

# cosc421\_project

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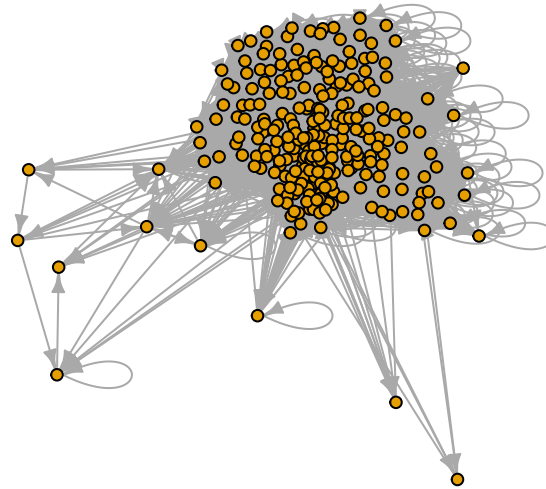
## Generate Network Graph Whole Network

```
nodes <- read.csv("Data_Nodes.csv", header = T)
edges <- read.csv("Data_Edges.csv", header = T)

graph <- graph_from_data_frame(edges, nodes, directed = T)

plot(
  graph,
  vertex.label = NA,
  vertex.size = 5,
  main = "Mobi Vancouver Bike Share Network",
  edge.arrow.size = 0.5
)
```

## Mobi Vancouver Bike Share Network



### In-Degree Whole Network

```
indeg <- degree(graph, mode = "in")
cat("In-Degree Distribution:", indeg, "\n\n")
```

```
## In-Degree Distribution: 97 105 126 156 129 150 38 144 168 108 140 177 161 62 118 141 74 122 112 145
```

```
topfive <- order(indeg, decreasing = TRUE)[1:5]
topnodes <- names(indeg)[topfive]
topvalues <- indeg[topfive]
```

```
cat("Top 5 Nodes by In-Degree:\n")
```

```
## Top 5 Nodes by In-Degree:
```

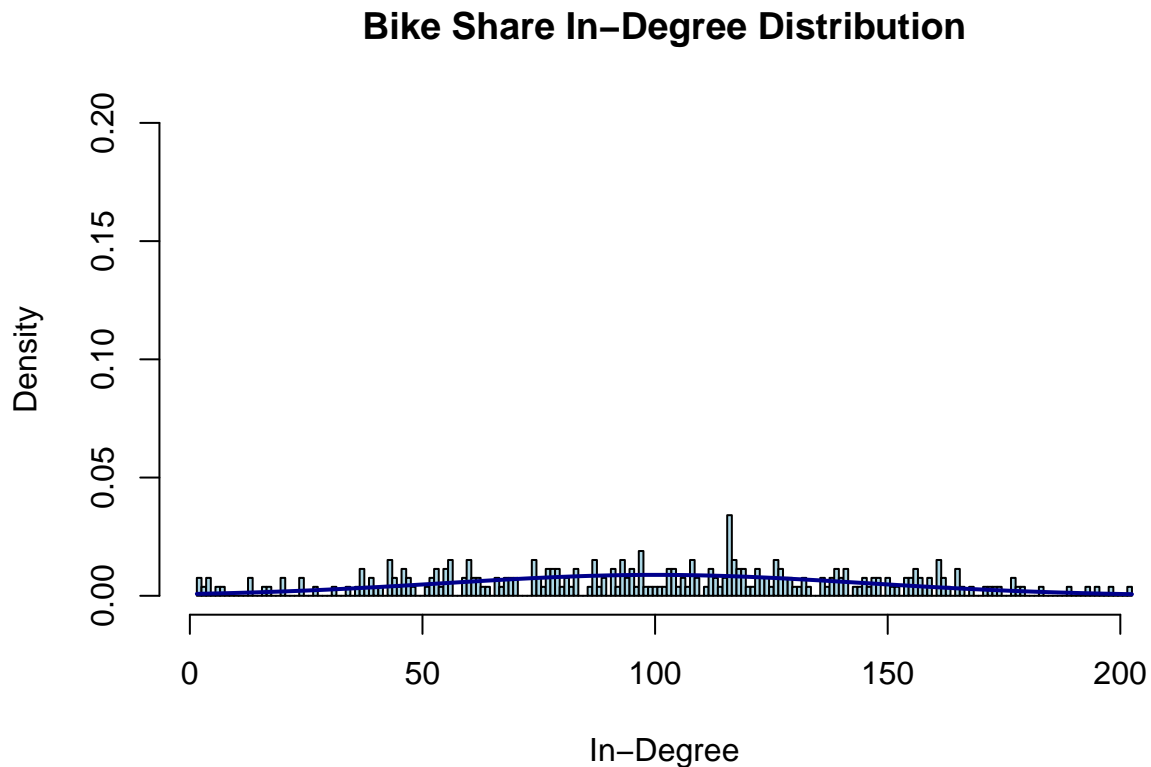
```
for (i in 1:5) {
  cat("Node:", topnodes[i], " with In-Degree:", topvalues[i], "\n")
}
```

```
## Node: 11  with In-Degree: 202
## Node: 174 with In-Degree: 198
## Node: 53  with In-Degree: 195
```

```
## Node: 189 with In-Degree: 193
## Node: 154 with In-Degree: 189
```

```
hist(
  indeg,
  breaks = seq(min(indeg) - 0.5, max(indeg) + 0.5, by = 1),
  col = "lightblue",
  border = "black",
  probability = T,
  main = "Bike Share In-Degree Distribution",
  xlab = "In-Degree",
  ylab = "Density",
  ylim = c(0, 0.2)
)

curve(dnorm(x, mean = mean(indeg), sd = sd(indeg)), col = "darkblue", lwd = 2, add = T)
```



## Out-Degree Whole Network

```
outdeg <- degree(graph, mode = "out")
cat("Out-Degree Distribution:", outdeg, "\n\n")
```

```
## Out-Degree Distribution: 98 114 146 160 120 150 42 154 152 114 123 177 136 67 144 126 100 116 131 130
```

```

topfive <- order(outdeg, decreasing = TRUE)[1:5]
topnodes <- names(outdeg)[topfive]
topvalues <- outdeg[topfive]

cat("Top 5 Nodes by Out-Degree:\n")

```

```
## Top 5 Nodes by Out-Degree:
```

```

for (i in 1:5) {
  cat("Node:", topnodes[i], " with Out-Degree:", topvalues[i], "\n")
}

```

```

## Node: 174  with Out-Degree: 192
## Node: 11  with Out-Degree: 190
## Node: 154 with Out-Degree: 180
## Node: 189 with Out-Degree: 180
## Node: 5   with Out-Degree: 177

```

```
sinks <- names(outdeg)[outdeg == 0 && indeg != 0]
```

```

## Warning in outdeg == 0 && indeg != 0: 'length(x) = 264 > 1' in coercion to
## 'logical(1)'

```

```
cat("\nSink Nodes (Out-Degree = 0):\n")
```

```

##
## Sink Nodes (Out-Degree = 0):

```

```

if (length(sinks) > 0) {
  cat(sinks, sep = ", ")
} else {
  cat("No sink nodes found.")
}

```

```
## No sink nodes found.
```

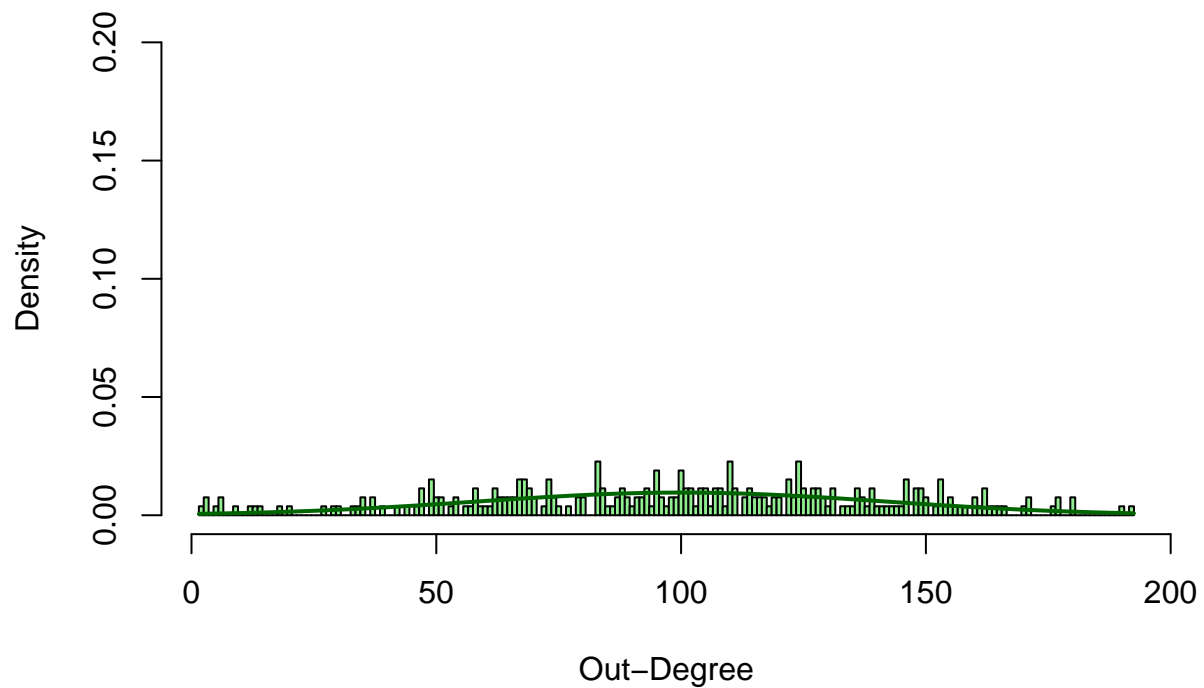
```

hist(
  outdeg,
  breaks = seq(min(outdeg) - 0.5, max(outdeg) + 0.5, by = 1),
  col = "lightgreen",
  border = "black",
  probability = T,
  main = "Bike Share Out-Degree Distribution",
  xlab = "Out-Degree",
  ylab = "Density",
  ylim = c(0, 0.2)
)

curve(dnorm(x, mean = mean(outdeg), sd = sd(outdeg)), col = "darkgreen", lwd = 2, add = T)

```

## Bike Share Out-Degree Distribution



### Average Degree Whole Network

```
avgdeg <- mean(degree(graph))  
cat("Average Degree:", avgdeg, "\n\n")
```

```
## Average Degree: 200
```

```
cat("Average In/Out-Degree:", avgdeg / 2)
```

```
## Average In/Out-Degree: 100
```

### Degree Ratio Whole Network

```
degratio <- indeg / outdeg  
  
topfive <- order(degratio, decreasing = TRUE)[1:5]  
topnodes <- names(degratio)[topfive]  
topvalues <- degratio[topfive]  
  
cat("Top 5 Nodes with Highest Degree Ratio:\n")
```

```
## Top 5 Nodes with Highest Degree Ratio:
```

```
for (i in 1:5) {  
  cat("Node:", topnodes[i], " with Degree Ratio:", topvalues[i], "\n")  
}
```

```
## Node: 982  with Degree Ratio: 3.5  
## Node: 980  with Degree Ratio: 2.22  
## Node: 236  with Degree Ratio: 1.51  
## Node: 233  with Degree Ratio: 1.39  
## Node: 83   with Degree Ratio: 1.36
```

```
topfive <- order(degratio, decreasing = FALSE)[1:5]  
topnodes <- names(degratio)[topfive]  
topvalues <- degratio[topfive]  
  
cat("\nTop 5 Nodes with Lowest Degree Ratio:\n")
```

```
##  
## Top 5 Nodes with Lowest Degree Ratio:
```

```
for (i in 1:5) {  
  cat("Node:", topnodes[i], " with Degree Ratio:", topvalues[i], "\n")  
}
```

```
## Node: 991  with Degree Ratio: 0.333  
## Node: 992  with Degree Ratio: 0.333  
## Node: 981  with Degree Ratio: 0.481  
## Node: 516  with Degree Ratio: 0.554  
## Node: 2132 with Degree Ratio: 0.576
```

## Generate Network Cluster 1

```
nodes <- read.csv("Cluster_1_Nodes.csv", header = T)  
edges <- read.csv("Cluster_1_Edges.csv", header = T)  
graph <- graph_from_data_frame(edges, nodes, directed = T)
```

## In-Degree Cluster 1

```
indeg <- degree(graph, mode = "in")  
cat("In-Degree Distribution:", indeg, "\n\n")
```

```
## In-Degree Distribution: 39 20 26 30 42 29 59 41 39 27 51 27 40 34 51 54 59 37 34 41 40 34 47 19 36 5
```

```
topfive <- order(indeg, decreasing = TRUE)[1:5]  
topnodes <- names(indeg)[topfive]  
topvalues <- indeg[topfive]  
  
cat("Top 5 Nodes by In-Degree:\n")
```

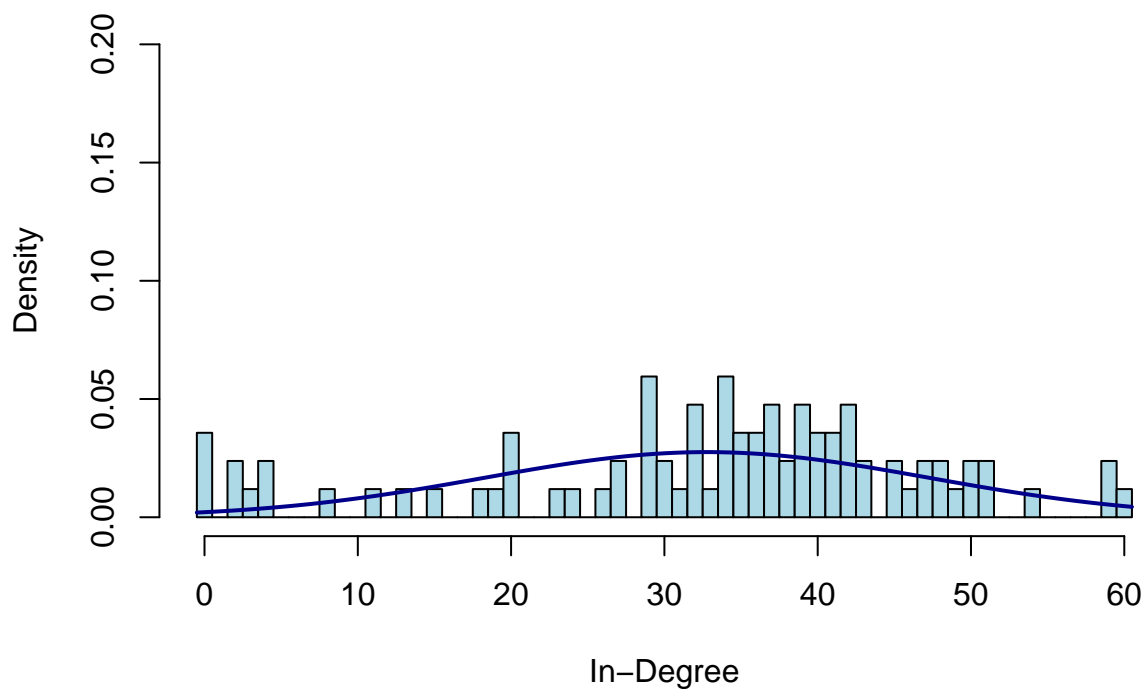
```
## Top 5 Nodes by In-Degree:
```

```
for (i in 1:5) {  
  cat("Node:", topnodes[i], " with In-Degree:", topvalues[i], "\n")  
}
```

```
## Node: 222  with In-Degree: 60  
## Node: 244  with In-Degree: 59  
## Node: 53   with In-Degree: 59  
## Node: 254  with In-Degree: 54  
## Node: 642  with In-Degree: 51
```

```
hist(  
  indeg,  
  breaks = seq(min(indeg) - 0.5, max(indeg) + 0.5, by = 1),  
  col = "lightblue",  
  border = "black",  
  probability = T,  
  main = "Bike Share In-Degree Distribution",  
  xlab = "In-Degree",  
  ylab = "Density",  
  ylim = c(0, 0.2)  
)  
  
curve(dnorm(x, mean = mean(indeg), sd = sd(indeg)), col = "darkblue", lwd = 2, add = T)
```

## Bike Share In-Degree Distribution



## Out-Degree Cluster 1

```
outdeg <- degree(graph, mode = "out")
cat("Out-Degree Distribution:", outdeg, "\n\n")
```

```
## Out-Degree Distribution: 40 24 24 30 35 37 56 50 44 30 45 35 39 30 47 49 51 34 29 50 31 52 51 15 34 4
```

```
topfive <- order(outdeg, decreasing = TRUE)[1:5]
topnodes <- names(outdeg)[topfive]
topvalues <- outdeg[topfive]
```

```
cat("Top 5 Nodes by Out-Degree:\n")
```

```
## Top 5 Nodes by Out-Degree:
```

```
for (i in 1:5) {
  cat("Node:", topnodes[i], " with Out-Degree:", topvalues[i], "\n")
}
```

```
## Node: 222 with Out-Degree: 59
## Node: 244 with Out-Degree: 56
## Node: 242 with Out-Degree: 52
## Node: 53 with Out-Degree: 51
## Node: 225 with Out-Degree: 51
```

```
sinks <- names(outdeg)[outdeg == 0 && indeg != 0]
```

```
## Warning in outdeg == 0 && indeg != 0: 'length(x) = 84 > 1' in coercion to
## 'logical(1)'
```

```
cat("\nSink Nodes (Out-Degree = 0):\n")
```

```
##
```

```
## Sink Nodes (Out-Degree = 0):
```

```
if (length(sinks) > 0) {
  cat(sinks, sep = ", ")
} else {
  cat("No sink nodes found.")
}
```

```
## No sink nodes found.
```

```
hist(
  outdeg,
  breaks = seq(min(outdeg) - 0.5, max(outdeg) + 0.5, by = 1),
  col = "lightgreen",
  border = "black",
```

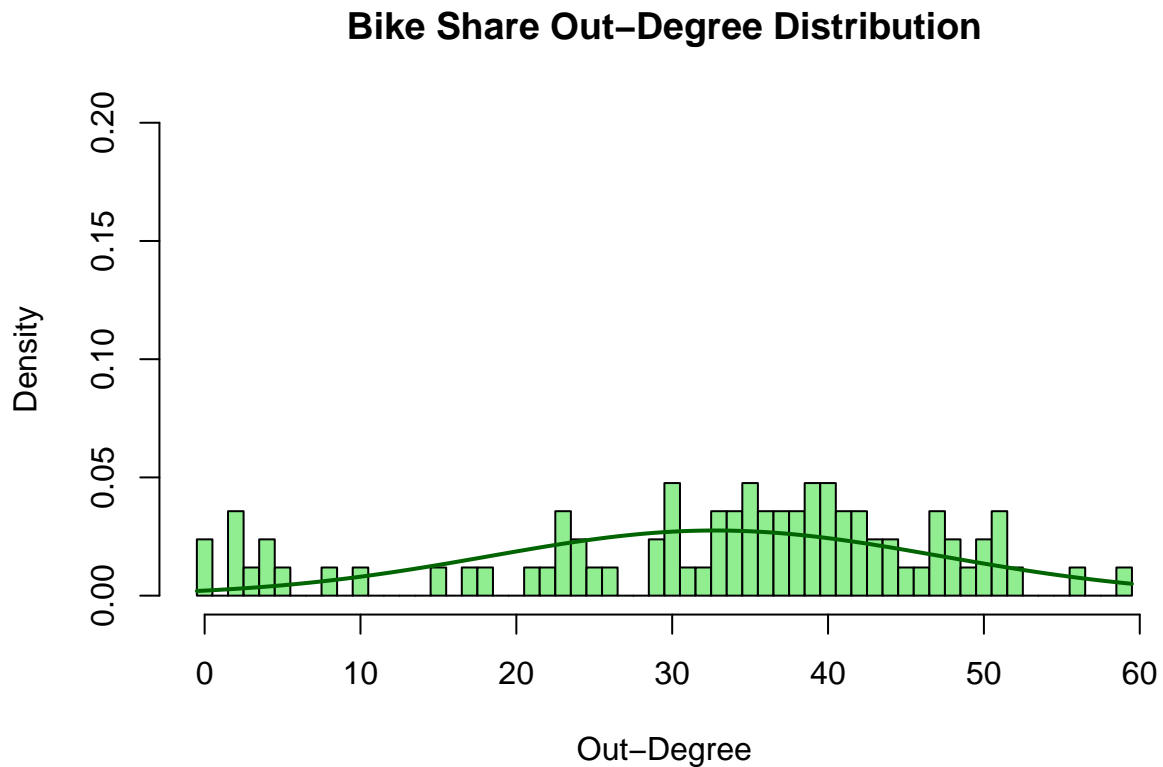


```

probability = T,
main = "Bike Share Out-Degree Distribution",
xlab = "Out-Degree",
ylab = "Density",
ylim = c(0, 0.2)
)

curve(dnorm(x, mean = mean(outdeg), sd = sd(outdeg)), col = "darkgreen", lwd = 2, add = T)

```



## Average Degree Cluster 1

```

avgdeg <- mean(degree(graph))
cat("Average Degree:", avgdeg, "\n\n")

```

```
## Average Degree: 65.5
```

```
cat("Average In/Out-Degree:", avgdeg / 2)
```

```
## Average In/Out-Degree: 32.8
```

## Degree Ratio Cluster 1

```
degratio <- indeg / outdeg

topfive <- order(degratio, decreasing = TRUE)[1:5]
topnodes <- names(degratio)[topfive]
topvalues <- degratio[topfive]

cat("Top 5 Nodes with Highest Degree Ratio:\n")
```

## Top 5 Nodes with Highest Degree Ratio:

```
for (i in 1:5) {
  cat("Node:", topnodes[i], " with Degree Ratio:", topvalues[i], "\n")
}
```

```
## Node: 980  with Degree Ratio: 2.2
## Node: 982  with Degree Ratio: 2
## Node: 287  with Degree Ratio: 1.71
## Node: 354  with Degree Ratio: 1.52
## Node: 236  with Degree Ratio: 1.5
```

```
topfive <- order(degratio, decreasing = FALSE)[1:5]
topnodes <- names(degratio)[topfive]
topvalues <- degratio[topfive]

cat("\nTop 5 Nodes with Lowest Degree Ratio:\n")
```

##  
## Top 5 Nodes with Lowest Degree Ratio:

```
for (i in 1:5) {
  cat("Node:", topnodes[i], " with Degree Ratio:", topvalues[i], "\n")
}
```

```
## Node: 992  with Degree Ratio: 0
## Node: 991  with Degree Ratio: 0.5
## Node: 260  with Degree Ratio: 0.625
## Node: 242  with Degree Ratio: 0.654
## Node: 283  with Degree Ratio: 0.69
```

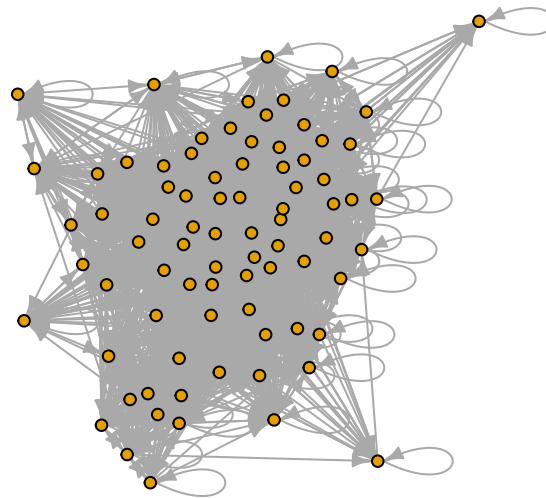
## Generate Network Cluster 2

```
nodes <- read.csv("Cluster_2_Nodes.csv", header = T)
edges <- read.csv("Cluster_2_Edges.csv", header = T)

graph <- graph_from_data_frame(edges, nodes, directed = T)
```

```
plot(
  graph,
  vertex.label = NA,
  vertex.size = 5,
  main = "Mobi Vancouver Bike Share Network",
  edge.arrow.size = 0.5
)
```

## Mobi Vancouver Bike Share Network



## In-Degree Cluster 2

```
indeg <- degree(graph, mode = "in")
cat("In-Degree Distribution:", indeg, "\n\n")
```

```
## In-Degree Distribution: 61 39 52 31 23 51 66 19 43 53 46 60 57 34 54 39 39 64 18 39 56 54 35 41 54 6
```

```
topfive <- order(indeg, decreasing = TRUE)[1:5]
topnodes <- names(indeg)[topfive]
topvalues <- indeg[topfive]

cat("Top 5 Nodes by In-Degree:\n")
```

```
## Top 5 Nodes by In-Degree:
```

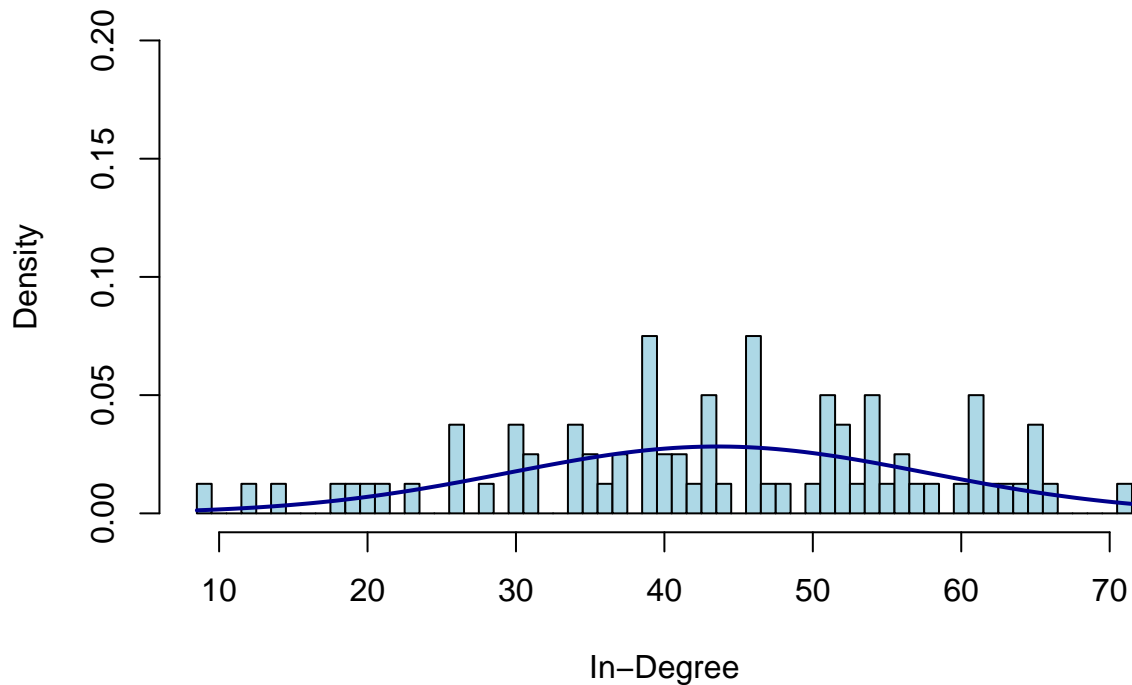
```
for (i in 1:5) {
  cat("Node:", topnodes[i], " with In-Degree:", topvalues[i], "\n")
}
```

```
## Node: 154   with In-Degree: 71
## Node: 204   with In-Degree: 66
## Node: 484   with In-Degree: 65
## Node: 189   with In-Degree: 65
## Node: 400   with In-Degree: 65
```

```
hist(
  indeg,
  breaks = seq(min(indeg) - 0.5, max(indeg) + 0.5, by = 1),
  col = "lightblue",
  border = "black",
  probability = T,
  main = "Bike Share In-Degree Distribution",
  xlab = "In-Degree",
  ylab = "Density",
  ylim = c(0, 0.2)
)

curve(dnorm(x, mean = mean(indeg), sd = sd(indeg)), col = "darkblue", lwd = 2, add = T)
```

## Bike Share In-Degree Distribution



## Out-Degree Cluster 2

```
outdeg <- degree(graph, mode = "out")
cat("Out-Degree Distribution:", outdeg, "\n\n")
```

```
## Out-Degree Distribution: 62 46 51 28 26 58 61 16 48 59 35 58 52 40 47 34 31 66 17 40 59 50 33 44 54 61
```

```
topfive <- order(outdeg, decreasing = TRUE)[1:5]
topnodes <- names(outdeg)[topfive]
topvalues <- outdeg[topfive]

cat("Top 5 Nodes by Out-Degree:\n")
```

```
## Top 5 Nodes by Out-Degree:
```

```
for (i in 1:5) {
  cat("Node:", topnodes[i], " with Out-Degree:", topvalues[i], "\n")
}
```

```
## Node: 154 with Out-Degree: 69
## Node: 66 with Out-Degree: 66
## Node: 109 with Out-Degree: 62
## Node: 189 with Out-Degree: 62
## Node: 159 with Out-Degree: 62
```

```
sinks <- names(outdeg)[outdeg == 0 && indeg != 0]
```

```
## Warning in outdeg == 0 && indeg != 0: 'length(x) = 80 > 1' in coercion to
## 'logical(1)'
```

```
cat("\nSink Nodes (Out-Degree = 0):\n")
```

```
##
```

```
## Sink Nodes (Out-Degree = 0):
```

```
if (length(sinks) > 0) {
  cat(sinks, sep = ", ")
} else {
  cat("No sink nodes found.")
}
```

```
## No sink nodes found.
```

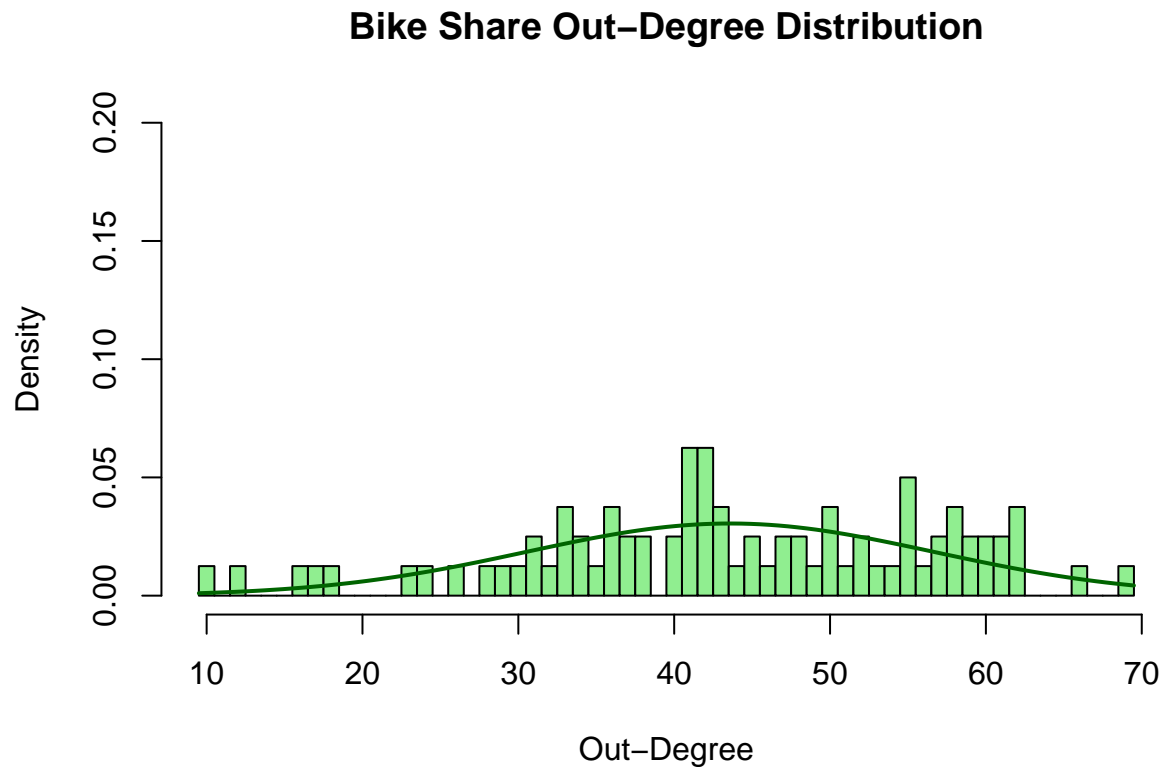
```
hist(
  outdeg,
  breaks = seq(min(outdeg) - 0.5, max(outdeg) + 0.5, by = 1),
  col = "lightgreen",
  border = "black",
```

```

probability = T,
main = "Bike Share Out-Degree Distribution",
xlab = "Out-Degree",
ylab = "Density",
ylim = c(0, 0.2)
)

curve(dnorm(x, mean = mean(outdeg), sd = sd(outdeg)), col = "darkgreen", lwd = 2, add = T)

```



## Average Degree Cluster 2

```

avgdeg <- mean(degree(graph))
cat("Average Degree:", avgdeg, "\n\n")

```

```
## Average Degree: 87.2
```

```
cat("Average In/Out-Degree:", avgdeg / 2)
```

```
## Average In/Out-Degree: 43.6
```

## Degree Ratio Cluster 2

```
degratio <- indeg / outdeg

topfive <- order(degratio, decreasing = TRUE)[1:5]
topnodes <- names(degratio)[topfive]
topvalues <- degratio[topfive]

cat("Top 5 Nodes with Highest Degree Ratio:\n")
```

```
## Top 5 Nodes with Highest Degree Ratio:
```

```
for (i in 1:5) {
  cat("Node:", topnodes[i], " with Degree Ratio:", topvalues[i], "\n")
}
```

```
## Node: 401  with Degree Ratio: 1.46
## Node: 73  with Degree Ratio: 1.31
## Node: 2143 with Degree Ratio: 1.26
## Node: 139 with Degree Ratio: 1.24
## Node: 153 with Degree Ratio: 1.2
```

```
topfive <- order(degratio, decreasing = FALSE)[1:5]
topnodes <- names(degratio)[topfive]
topvalues <- degratio[topfive]

cat("\nTop 5 Nodes with Lowest Degree Ratio:\n")
```

```
##
## Top 5 Nodes with Lowest Degree Ratio:
```

```
for (i in 1:5) {
  cat("Node:", topnodes[i], " with Degree Ratio:", topvalues[i], "\n")
}
```

```
## Node: 2114 with Degree Ratio: 0.512
## Node: 2132 with Degree Ratio: 0.619
## Node: 211 with Degree Ratio: 0.619
## Node: 716 with Degree Ratio: 0.667
## Node: 113 with Degree Ratio: 0.738
```

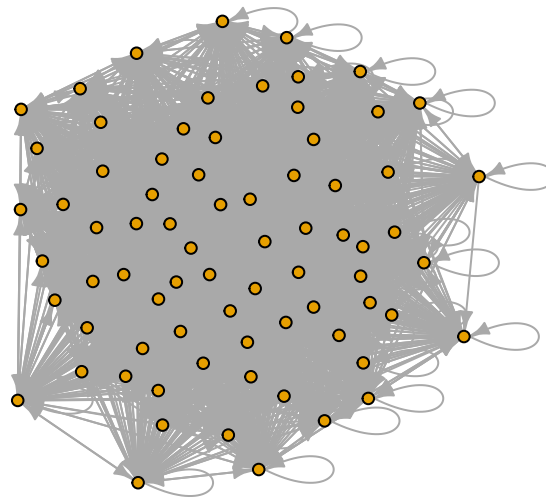
## Generate Network Cluster 3

```
nodes <- read.csv("Cluster_3_Nodes.csv", header = T)
edges <- read.csv("Cluster_3_Edges.csv", header = T)

graph <- graph_from_data_frame(edges, nodes, directed = T)
```

```
plot(
  graph,
  vertex.label = NA,
  vertex.size = 5,
  main = "Mobi Vancouver Bike Share Network",
  edge.arrow.size = 0.5
)
```

## Mobi Vancouver Bike Share Network



### In-Degree Cluster 3

```
indeg <- degree(graph, mode = "in")
cat("In-Degree Distribution:", indeg, "\n\n")
```

```
## In-Degree Distribution: 62 68 70 72 72 70 71 67 63 73 71 63 62 72 73 74 68 63 72 71 71 70 71 72 64 7
```

```
topfive <- order(indeg, decreasing = TRUE)[1:5]
topnodes <- names(indeg)[topfive]
topvalues <- indeg[topfive]

cat("Top 5 Nodes by In-Degree:\n")
```

```
## Top 5 Nodes by In-Degree:
```



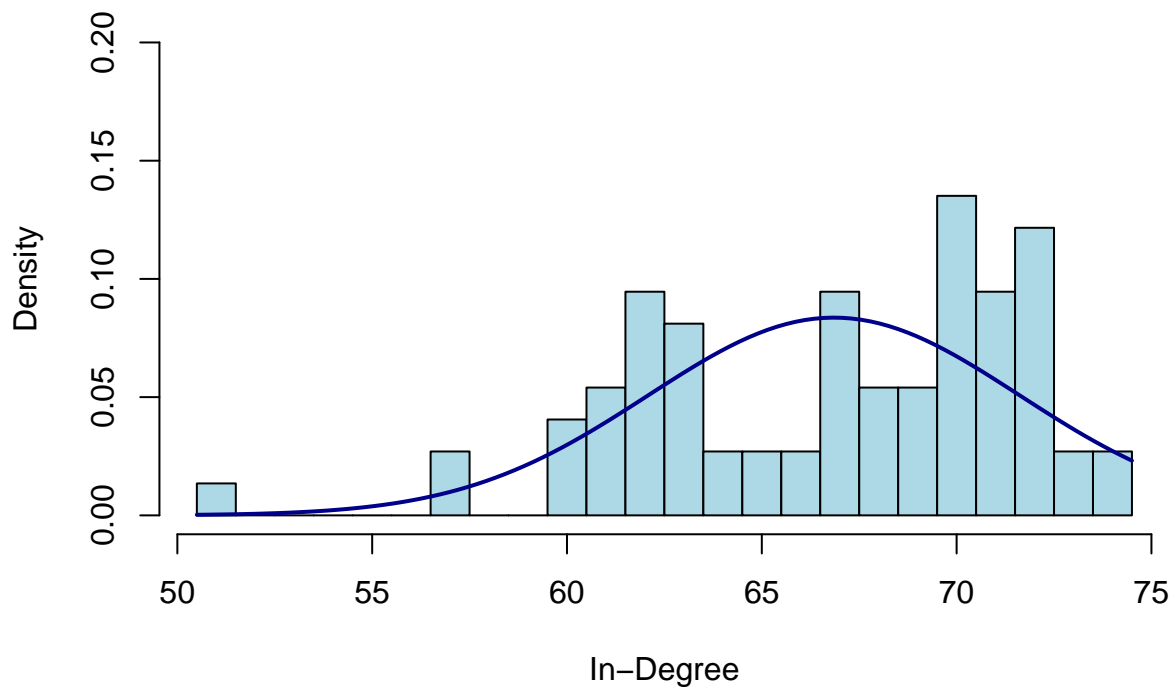
```
for (i in 1:5) {
  cat("Node:", topnodes[i], " with In-Degree:", topvalues[i], "\n")
}
```

```
## Node: 196  with In-Degree: 74
## Node: 58  with In-Degree: 74
## Node: 92  with In-Degree: 73
## Node: 122 with In-Degree: 73
## Node: 187 with In-Degree: 72
```

```
hist(
  indeg,
  breaks = seq(min(indeg) - 0.5, max(indeg) + 0.5, by = 1),
  col = "lightblue",
  border = "black",
  probability = T,
  main = "Bike Share In-Degree Distribution",
  xlab = "In-Degree",
  ylab = "Density",
  ylim = c(0, 0.2)
)

curve(dnorm(x, mean = mean(indeg), sd = sd(indeg)), col = "darkblue", lwd = 2, add = T)
```

## Bike Share In-Degree Distribution



## Out-Degree Cluster 3

```
outdeg <- degree(graph, mode = "out")
cat("Out-Degree Distribution:", outdeg, "\n\n")
```

```
## Out-Degree Distribution: 71 71 67 73 71 71 73 63 73 71 73 71 58 72 73 74 67 61 70 68 71 73 71 72 58
```

```
topfive <- order(outdeg, decreasing = TRUE)[1:5]
topnodes <- names(outdeg)[topfive]
topvalues <- outdeg[topfive]
```

```
cat("Top 5 Nodes by Out-Degree:\n")
```

```
## Top 5 Nodes by Out-Degree:
```

```
for (i in 1:5) {
  cat("Node:", topnodes[i], " with Out-Degree:", topvalues[i], "\n")
}
```

```
## Node: 196  with Out-Degree: 74
## Node: 58  with Out-Degree: 74
## Node: 187 with Out-Degree: 73
## Node: 5   with Out-Degree: 73
## Node: 50  with Out-Degree: 73
```

```
sinks <- names(outdeg)[outdeg == 0 && indeg != 0]
```

```
## Warning in outdeg == 0 && indeg != 0: 'length(x) = 74 > 1' in coercion to
## 'logical(1)'
```

```
cat("\nSink Nodes (Out-Degree = 0):\n")
```

```
##
```

```
## Sink Nodes (Out-Degree = 0):
```

```
if (length(sinks) > 0) {
  cat(sinks, sep = ", ")
} else {
  cat("No sink nodes found.")
}
```

```
## No sink nodes found.
```

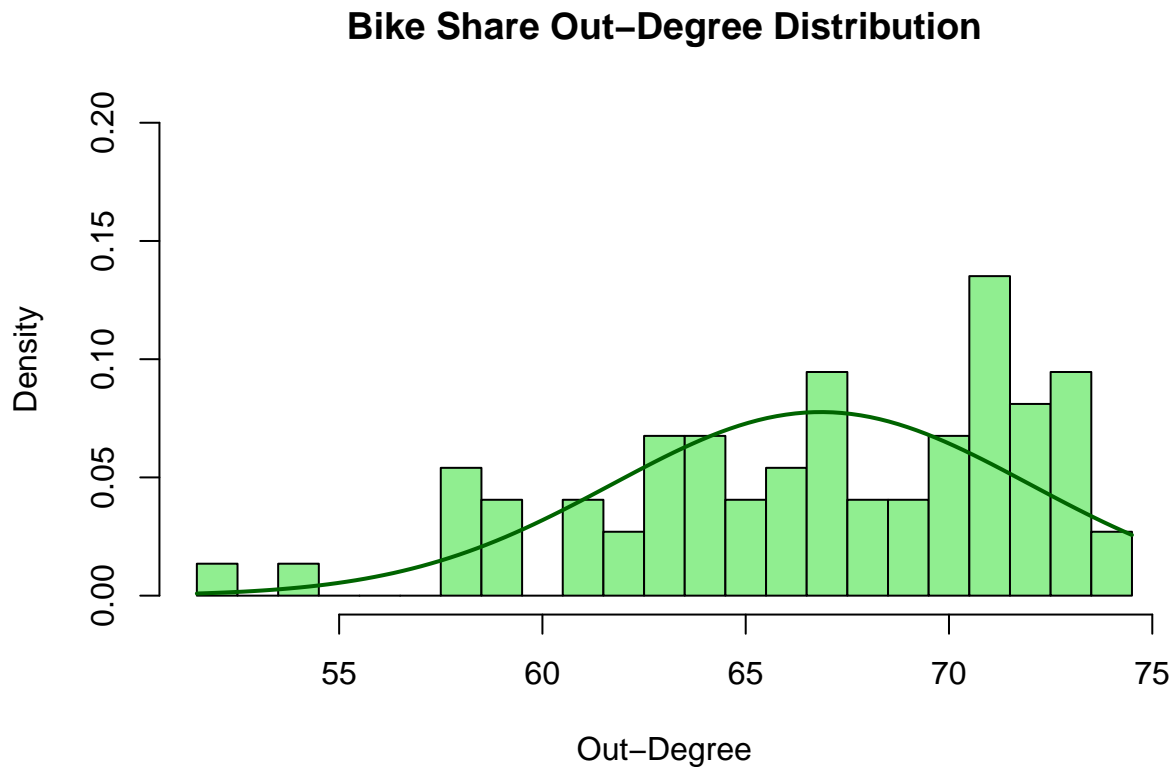
```
hist(
  outdeg,
  breaks = seq(min(outdeg) - 0.5, max(outdeg) + 0.5, by = 1),
  col = "lightgreen",
  border = "black",
```

```

probability = T,
main = "Bike Share Out-Degree Distribution",
xlab = "Out-Degree",
ylab = "Density",
ylim = c(0, 0.2)
)

curve(dnorm(x, mean = mean(outdeg), sd = sd(outdeg)), col = "darkgreen", lwd = 2, add = T)

```



### Average Degree Cluster 3

```

avgdeg <- mean(degree(graph))
cat("Average Degree:", avgdeg, "\n\n")

```

```
## Average Degree: 134
```

```
cat("Average In/Out-Degree:", avgdeg / 2)
```

```
## Average In/Out-Degree: 66.9
```

## Degree Ratio Cluster 3

```
degratio <- indeg / outdeg

topfive <- order(degratio, decreasing = TRUE)[1:5]
topnodes <- names(degratio)[topfive]
topvalues <- degratio[topfive]

cat("Top 5 Nodes with Highest Degree Ratio:\n")
```

## Top 5 Nodes with Highest Degree Ratio:

```
for (i in 1:5) {
  cat("Node:", topnodes[i], " with Degree Ratio:", topvalues[i], "\n")
}
```

```
## Node: 308  with Degree Ratio: 1.17
## Node: 17   with Degree Ratio: 1.11
## Node: 200  with Degree Ratio: 1.11
## Node: 21   with Degree Ratio: 1.1
## Node: 47   with Degree Ratio: 1.1
```

```
topfive <- order(degratio, decreasing = FALSE)[1:5]
topnodes <- names(degratio)[topfive]
topvalues <- degratio[topfive]

cat("\nTop 5 Nodes with Lowest Degree Ratio:\n")
```

##  
## Top 5 Nodes with Lowest Degree Ratio:

```
for (i in 1:5) {
  cat("Node:", topnodes[i], " with Degree Ratio:", topvalues[i], "\n")
}
```

```
## Node: 25  with Degree Ratio: 0.861
## Node: 50  with Degree Ratio: 0.863
## Node: 63  with Degree Ratio: 0.873
## Node: 87  with Degree Ratio: 0.873
## Node: 310 with Degree Ratio: 0.887
```

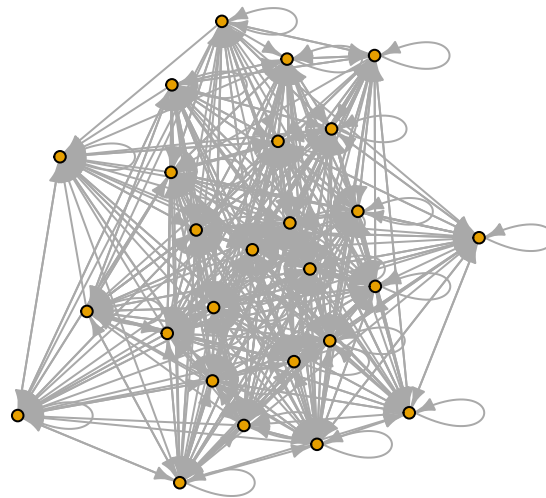
## Generate Network Cluster 4

```
nodes <- read.csv("Cluster_4_Nodes.csv", header = T)
edges <- read.csv("Cluster_4_Edges.csv", header = T)

graph <- graph_from_data_frame(edges, nodes, directed = T)
```

```
plot(
  graph,
  vertex.label = NA,
  vertex.size = 5,
  main = "Mobi Vancouver Bike Share Network",
  edge.arrow.size = 0.5
)
```

## Mobi Vancouver Bike Share Network



### In-Degree Cluster 4

```
indeg <- degree(graph, mode = "in")
cat("In-Degree Distribution:", indeg, "\n\n")
```

```
## In-Degree Distribution: 26 22 21 19 22 19 19 16 21 13 23 21 18 26 22 21 22 13 25 23 18 18 24 22 16 1
```

```
topfive <- order(indeg, decreasing = TRUE)[1:5]
topnodes <- names(indeg)[topfive]
topvalues <- indeg[topfive]

cat("Top 5 Nodes by In-Degree:\n")
```

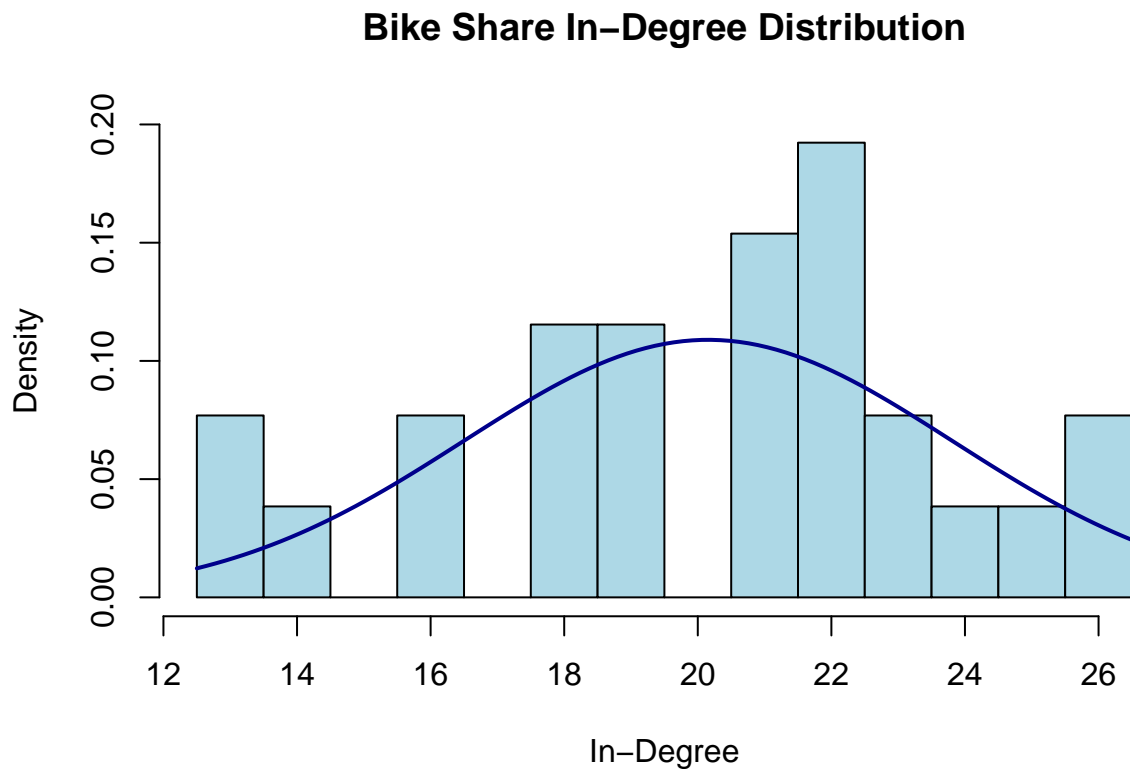
```
## Top 5 Nodes by In-Degree:
```

```
for (i in 1:5) {
  cat("Node:", topnodes[i], " with In-Degree:", topvalues[i], "\n")
}
```

```
## Node: 1   with In-Degree: 26
## Node: 106 with In-Degree: 26
## Node: 557 with In-Degree: 25
## Node: 132 with In-Degree: 24
## Node: 531 with In-Degree: 23
```

```
hist(
  indeg,
  breaks = seq(min(indeg) - 0.5, max(indeg) + 0.5, by = 1),
  col = "lightblue",
  border = "black",
  probability = T,
  main = "Bike Share In-Degree Distribution",
  xlab = "In-Degree",
  ylab = "Density",
  ylim = c(0, 0.2)
)

curve(dnorm(x, mean = mean(indeg), sd = sd(indeg)), col = "darkblue", lwd = 2, add = T)
```



## Out-Degree Cluster 4

```
outdeg <- degree(graph, mode = "out")
cat("Out-Degree Distribution:", outdeg, "\n\n")
```

```
## Out-Degree Distribution: 22 18 21 8 23 20 19 11 21 20 24 22 24 21 23 24 25 17 22 22 20 21 23 22 15 1
```

```
topfive <- order(outdeg, decreasing = TRUE)[1:5]
topnodes <- names(outdeg)[topfive]
topvalues <- outdeg[topfive]

cat("Top 5 Nodes by Out-Degree:\n")
```

```
## Top 5 Nodes by Out-Degree:
```

```
for (i in 1:5) {
  cat("Node:", topnodes[i], " with Out-Degree:", topvalues[i], "\n")
}
```

```
## Node: 561  with Out-Degree: 25
## Node: 531  with Out-Degree: 24
## Node: 511  with Out-Degree: 24
## Node: 524  with Out-Degree: 24
## Node: 71   with Out-Degree: 23
```

```
sinks <- names(outdeg)[outdeg == 0 && indeg != 0]
```

```
## Warning in outdeg == 0 && indeg != 0: 'length(x) = 26 > 1' in coercion to
## 'logical(1)'
```

```
cat("\nSink Nodes (Out-Degree = 0):\n")
```

```
##
## Sink Nodes (Out-Degree = 0):
```

```
if (length(sinks) > 0) {
  cat(sinks, sep = ", ")
} else {
  cat("No sink nodes found.")
}
```

```
## No sink nodes found.
```

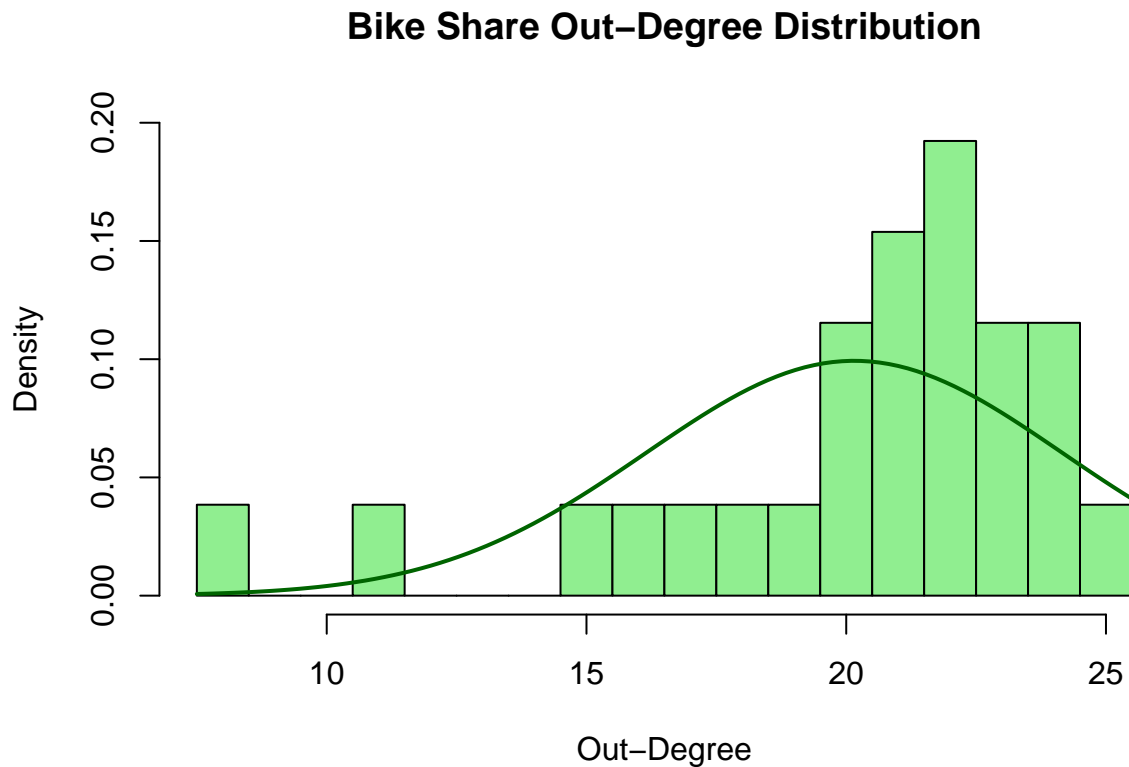
```
hist(
  outdeg,
  breaks = seq(min(outdeg) - 0.5, max(outdeg) + 0.5, by = 1),
  col = "lightgreen",
  border = "black",
```

```

probability = T,
main = "Bike Share Out-Degree Distribution",
xlab = "Out-Degree",
ylab = "Density",
ylim = c(0, 0.2)
)

curve(dnorm(x, mean = mean(outdeg), sd = sd(outdeg)), col = "darkgreen", lwd = 2, add = T)

```



### Average Degree Cluster 4

```

avgdeg <- mean(degree(graph))
cat("Average Degree:", avgdeg, "\n\n")

```

```
## Average Degree: 40.3
```

```
cat("Average In/Out-Degree:", avgdeg / 2)
```

```
## Average In/Out-Degree: 20.2
```



## Degree Ratio Cluster 4

```
degratio <- indeg / outdeg

topfive <- order(degratio, decreasing = TRUE)[1:5]
topnodes <- names(degratio)[topfive]
topvalues <- degratio[topfive]

cat("Top 5 Nodes with Highest Degree Ratio:\n")
```

## Top 5 Nodes with Highest Degree Ratio:

```
for (i in 1:5) {
  cat("Node:", topnodes[i], " with Degree Ratio:", topvalues[i], "\n")
}
```

```
## Node: 256  with Degree Ratio: 2.38
## Node: 257  with Degree Ratio: 1.45
## Node: 106  with Degree Ratio: 1.24
## Node: 130  with Degree Ratio: 1.22
## Node: 1    with Degree Ratio: 1.18
```

```
topfive <- order(degratio, decreasing = FALSE)[1:5]
topnodes <- names(degratio)[topfive]
topvalues <- degratio[topfive]

cat("\nTop 5 Nodes with Lowest Degree Ratio:\n")
```

##  
## Top 5 Nodes with Lowest Degree Ratio:

```
for (i in 1:5) {
  cat("Node:", topnodes[i], " with Degree Ratio:", topvalues[i], "\n")
}
```

```
## Node: 516  with Degree Ratio: 0.65
## Node: 511  with Degree Ratio: 0.75
## Node: 311  with Degree Ratio: 0.765
## Node: 563  with Degree Ratio: 0.857
## Node: 524  with Degree Ratio: 0.875
```