Network Analysis and Centrality Measures

```
knitr::opts_chunk$set(echo = TRUE)
library(tidyverse)
```

```
## Warning: package 'ggplot2' was built under R version 4.3.1
```

```
## Warning: package 'lubridate' was built under R version 4.3.1
```

```
## ── Attaching core tidyverse packages ──────────────────────── tidyverse 2.0.0 ──
## ✔ dplyr     1.1.2     ✔ readr     2.1.4
## ✔ forcats   1.0.0     ✔ stringr   1.5.0
## ✔ ggplot2   3.5.0     ✔ tibble    3.2.1
## ✔ lubridate 1.9.3     ✔ tidyr     1.3.0
## ✔ purrr     1.0.1
## ── Conflicts ────────────────────────────────────────── tidyverse_conflicts() ──
## ✖ dplyr::filter() masks stats::filter()
## ✖ dplyr::lag()    masks stats::lag()
## ℹ Use the conflicted package (<http://conflicted.r-lib.org/>) to force all conflicts
to become errors
```

```
library(igraph)
```

```
## Warning: package 'igraph' was built under R version 4.3.1
```

```
##
## Attaching package: 'igraph'
##
## The following objects are masked from 'package:lubridate':
##
##     %--%, union
##
## The following objects are masked from 'package:dplyr':
##
##     as_data_frame, groups, union
##
## The following objects are masked from 'package:purrr':
##
##     compose, simplify
##
## The following object is masked from 'package:tidyr':
##
##     crossing
##
## The following object is masked from 'package:tibble':
##
##     as_data_frame
##
## The following objects are masked from 'package:stats':
##
##     decompose, spectrum
##
## The following object is masked from 'package:base':
##
##     union
```

```
library(kableExtra)
```

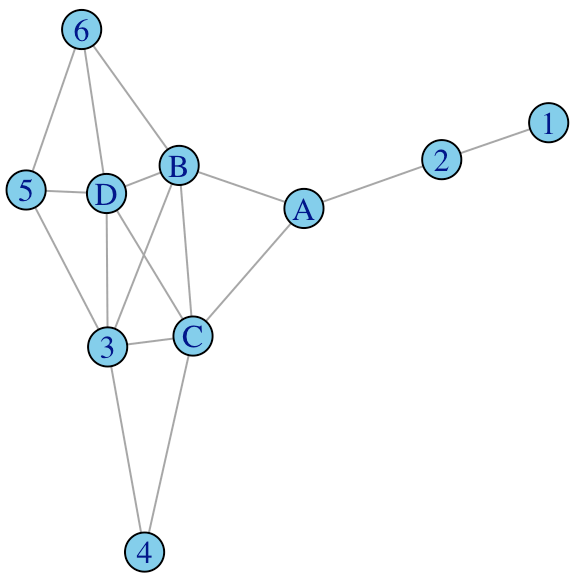
```
## Warning: package 'kableExtra' was built under R version 4.3.1
```

```
##
## Attaching package: 'kableExtra'
##
## The following object is masked from 'package:dplyr':
##
##     group_rows
```

```
# Create a blank matrix
adjacency_matrix <- matrix(0, nrow=10, ncol=10)

# Define the names for the rows and columns for clarity
rownames(adjacency_matrix) <- c("5", "6", "D", "3", "4", "B", "C", "A", "2", "1")
colnames(adjacency_matrix) <- c("5", "6", "D", "3", "4", "B", "C", "A", "2", "1")

# Connections for 5
adjacency_matrix["5", c("D", "6", "3")] <- 1

# Connections for 6
adjacency_matrix["6", c("D", "B", "5")] <- 1

# Connections for D
adjacency_matrix["D", c("5", "6", "3", "B", "C")] <- 1

# Connections for 3
adjacency_matrix["3", c("D", "4", "C", "B", "5")] <- 1

# Connections for 4
adjacency_matrix["4", c("3", "C")] <- 1

# Connections for B
adjacency_matrix["B", c("6", "D", "C", "A", "3")] <- 1

# Connections for C
adjacency_matrix["C", c("3", "4", "B", "D", "A")] <- 1

# Connections for A
adjacency_matrix["A", c("C", "B", "2")] <- 1

# Connections for 2
adjacency_matrix["2", c("A", "1")] <- 1

# Connections for 1
adjacency_matrix["1", "2"] <- 1

# Since the graph is undirected, we mirror the matrix along the diagonal
adjacency_matrix <- adjacency_matrix + t(adjacency_matrix)
# convert where the value is 2 to 1
adjacency_matrix[adjacency_matrix == 2] <- 1

#sort the matrix
adjacency_matrix <- adjacency_matrix[order(rownames(adjacency_matrix)), order(colnames(a
djacency_matrix))]

# Print out the matrix
adjacency_matrix
```

```
##   1 2 3 4 5 6 A B C D
## 1 0 1 0 0 0 0 0 0 0 0
## 2 1 0 0 0 0 0 1 0 0 0
## 3 0 0 0 1 1 0 0 1 1 1
## 4 0 0 1 0 0 0 0 0 1 0
## 5 0 0 1 0 0 1 0 0 0 1
## 6 0 0 0 0 1 0 0 1 0 1
## A 0 1 0 0 0 0 0 1 1 0
## B 0 0 1 0 0 1 1 0 1 1
## C 0 0 1 1 0 0 1 1 0 1
## D 0 0 1 0 1 1 0 1 1 0
```

```
library(igraph)

graph <- graph_from_adjacency_matrix(adjacency_matrix, mode = "undirected")

# Plot the graph
plot(graph, layout = layout_nicely(graph), vertex.color = "skyblue", edge.arrow.size =
0.5)
```



```
# Calculate degree centrality for all nodes
degree_centrality <- degree(graph, mode = "all")

# Calculate closeness centrality for all nodes
closeness_centrality <- closeness(graph, mode = "all")

# Calculate betweenness centrality for all nodes
betweenness_centrality <- betweenness(graph, directed = FALSE, normalized = TRUE)

centrality_measures_all <- data.frame(
  Degree = degree_centrality,
  Closeness = closeness_centrality,
  Betweenness = betweenness_centrality
)

centrality_measures_all
```

```
##   Degree  Closeness Betweenness
## 1      1 0.03333333  0.00000000
## 2      2 0.04545455  0.22222222
## 3      5 0.06250000  0.12870370
## 4      2 0.05000000  0.00000000
## 5      3 0.04761905  0.01481481
## 6      3 0.05263158  0.02592593
## A      3 0.06250000  0.38888889
## B      5 0.07142857  0.25092593
## C      5 0.07142857  0.23888889
## D      5 0.06250000  0.09074074
```

```
# Extract the centralities for seats A-D
seat_choices <- c('A', 'B', 'C', 'D')
centrality_measures <- data.frame(
  Degree = degree_centrality[seat_choices],
  Closeness = closeness_centrality[seat_choices],
  Betweenness = betweenness_centrality[seat_choices]
)
rownames(centrality_measures) <- seat_choices
```

Centrality Measures for Seats A-D

	Degree	Closeness	Betweenness
A	3	0.06250	0.388889
B	5	0.07143	0.250926
C	5	0.07143	0.238889
D	5	0.06250	0.090741

Seat A

- **Key Feature**: Highest betweenness centrality, lowest degree centrality.
- **Benefit**: Sitting in Seat A positions you as a key bridge in the network, connecting different coworker groups. This is beneficial for meeting diverse individuals –> can offer broad insights into the company culture and cross-departmental projects.
- **Drawback**: The lower degree centrality means you might have fewer direct connections, potentially making it harder to quickly form a close-knit group of friends.

Seat B

- **Key Feature**: High degree and closeness centrality.
- **Benefit**: access to a larger direct network and easier communication with others due to the high closeness centrality, facilitating exchange of information and support.
- **Drawback**: the focus here is less on being the sole connector and more on being part of a cohesive network, which might **limit exclusive networking**.

Seat C

- **Key Feature**: Similar to Seat B.

Seat D

- **Key Feature**: High degree and closeness centrality but lowest betweenness centrality.
- **Benefit**: Similar to B and C
- **Drawback**: The lowest betweenness centrality = less ideal for those looking to play a bridging role between unconnected coworker groups (less networkhub role).

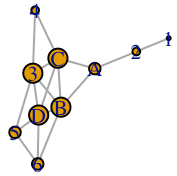
In Summary: - **For broad networking across diverse groups**: **Seat A** - **For quickly establishing a strong, central presence in your immediate network**: **Seats B, C, and D**

What if… - if you want to make the strongest bond with one person in the bus, where should you sit, assuming every seat is available? - 1 or 2 - they have the least number of connections, they are far from the rest of the network, and they are not in the middle of the network.

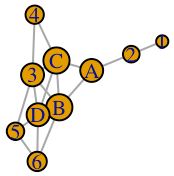
> If you choose 1, then 2 is your only bet and 2 has more “opportunities”. So if you want to make the strongest connection, you would sit in seat 2 and only talk to the person in seat 1.

```
degree_centrality <- degree(graph, mode = "all")
closeness_centrality <- closeness(graph, mode = "all")
betweenness_centrality <- betweenness(graph, directed = FALSE)

# Set up the layout of the graph just once to use in all plots
layout <- layout_with_fr(graph)

# Set up the plotting area
par(mfrow = c(2, 2))

# Degree Centrality Plot
plot(graph, layout = layout,
     vertex.label = V(graph)$name,
     vertex.size = degree_centrality * 5,
     vertex.label.cex = 0.8,
     edge.arrow.size = 0.5,
     main = "Degree Centrality")

# Closeness Centrality Plot
plot(graph, layout = layout,
     vertex.label = V(graph)$name,
     vertex.size = closeness_centrality * 500,  # Scale factor to make the sizes visibl
e, adjust as needed
     vertex.label.cex = 0.8,
     edge.arrow.size = 0.5,
     main = "Closeness Centrality")

# Betweenness Centrality Plot
plot(graph, layout = layout,
     vertex.label = V(graph)$name,
     vertex.size = betweenness_centrality / max(betweenness_centrality) * 50,  # Normali
ze and scale, adjust as needed
     vertex.label.cex = 0.8,
     edge.arrow.size = 0.5,
     main = "Betweenness Centrality")

# Resetting to default single plotting layout
par(mfrow = c(1, 1))
```

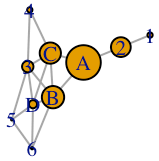
Degree Centrality



Closeness Centrality



Betweenness Centrality




```
par(mai = c(0, 0, 0.5, 0.5))
```