518
                   1                    1                    1                    1
  0.0115252239644098   0.0117039974477907   0.0158242368417344   0.0162812465046619
                   1                    1                    1                    1
  0.0164623656360214   0.0170079568399616   0.0185297442436664   0.0212970082774384
                   1                    1                    1                    1
  0.0224771235254446   0.0230902101546933   0.0236404775538424   0.0254120481804312
                   1                    1                    1                    1
  0.0260928543668846    0.026621148930521   0.0286135622949502   0.0290523128656054
                   1                    1                    1                    1
  0.0300954814778261   0.0305612213583995   0.0327507550219344   0.0343140688487249
                   1                    1                    1                    1
  0.0381392495875336   0.0383248554724156   0.0431919109468019   0.0449591400608149
                   1                    1                    1                    1
  0.0451883447793734   0.0466898488781656   0.0508486099247228   0.0553183834276055
                   1                    1                    1                    1
  0.0599079102204517   0.0605159009848361   0.0626831508575472   0.0650044986655938
                   1                    1                    1                    1
  0.0670564945212339   0.0720989592670032   0.0729566210061339   0.0790675910613562
                   1                    1                    1                    1
  0.0794865814847264    0.093064392461044   0.0957049326594976   0.0957693709440998
                   1                    1                    1                    1
   0.096887275088277   0.0992155498639656    0.109951673656711    0.112890093450687
                   1                    1                    1                    1
   0.118216235429992    0.122109236618126    0.132199316446206    0.133771598115319
                   1                    1                    1                    1
   0.146567829224392    0.154182269520442    0.159685791577978    0.161840272991293
                   1                    1                    1                    1
   0.166629123641734    0.170019049829044    0.171126483016777    0.177621473968208
                   1                    1                    1                    1
   0.184501815641657    0.190504602036361    0.204768449403281    0.204836154933052
                   1                    1                    1                    1
   0.219526523922046    0.221941324468511    0.224597389937396    0.226743191981378
                   1                    1                    1                    1
   0.234203973112663    0.234436458282763      0.2438884806339    0.246379724159496
                   1                    1                    1                    1
   0.252410555100189    0.264450610377109    0.267494687406495     0.26751486534141
                   1                    1                    1                    1
   0.311610331920564     0.33233549278111    0.346764235448642    0.348680573059656
                   1                    1                    1                    1
   0.389459617346603    0.407548820839864    0.422178841054371    0.427828812802805
                   1                    1                    1                    1
   0.436005330798049    0.437063072143383    0.483048342077561    0.483809692039499
                   1                    1                    1                    1
   0.510321617287931    0.523333572166081    0.582045803507609    0.585257554653847
                   1                    1                    1                    1
   0.588177308990057    0.621571910658208    0.629702572544711    0.633844085302707
                   1                    1                    1                    1
   0.679642910742591    0.758540007127527    0.760691900375003    0.869021435089023
                   1                    1                    1                    1
                   1
                   1
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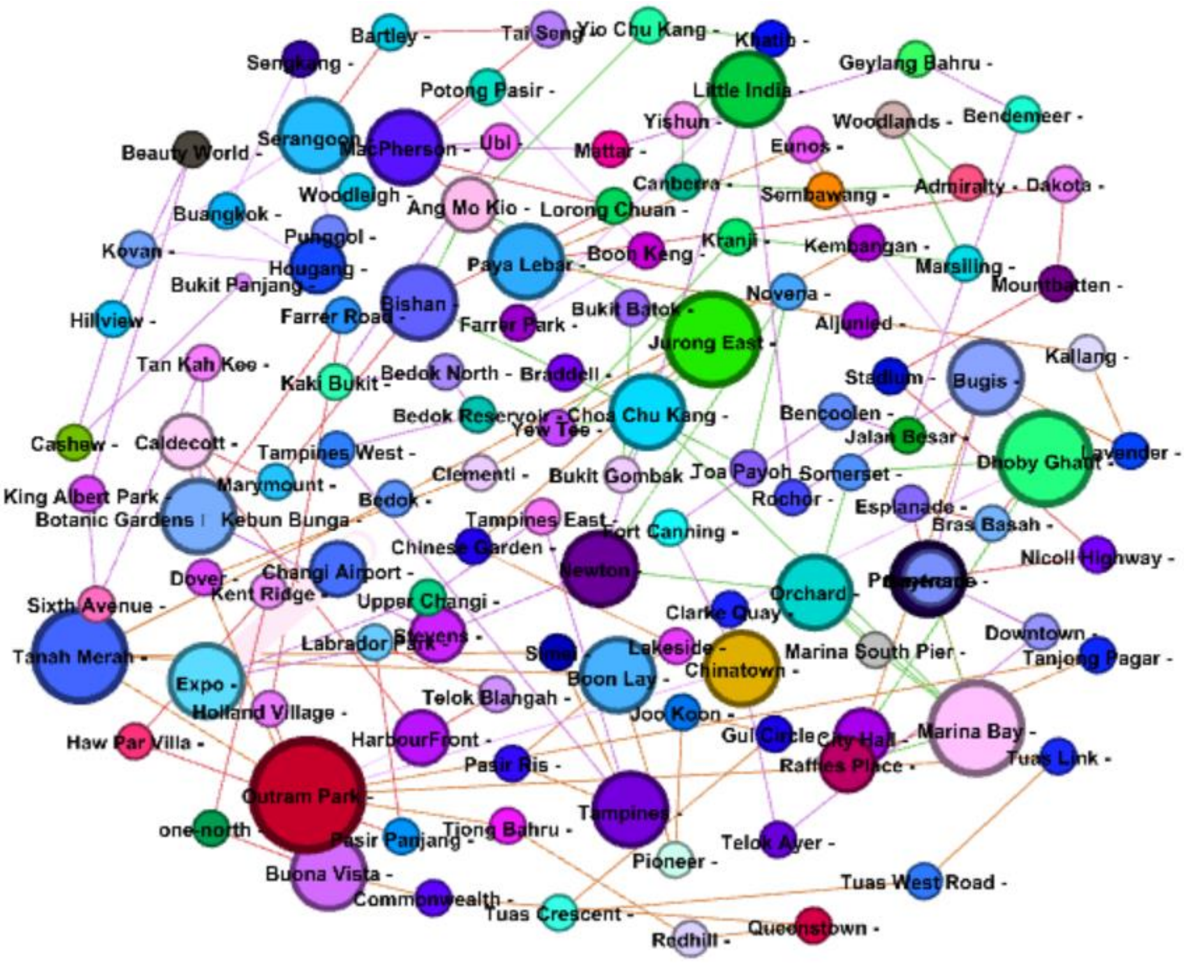
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Eunos
Canberra
Admiralty
Dakota
Woodleigh
Ang Mo Kio
Lorong Chuan
Sembawang
Buangkok
Punggol
Kranji
Kembangan
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Paya Lebar
Boon Keng
Marsiling
Bukit Panjang
Novena
Mountbatten
Hillview
Farrer Road
Bishan
Farrer Park
Bukit Batok
Aljunied
Jurong East
Tan Kah Kee
Kallang
Kaki Bukit
Bedok North
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Bencoolen
Cashew
Caldecott
Yew Tee
Jalan Besar
Tampines West
Lavender
Dhoby Ghaut
Clementi
Bukit Gombak
Toa Payoh
Somerset
Marymount
King Albert Park
Rochor
Esplanade
Bedok
Botanic Gardens
Kebun Bunga
Tampines East
Bras Basah
Fort Canning
Chinese Garden
Nicoll Highway
Dover
Changi Airport
Newton
Orchard
Kent Ridge
Sixth Avenue
Upper Changi
Clarke Quay
Downtown
Labrador Park
Stevens
Lakeside
Marina South Pier
Tanah Merah
Tanjong Pagar
Expo
Boon Lay
Chinatown
Holland Village
Telok Blangah
Joo Koon
Gul Circle
City Hall
Marina Bay
Haw Par Villa
HarbourFront
Raffles Place
Tuas Link
Pasir Ris
Outram Park
Tampines
one-north
Pasir Panjang
Tiong Bahru
Telok Ayer
Pioneer
Buona Vista
Tuas West Road
Commonwealth
Tuas Crescent
Redhill
Queenstown

Gephi 0.9.2 - sinproject.gephi

File Workspace View Tools Window Help

Overview | Data Laboratory | Preview

Workspace 1

Data Table

Nodes Edges | Configuration | Add node | Add edge | Search/Replace | Import Spreadsheet | Export table | More actions | Filter: | Id

Id	Label	Interval	Degree	Eigenvector Centrality	Closeness Centrality	Betweenness Centrality
Jurong East			5	0.628004	0.187994	1180.983333
Bukit Batok			2	0.300487	0.158879	25.583333
Bukit Gombak			2	0.304273	0.156785	20.933333
Choa Chu Kang			4	0.662906	0.18507	1057.0
Yew Tee			2	0.256273	0.158667	449.583333
Kranji			2	0.126076	0.138856	342.583333
Marsiling			2	0.088568	0.123444	235.583333
Woodlands			2	0.079178	0.111111	128.583333
Admiralty			2	0.077198	0.102852	49.0
Sembawang			2	0.077047	0.102234	42.416667
Canberra			2	0.078187	0.10988	115.416667
Yishun			2	0.083774	0.121926	222.416667
Khatib			2	0.105903	0.136939	329.416667
Yio Chu Kang			2	0.180617	0.156168	436.416667
Ang Mo Kio			3	0.402173	0.181679	998.216667
Bishan			4	0.381023	0.185938	1229.566667
Braddell			2	0.189862	0.164365	97.5
Toa Payoh			2	0.156652	0.159517	78.4
Novena			2	0.26847	0.170977	122.9
Newton			4	0.690722	0.192869	850.269048
Orchard			4	0.776443	0.181957	388.183333
Somerset			2	0.459566	0.168794	40.869048
Dhoby Ghaut			5	0.743997	0.180577	431.452381
City Hall			3	0.578163	0.179217	250.569048
Raffles Place			3	0.599121	0.18949	468.659524
Marina Bay			5	0.927122	0.192557	1022.661905
Marina South Pier			2	0.507736	0.168794	0.0
Pasir Ris			2	0.298958	0.159304	132.3
Tampines			4	0.365586	0.154545	363.083333
Simei			2	0.404249	0.170977	246.616667
Tanah Merah			5	0.910191	0.201014	1306.27619
Bedok			2	0.34094	0.177083	458.52619
Kembangan			2	0.175788	0.161465	394.692857
Eunos			2	0.182506	0.151207	349.442857
Paya Lebar			4	0.321219	0.149686	597.22381
Aljunied			2	0.175348	0.140165	158.104762
Kallang			2	0.144412	0.141667	162.804762
Lavender			2	0.225401	0.151786	216.304762
Bugis			4	0.532036	0.168555	416.038095
Tanjong Pagar			2	0.484026	0.191935	366.033333
Outram Park			6	1.0	0.209139	1692.166667
Tiong Bahru			2	0.363753	0.177083	271.466667
Redhill			2	0.16251	0.154545	176.3
Queenstown			2	0.118379	0.142174	113.633333
Commonwealth			2	0.148602	0.14133	104.633333
Buona Vista			4	0.257298	0.148564	412.916667
Dover			2	0.192784	0.152369	288.766667
Clementi			2	0.274393	0.165508	347.516667
Chinese Garden			2	0.291853	0.174743	389.433333
Lakeside			2	0.269499	0.175	386.433333
Boon Lay			4	0.543438	0.184496	690.683333
Pioneer			2	0.22155	0.157407	189.416667
Joo Koon			2	0.117799	0.137255	78.416667
Gul Circle			2	0.090647	0.126193	18.166667
Tuas Crescent			2	0.098237	0.132812	56.75
Tuas West Road			2	0.156761	0.150442	155.583333
Tuas Link			2	0.362443	0.175	266.583333
Expo			4	0.633592	0.190705	704.059524
Changi Airport			3	0.288951	0.160377	0.0
HarbourFront			3	0.507188	0.19637	874.7
Chinatown			4	0.602288	0.187994	778.859524
Clarke Quay			2	0.417289	0.173723	249.97619
Little India			4	0.64008	0.183642	626.959524
Farrer Park			2	0.249592	0.161247	255.066667
Boon Keng			2	0.130199	0.147826	186.566667
Potong Pasir			2	0.112124	0.14133	151.566667
Woodleigh			2	0.155038	0.145299	172.25
Serangoon			4	0.285872	0.160162	1058.95
Kovan			2	0.178649	0.139508	460.0
Hougang			3	0.169382	0.123316	348.5
Buangkok			2	0.114847	0.110083	58.5
Sengkang			2	0.099607	0.099415	0.5
Punggol			2	0.114847	0.110083	58.5
Bras Basah			2	0.315377	0.156168	72.25
Esplanade			2	0.261215	0.149497	25.916667
Promenade			4	0.492532	0.159732	408.769048
Nicoll Highway			2	0.209632	0.144242	188.259524
Stadium			2	0.121568	0.134463	129.259524
Mountbatten			2	0.114184	0.131347	109.092857
Dakota			2	0.167954	0.136468	141.42619
MacPherson			4	0.321529	0.144417	666.390476
Tai Seng			2	0.188725	0.142857	418.55
Bartley			2	0.179115	0.14746	445.883333

Id	Label	Interval	Degree	Eigenvector Centrality	Closeness Centrality	Betweenness Centrality
Lorong Chuan			2	0.24086	0.169516	840.166667
Marymount			2	0.263402	0.183359	612.983333
Caldecott			3	0.39918	0.193496	872.316667
Botanic Gardens � Kebun Bunga			4	0.451965	0.1904	1164.466667
Farrer Road			2	0.217102	0.165049	239.933333
Holland Village			2	0.176933	0.150442	169.35
one-north			2	0.144665	0.130913	129.916667
Kent Ridge			2	0.099222	0.120202	56.333333
Haw Par Villa			2	0.084451	0.120202	60.416667
Pasir Panjang			2	0.086112	0.129771	128.083333
Labrador Park			2	0.111356	0.145477	223.083333
Telok Blangah			2	0.20567	0.166667	327.583333
Bukit Panjang			1	0.030407	0.084457	0.0
Cashew			2	0.054312	0.092177	118.0
Hillview			2	0.068492	0.101277	234.0
Beauty World			2	0.075984	0.112158	348.0
King Albert Park			2	0.084706	0.125395	460.0
Sixth Avenue			2	0.111021	0.141836	570.0
Tan Kah Kee			2	0.196602	0.162791	678.0
Stevens			3	0.557899	0.197347	997.659524
Rochor			2	0.369458	0.164138	163.97619

Id	Label	Interval	Degree	Eigenvector Centrality	Closeness Centrality	Betweenness Centrality
King Albert Park			2	0.084706	0.125395	460.0
Sixth Avenue			2	0.111021	0.141836	570.0
Tan Kah Kee			2	0.196602	0.162791	678.0
Stevens			3	0.557899	0.197347	997.659524
Rochor			2	0.369458	0.164138	163.97619
Bayfront			3	0.519046	0.174231	448.569048
Downtown			2	0.249132	0.164365	115.983333
Telok Ayer			2	0.269599	0.17	132.233333
Fort Canning			2	0.237005	0.162347	334.309524
Bencoolen			2	0.121079	0.145299	248.142857
Jalan Besar			2	0.089019	0.133708	177.142857
Bendemeer			2	0.086471	0.126059	124.309524
Geylang Bahru			2	0.105427	0.122807	105.642857
Mattar			2	0.166431	0.128649	148.583333
Ubi			2	0.166657	0.12851	161.366667
Kaki Bukit			2	0.106592	0.121181	111.55
Bedok North			2	0.091353	0.123572	127.733333
Bedok Reservoir			2	0.105998	0.13034	175.8
Tampines West			2	0.170824	0.140165	240.616667
Tampines East			2	0.213986	0.146914	62.8
Upper Changi			2	0.271221	0.163462	124.716667

7.Results and discussion:

From the results obtained from the different centrality measures applied to the MRT network, we could often see that the station '**Outram Park'** frequently appears as one of the significant nodes suggesting that it could likely be the most important node in the MRT network.

The consequences of removing such a node might ***breaks the network into different smaller networks and reduce connectivity among the network***, seriously impairing the connectivity and coverage of the MRT services.

Id	Label	Interval	Degree	Eigenvector Centrality	Closeness Centrality	Betweenness Centrality
Somerset			2	0.459566	0.168794	40.869048
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