Name: Ankit Jaiswar
Roll no: 40
Academic Year: 2021-2022
Class: MSc CS Part I

Subject: Social Network Analysis

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Practical 1

Aim: Write a program to compute the following for a given a network:

- number of edges
- number of nodes
- degree of node
- node with lowest degree
- the adjacency list
- matrix of the graph.

Software(s) used:

- R ver. 4.1.3
- RStudio ver. 2022.02.0+433

External packages required:

- igraph

Description:

- The igraph package: igraph is a library and R package for network analysis.
  The main goals of the igraph library is to provide a set of data types and functions for:
  - pain-free implementation of graph algorithms,
  - fast handling of large graphs, with millions of vertices and edges, allowing rapid prototyping via high level languages like R.

- **library():** library() loads and attach add-on packages.
- **graph.formula():**
  - Creating (small) graphs via a simple interface
  - This function is useful if you want to create a small (named) graph quickly, it works for both directed and undirected graphs.
- **plot():** Use to plot any graph.
- **ecount():** Returns the count of number of edges in graph
- **vcount():** Returns the count of number of vertices in graph
- **E():**
  - Edges of a graph
  - An edge sequence is a vector containing numeric edge ids, with a special class attribute that allows custom operations: selecting subsets of edges based on attributes, or graph structure, creating the intersection, union of edges, etc.
- **V():**
  - Vertices of a graph
  - Create a vertex sequence (vs) containing all vertices of a graph.
- **degree():**
  - Degree and degree distribution of the vertices
  - The degree of a vertex is its most basic structural property, the number of its adjacent edges.
  - Mode-Character string, "out" for out-degree, "in" for in- degree or "total" for the sum of the two. For undirected graphs this argument is ignored. "all" is a synonym of "total".

- **max() and min():**
  - **Maxima and Minima**
  - **Returns the (regular or parallel) maxima and minima of the input values.**
- **get.adjacency(): Convert a graph to an adjacency matrix**
- **get.adjlist():**
  - **Adjacency lists**
  - **Create adjacency lists from a graph, either for adjacent edges or for neighboring vertices**

Source Code:

```
library(igraph)

u_graph - graph.formula(A - B, A - C, A - D, B - C, B - F, C -
D, C - E, C - F, D - E, E - F, F - G, G - H)
d_graph - graph.formula(A + B, A + D, A -+ C, B -+ C, B -+ E,
B -+ F, C -+ D, C -+ F, D -+ E)

e_count(u_graph
)
e_count(d_graph
)

v_count(u_graph
)
v_count(d_graph
)

E(u_graph)
E(d_graph)

V(u_graph)
V(d_graph)
```

```
degree(u_graph)
degree(u_graph, mode =
"in") degree(u_graph, mode
= "out")

degree(d_graph)
degree(d_graph, mode =
"in") degree(d_graph, mode
= "out")

V(u_graph)$name[degree(u_graph)  =
min(degree(u_graph))] V(d_graph)$name[degree(d_graph,
mode = "in") = min(degree(d_graph, mode = "in"))]
V(d_graph)$name[degree(d_graph, mode = "out") =
min(degree(d_graph, mode = "out"))]

get.adjacency(u_grap
h)
get.adjacency(d_grap
h)

get.adjlist(u_grap
h)
get.adjlist(d_grap
h)
```

Output:

```
> library(igraph)
>
> u_graph ← graph.formula(A - B, A - C, A - D, B - C, B - F, C - D, C - E, C - F, D - E, E - F, F - G, G
 - H)
> d_graph ← graph.formula(A ++ B, A ++ D, A -+ C, B -+ C, B -+ E, B -+ F, C -+ D, C -+ F, D -+ E)
>
> ecount(d_graph)
[1] 11
> ecount(d_graph)
[1] 11
>
> vcount(u_graph)
[1] 8
> vcount(d_graph)
[1] 6
>
> E(u_graph)
+ 12/12 edges from 535b776 (vertex names):
 [1] A--B A--C A--D B--C B--F C--D C--F C--E D--E F--E F--G G--H
> E(d_graph)
+ 11/11 edges from 5365b0b (vertex names):
 [1] A->B A->D A->C B->A B->C B->E B->F D->A D->E C->D C->F
```

```
> V(u_graph)
+ 8/8 vertices, named, from 535b776:
[1] A B C D F E G H
> V(d_graph)
+ 6/6 vertices, named, from 5365b0b:
[1] A B D C E F
>
> degree(u_graph)
A B C D F E G H
3 3 5 3 4 3 2 1
> degree(u_graph, mode = "in")
A B C D F E G H
3 3 5 3 4 3 2 1
> degree(u_graph, mode = "out")
A B C D F E G H
3 3 5 3 4 3 2 1
>
> degree(d_graph)
A B D C E F
5 5 4 4 2 2
```

```
> degree(d_graph, mode = "in")
A B D C E F
2 1 2 2 2 2
> degree(d_graph, mode = "out")
A B D C E F
3 4 2 2 0 0
>
> V(u_graph)$name[degree(u_graph) == min(degree(u_graph))]
[1] "H"
> V(d_graph)$name[degree(d_graph, mode = "in") == min(degree(d_graph, mode = "in"))]
[1] "B"
> V(d_graph)$name[degree(d_graph, mode = "out") == min(degree(d_graph, mode = "out"))]
[1] "E" "F"
>
```

```
> get.adjacency(u_graph)
8 x 8 sparse Matrix of class "dgCMatrix"
  A B C D F E G H
A . 1 1 1 . . . .
B 1 . 1 . 1 . . .
C 1 1 . 1 1 1 . .
D 1 . 1 . . 1 . .
F . 1 1 . . 1 1 .
E . . 1 1 1 . . .
G . . . . 1 . . 1
H . . . . . . 1 .
> get.adjacency(d_graph)
6 x 6 sparse Matrix of class "dgCMatrix"
  A B D C E F
A . 1 1 1 . .
B 1 . . 1 1 1
D 1 . . . 1 .
C . . 1 . . 1
E . . . . . .
F . . . . . .
>
```

```
> get.adjlist(u_graph)
$A
+ 3/8 vertices, named, from 535b776:
[1] B C D

$B
+ 3/8 vertices, named, from 535b776:
[1] A C F

$C
+ 5/8 vertices, named, from 535b776:
[1] A B D F E

$D
+ 3/8 vertices, named, from 535b776:
[1] A C E

$F
+ 4/8 vertices, named, from 535b776:
[1] B C E G
```

```
$E
+ 3/8 vertices, named, from 535b776:
[1] C D F

$G
+ 2/8 vertices, named, from 535b776:
[1] F H

$H
+ 1/8 vertex, named, from 535b776:
[1] G

> get.adjlist(d_graph)
$A
+ 5/6 vertices, named, from 5365b0b:
[1] B B D D C

$B
+ 5/6 vertices, named, from 5365b0b:
[1] A A C E F
```

```
$D
+ 4/6 vertices, named, from 5365b0b:
[1] A A C E

$C
+ 4/6 vertices, named, from 5365b0b:
[1] A B D F

$E
+ 2/6 vertices, named, from 5365b0b:
[1] B D

$F
+ 2/6 vertices, named, from 5365b0b:
[1] B C
```

Practical 2

Aim: Perform following tasks:

- **View data collection forms and/or import onemode/two-mode datasets.**
- **Basic Networks matrices transformations.**

Software(s) used:

- **R ver. 4.1.3**
- **RStudio ver. 2022.02.0+433**

External packages required:

- **igraph**

Description:

- **The igraph package: igraph is a library and R package for network analysis.**
  The main goals of the igraph library is to provide a set of data types and functions for:
  - **pain-free implementation of graph algorithms,**
  - **fast handling of large graphs, with millions of vertices and edges, allowing rapid prototyping via high level languages like R.**
- **getwd(): Used to get the absolute filepath of the current R session.**
- **require(): library() and require() load and attach add-on packages.**

- **read.csv(): Reads a file in table format and creates a data frame from it, with cases corresponding to lines and variables to fields in the file.**

- **head(): Returns the first part of a vector, matrix, table, data frame or function. Since head() and tail() are generic functions, they may also have been extended to other classes.**

- **graph.data.frame(): This function creates an igraph graph from one or two data frames containing the (symbolic) edge list and edge/vertex attributes.**

- **get.adjacency(): Sometimes it is useful to work with a standard representation of a graph, like an adjacency matrix.**

- **plot(): Draw a scatter plot with decorations such as axes and titles in the active graphics window.**

<u>Source Code:</u>

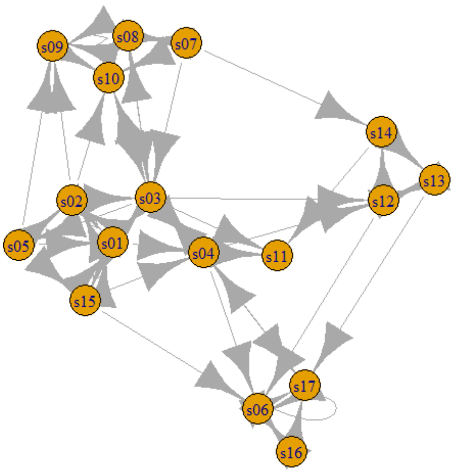
```
require(”igraph”)

edges  - read.csv(”C:/Temp/input_files/edges.csv”)
nodes  -
read.csv(”C:/Temp/input_files/nodes.csv”)

head(edges)
head(nodes)

dir_graph  - graph.data.frame(d = edges, vertices =
nodes, directed = T)
get.adjacency(dir_graph)

plot(dir_graph)
```

Output:

```
> require("igraph")
>
> edges <- read.csv("C:/Temp/input_files/edges.csv")
> nodes <- read.csv("C:/Temp/input_files/nodes.csv")
>
> head(edges)
  from  to weight      type
1  s01 s02     10 hyperlink
2  s01 s02     12 hyperlink
3  s01 s03     22 hyperlink
4  s01 s04     21 hyperlink
5  s04 s11     22   mention
6  s05 s15     21   mention
> head(nodes)
   id               media media.type type.label audience.size
1 s01            NY Times          1  Newspaper            20
2 s02     Washington Post          1  Newspaper            25
3 s03 Wall Street Journal          1  Newspaper            30
4 s04           USA Today          1  Newspaper            32
5 s05            LA Times          1  Newspaper            20
6 s06       New York Post          1  Newspaper            50
>
```

```
> dir_graph <- graph.data.frame(d = edges, vertices = nodes, directed = T)
> get.adjacency(dir_graph)
17 x 17 sparse Matrix of class "dgCMatrix"
   [[ suppressing 17 column names 's01', 's02', 's03'  ... ]]

s01 . 2 1 1 . . . . . . . . . . 1 . .
s02 1 . 1 . . . . . 1 1 . . . . . . .
s03 1 . . 1 1 . . 1 . 1 1 1 . . . . .
s04 . . 1 . . 1 . . . . 1 1 . . . . 1
s05 1 1 . . . . . . 1 . . . . . 1 . .
s06 . . . . . 1 . . . . . . . . . 1 1
s07 . . 1 . . . . 1 . 1 . . . 1 . . .
s08 . . 1 . . . 1 . 2 . . . . . . . .
s09 . . . . . . . . . 1 . . . . . . .
s10 . . 1 . . . . . . . . . . . . . .
s11 . . . . . . . . . . . . . . . . .
s12 . . . . . 1 . . . . . . 1 1 . . .
s13 . . . . . . . . . . . 1 . . . . 1
s14 . . . . . . . . . . 1 . 1 . . . .
s15 2 . . 1 . 1 . . . . . . . . . . .
s16 . . . . . 1 . . . . . . . . . . 1
s17 . . . 1 . . . . . . . . . . . . .
```

```
>
> plot(dir_graph)
>
```



Practical 3

Aim: Compute the following node level measures:

- Density
- Degree
- Reciprocity
- Transitivity
- Centralization
- Clustering.

Software(s) used:

- R ver. 4.1.3
- RStudio ver. 2022.02.0+433

External packages required:

- igraph

Description:

- The igraph package: igraph is a library and R package for network analysis.
  The main goals of the igraph library is to provide a set of data types and functions for:
  - pain-free implementation of graph algorithms,
  - fast handling of large graphs, with millions of vertices and edges, allowing rapid prototyping via high level languages like R.

- library(): library() and require() load and attach add-on packages.
- graph.famous(): Create an igraph graph from a list of edges, or a notable graph.
- ecount(): Returns the count of number of edges in graph
- vcount(): Returns the count of number of vertices in graph
- graph.formula(): This function is useful if you want to create a small (named) graph quickly, it works for both directed and undirected graphs.
- plot(): Draw a scatter plot with decorations such as axes and titles in the active graphics window.
- reciprocity(): Calculates the reciprocity of a directed graph.
- dyad.census(): Classify dyads in a directed graphs. The relationship between each pair of vertices is measured. It can be in three states: mutual, asymmetric or non-existent.
- adjacent.triangles(): Count how many triangles a vertex is part of, in a graph, or just list the triangles of a graph.
- transitivity(): Transitivity measures the probability that the adjacent vertices of a vertex are connected. This is sometimes also called the clustering coefficient.
- degree(): The degree of a vertex is its most basic structural property, the number of its adjacent edges.

- **barabasi.game()**: The BA-model is a very simple stochastic algorithm for building a graph.
- **watts.strogatz.game()**: Generate a graph according to the Watts-Strogatz network model.
- **graph.union()**: The union of two or more graphs are created. The graphs may have identical or overlapping vertex sets.
- **simplify()**: Simple graphs are graphs which do not contain loop and multiple edges.

Source Code:

```
library("igraph")


kite -
graph.famous("Krackhardt_Kite")
vcount(kite)
ecount(kite)
ecount(kite) / (vcount(kite) * (vcount(kite) - 1) / 2)


dir_graph - graph.formula(A + B, A + D, A -+ C, B -+ C, B -+
E, B -+ F, C -+ D, C -+ F, D -+ E)
plot(dir_graph)
reciprocity(dir_graph)
dyad.census(dir_graph)
mutual - dyad.census(dir_graph)$mut
```

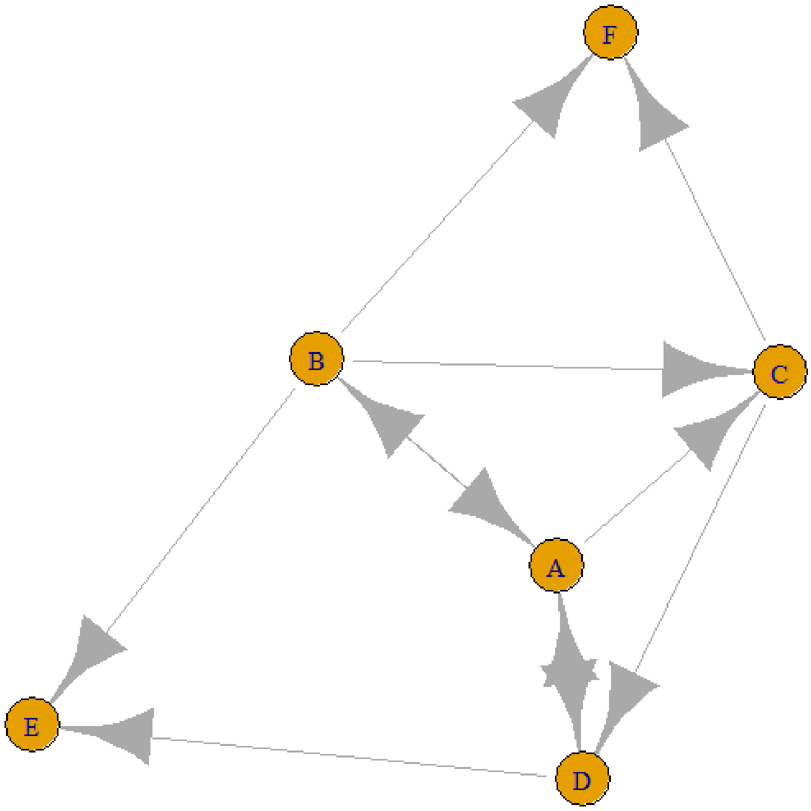
```
mutual / (ecount(dir_graph))

atri - adjacent.triangles(kite)
plot(kite, vertex.label = atri)
transitivity(kite, type =
"local")
adjacent.triangles(kite) / (degree(kite) * (degree(kite) -
1) / 2)

graph_2  - barabasi.game(50, p = 2, directed = F)
graph_1  - watts.strogatz.game(1, size = 100, nei = 5, p =
0.05)
graph - graph.union(graph_1,
graph_2) graph  -  simplify(graph)
plot(graph)
```

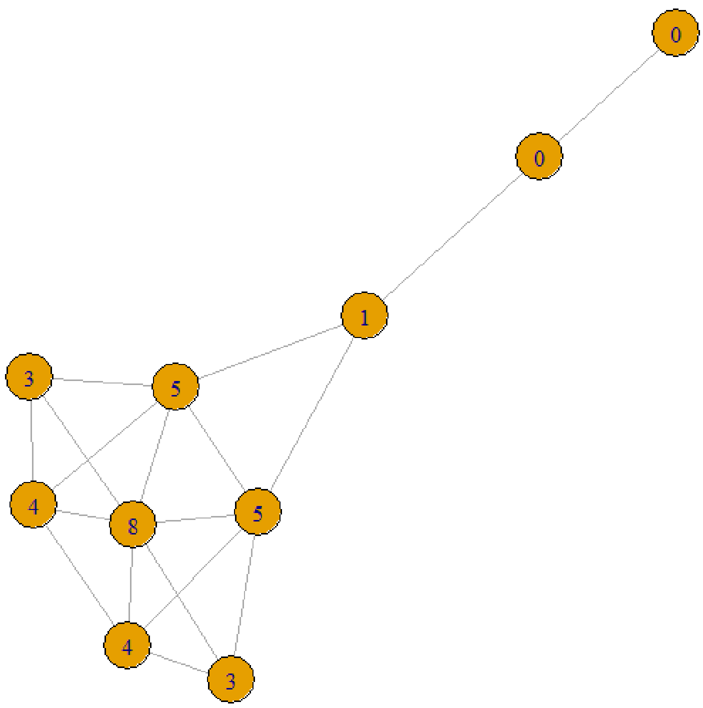
Output:

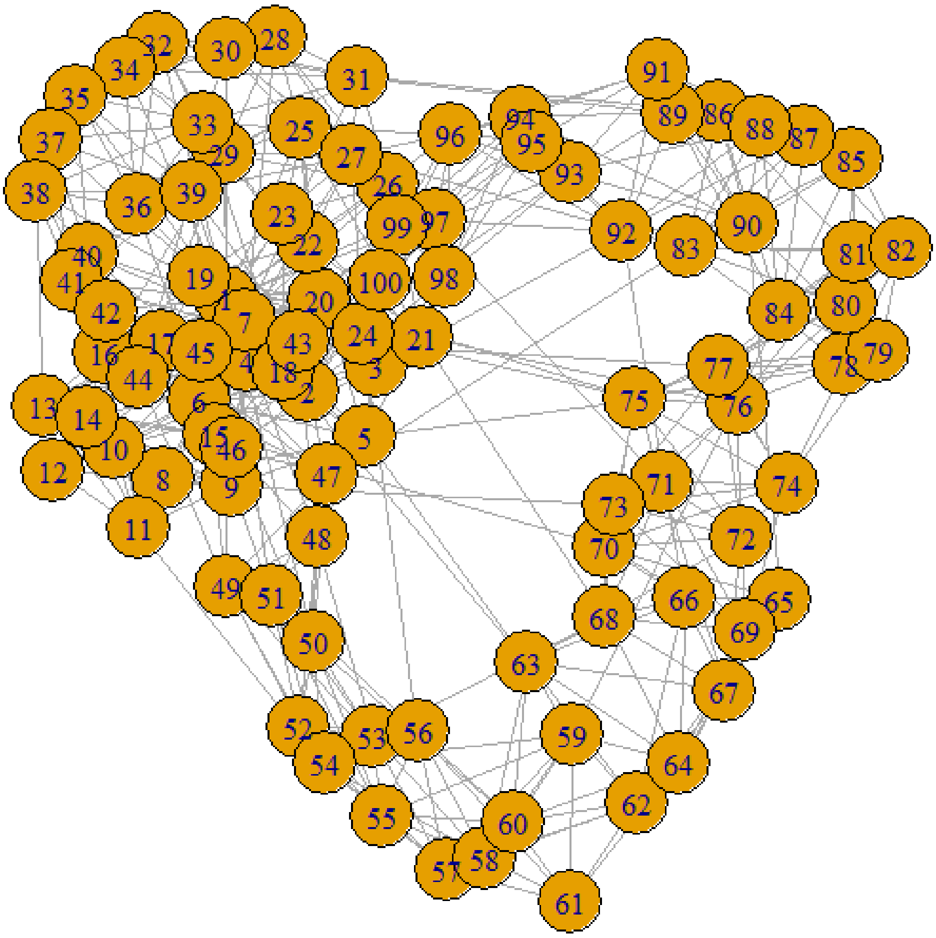
```
> library("igraph")
>
> kite ← graph.famous("Krackhardt_Kite")
> vcount(kite)
[1] 10
> ecount(kite)
[1] 18
> ecount(kite) / (vcount(kite) * (vcount(kite) - 1) / 2)
[1] 0.4
>
> dir_graph ← graph.formula(A ++ B, A ++ D, A -+ C, B -+ C, B -+ E, B -+ F, C -+ D, C -+ F, D -+ E)
> plot(dir_graph)
> reciprocity(dir_graph)
[1] 0.3636364
```

```
> reciprocity(dir_graph)
[1] 0.3636364
> dyad.census(dir_graph)
$mut
[1] 2

$asym
[1] 7

$null
[1] 6

> mutual <- dyad.census(dir_graph)$mut
> mutual / (ecount(dir_graph))
[1] 0.1818182
>
> atri <- adjacent.triangles(kite)
> plot(kite, vertex.label = atri)
> transitivity(kite, type = "local")
 [1] 0.6666667 0.6666667 1.0000000 0.5333333 1.0000000 0.5000000 0.5000000 0.3333333 0.0000000
[10]       NaN
```

```
> adjacent.triangles(kite) / (degree(kite) * (degree(kite) - 1) / 2)
 [1] 0.6666667 0.6666667 1.0000000 0.5333333 1.0000000 0.5000000 0.5000000 0.3333333 0.0000000
[10]       NaN
>
> graph_2 <- barabasi.game(50, p = 2, directed = F)
> graph_1 <- watts.strogatz.game(1, size = 100, nei = 5, p = 0.05)
> graph <- graph.union(graph_1, graph_2)
> graph <- simplify(graph)
> plot(graph)
```


F
B
C
A
E
D


0
0
1
3
5
4
8
5
4
3


1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100

Practical 4

Aim: For a given network find the following:

- ♦ Length of the shortest path from a given node to another node
- ♦ The density of the graph
- ♦ Draw egocentric network of node G with chosen configuration parameters.

Software(s) used:

- ♦ R ver. 4.1.3
- ♦ RStudio ver. 2022.02.0+433

External packages required:

- ♦ igraph

Description:

- The igraph package: igraph is a library and R package for network analysis.
  The main goals of the igraph library is to provide a set of data types and functions for:
  - ♦ pain-free implementation of graph algorithms,
  - ♦ fast handling of large graphs, with millions of vertices and edges, allowing rapid prototyping via high level languages like R.
- library(): library() and require() load and attach add-on packages.

- **as.matrix():** matrix() creates a matrix from the given set of values. as.matrix() attempts to turn its argument into a matrix.

- **read.table():** Reads a file in table format and creates a data frame from it, with cases corresponding to lines and variables to fields in the file.

- **colnames() and rownames():** Retrieve or set the row or column names of a matrix-like object.

- **is.na():** The generic function is.na() indicates which elements are missing.

- **graph.adjacency():** graph_from_adjacency_matrix() is a flexible function for creating igraph graphs from adjacency matrices.

- **plot():** Draw a scatter plot with decorations such as axes and titles in the active graphics window.

- **shortest.paths():** shortest_paths() calculates one shortest path (the path itself, and not just its length) from or to the given vertex.

- **print():** print() prints its argument and returns it invisibly.

- **graph.formula():** This function is useful if you want to create a small (named) graph quickly, it works for both directed and undirected graphs.

- **graph.density():** The density of a graph is the ratio of the number of edges and the number of possible edges.

- **simplify()**: Simple graphs are graphs which do not contain loop and multiple edges.

Source Code:

```
library(igraph)

matt - as.matrix(read.table(text=
                                        "node R S T U
                                              R 7 5 0 0
                                              S 7 0 0 2
                                              T 0 6 0 0
                                              U 4 0 1 0",  header=T))

nms  - matt[, 1]

matt - matt[, -1]

colnames(matt) - rownames(matt) - nms

matt[is.na(matt)] - 0

g -                                          )
graph.adjacency(matt,weighted=TRUE

plot(g)


s.paths  – shortest.paths(g, algorithm =

"dijkstra") print(s.paths)


shortest.paths(g, v="R", to="S")

plot(g, edge.label=E(g)$weight)
```

dg - graph.formula(1-+2, 1-+3, 2 +3)

plot(dg)

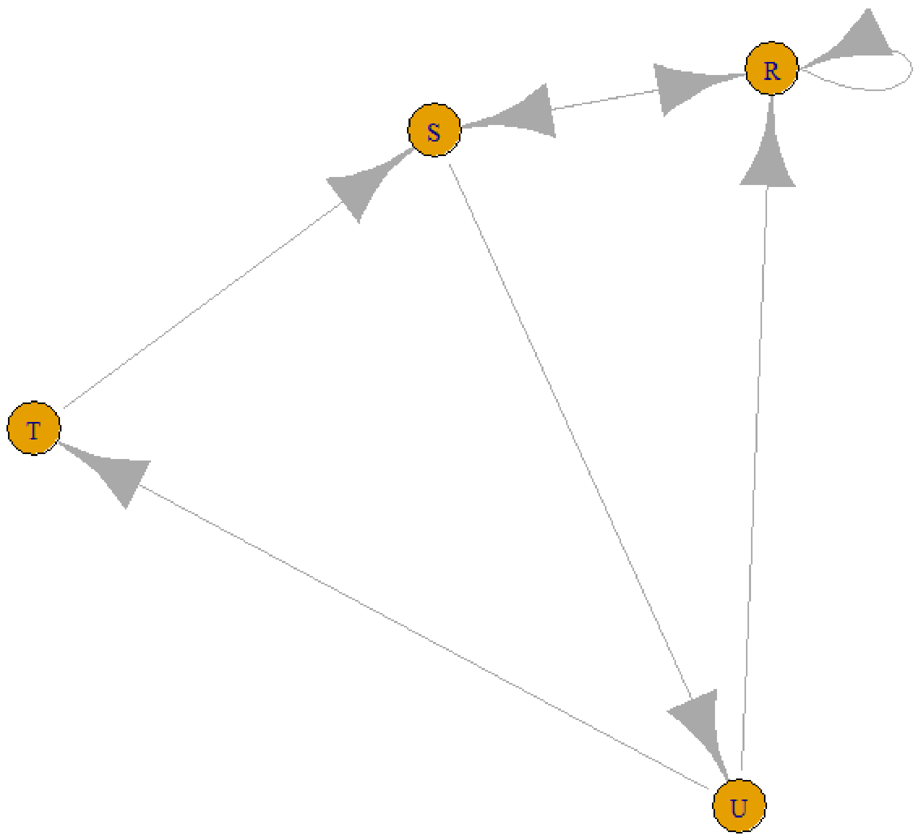
graph.density(dg, loops=TRUE)

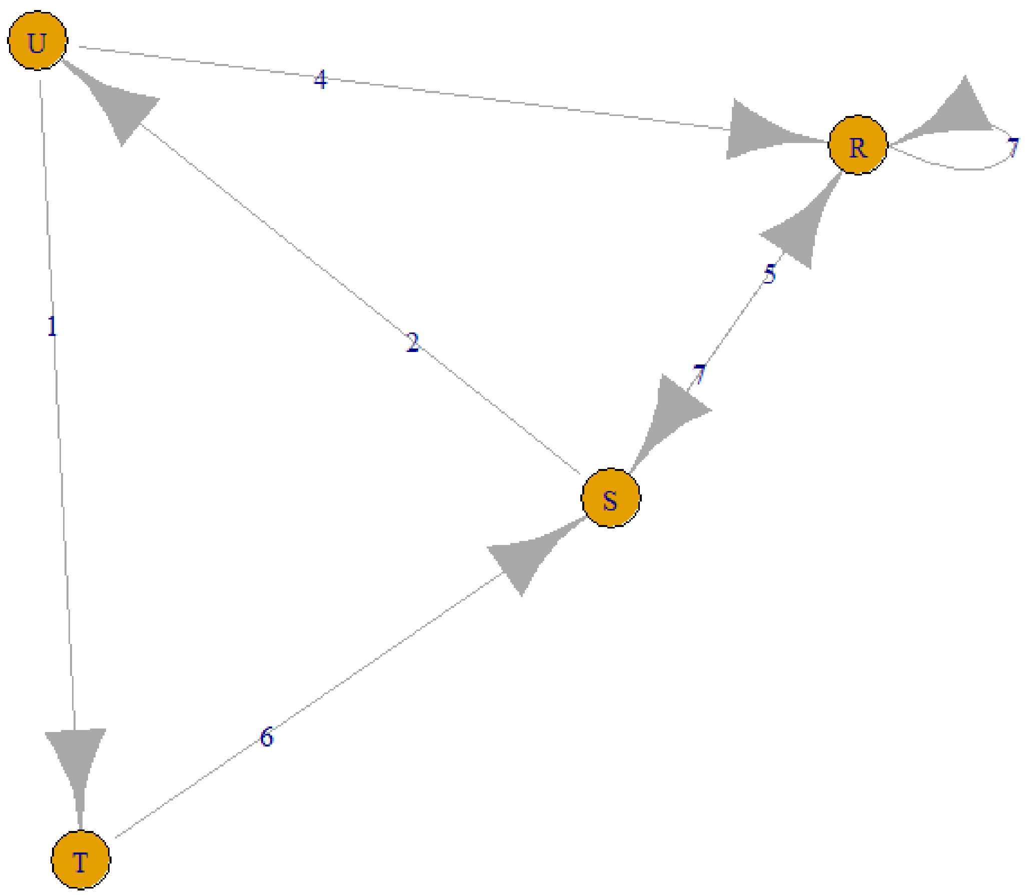
graph.density(simplify(dg), loops=FALSE)

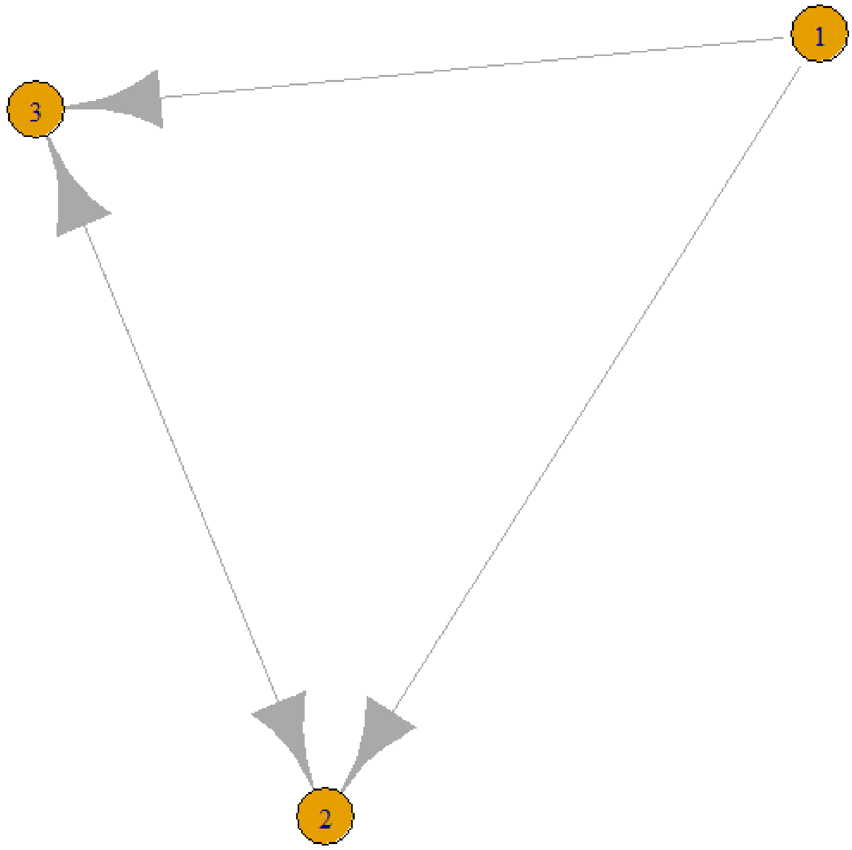
Output:

```
> library(igraph)
> matt ← as.matrix(read.table(text=
+                                  "node R S T U
+                                        R 7 5 0 0
+                                        S 7 0 0 2
+                                        T 0 6 0 0
+                                        U 4 0 1 0", header=T))
> nms ← matt[, 1]
> matt ← matt[, -1]
> colnames(matt) ← rownames(matt) ← nms
> matt[is.na(matt)] ← 0
> g ← graph.adjacency(matt,weighted=TRUE)
> plot(g)
>
> s.paths ← shortest.paths(g, algorithm = "dijkstra")
> print(s.paths)
  R S T U
R 0 5 5 4
S 5 0 3 2
T 5 3 0 1
U 4 2 1 0
>
```

```
> shortest.paths(g, v="R", to="S")
  S
R 5
> plot(g, edge.label=E(g)$weight)
>
> dg <- graph.formula(1-+2, 1-+3, 2++3)
> plot(dg)
>
> graph.density(dg, loops=TRUE)
[1] 0.4444444
> graph.density(simplify(dg), loops=FALSE)
[1] 0.6666667
>
```




U
R
S
T
4
7
5
7
2
1
6


1
3
2

Practical 5

<u>Aim</u>: Write a program to distinguish between a network as a matrix, a network as an edge list and a network as a sociogram (or "network graph") using 3 distinct networks representatives of each.

<u>Software(s) used:</u>

- **R ver. 4.1.3**
- **RStudio ver. 2022.02.0+433**

<u>External packages required:</u>

- **igraph**

<u>Description</u>:

- **The igraph package: igraph is a library and R package for network analysis.**
  The main goals of the igraph library is to provide a set of data types and functions for:
  - **pain-free implementation of graph algorithms,**
  - **fast handling of large graphs, with millions of vertices and edges, allowing rapid prototyping via high level languages like R.**
- **library(): library() and require() load and attach add-on packages.**

- **graph.formula():** This function is useful if you want to create a small (named) graph quickly, it works for both directed and undirected graphs.
- **plot():** Draw a scatter plot with decorations such as axes and titles in the active graphics window.
- **get.adjacency():** Sometimes it is useful to work with a standard representation of a graph, like an adjacency matrix.
- **E():** An edge sequence is a vector containing numeric edge ids, with a special class attribute that allows custom operations:
  selecting subsets of edges based on attributes, or graph structure, creating the intersection, union of edges, etc.
- **get.adjedgelist():** Create adjacency lists from a graph, either for adjacent edges or for neighboring vertices.

Source Code:

```
library(igraph)


sociogram  -  graph.formula(Andy  +Garth,Garth-+Bill,Bill-
                                      +Elena,Elena +Frank,Carol-
                                      +Andy,Carol-+Elena,Carol+
                                      +Dan,Carol  +Bill,Dan
                                       +Andy,  Dan  +Bill)


plot(sociogram)
```

get.adjacency(sociogra

m) E(sociogram)

get.adjedgelist(sociogram

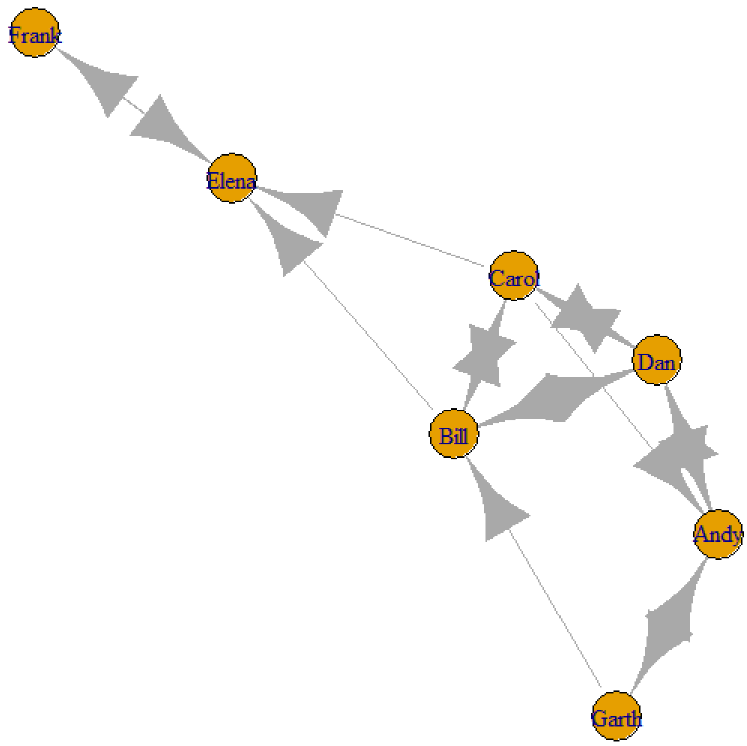
)

<u>Output:</u>

```
> library(igraph)
>
> sociogram <- graph.formula(Andy++Garth,Garth-+Bill,Bill-
+                           +Elena,Elena++Frank,Carol-+Andy,Carol-
+                           +Elena,Carol++Dan,Carol++Bill,Dan++Andy,Dan++Bill)
>
> plot(sociogram)
>
> get.adjacency(sociogram)
7 x 7 sparse Matrix of class "dgCMatrix"
      Andy Garth Bill Elena Frank Carol Dan
Andy     .     1    .     .     .     .   1
Garth    1     .    1     .     .     .   .
Bill     .     .    .     1     .     1   1
Elena    .     .    .     .     1     .   .
Frank    .     .    .     1     .     .   .
Carol    1     .    1     1     .     .   1
Dan      1     .    1     .     .     1   .
```

```
> E(sociogram)
+ 16/16 edges from f262a60 (vertex names):
 [1] Andy ->Garth Andy ->Dan   Garth->Andy  Garth->Bill
 [5] Bill ->Elena Bill ->Carol Bill ->Dan   Elena->Frank
 [9] Frank->Elena Carol->Andy  Carol->Bill  Carol->Elena
[13] Carol->Dan   Dan  ->Andy  Dan  ->Bill  Dan  ->Carol
> get.adjedgelist(sociogram)
$Andy
+ 5/16 edges from f262a60 (vertex names):
[1] Andy ->Garth Andy ->Dan   Garth->Andy  Carol->Andy
[5] Dan  ->Andy

$Garth
+ 3/16 edges from f262a60 (vertex names):
[1] Garth->Andy  Garth->Bill  Andy ->Garth

$Bill
+ 6/16 edges from f262a60 (vertex names):
[1] Bill ->Elena Bill ->Carol Bill ->Dan   Garth->Bill
[5] Carol->Bill  Dan  ->Bill
```

```
$Elena
+ 4/16 edges from f262a60 (vertex names):
[1] Elena->Frank Bill ->Elena Frank->Elena Carol->Elena

$Frank
+ 2/16 edges from f262a60 (vertex names):
[1] Frank->Elena Elena->Frank

$Carol
+ 6/16 edges from f262a60 (vertex names):
[1] Carol->Andy  Carol->Bill  Carol->Elena Carol->Dan
[5] Bill ->Carol Dan  ->Carol

$Dan
+ 6/16 edges from f262a60 (vertex names):
[1] Dan  ->Andy  Dan  ->Bill  Dan  ->Carol Andy ->Dan
[5] Bill ->Dan   Carol->Dan
```



Practical 6

Aim: **Write a program to exhibit structural equivalence, automatic equivalence, and regular equivalence from a network.**

Software(s) used:

- **R ver. 4.1.3**
- **RStudio ver. 2022.02.0+433**

External packages required:

- **igraph**
- **sna**

Description:

- **The igraph package: igraph is a library and R package for network analysis.**
  The main goals of the igraph library is to provide a set of data types and functions for:
  - **pain-free implementation of graph algorithms,**
  - **fast handling of large graphs, with millions of vertices and edges, allowing rapid prototyping via high level languages like R.**
- **The sna package: sna is a package containing a range of tools for social network analysis. Supported functionality includes node and graph-level indices, structural distance and covariance methods, structural equivalence detection, p* modeling, random graph generation, and 2D/3D network visualization (among other things).**

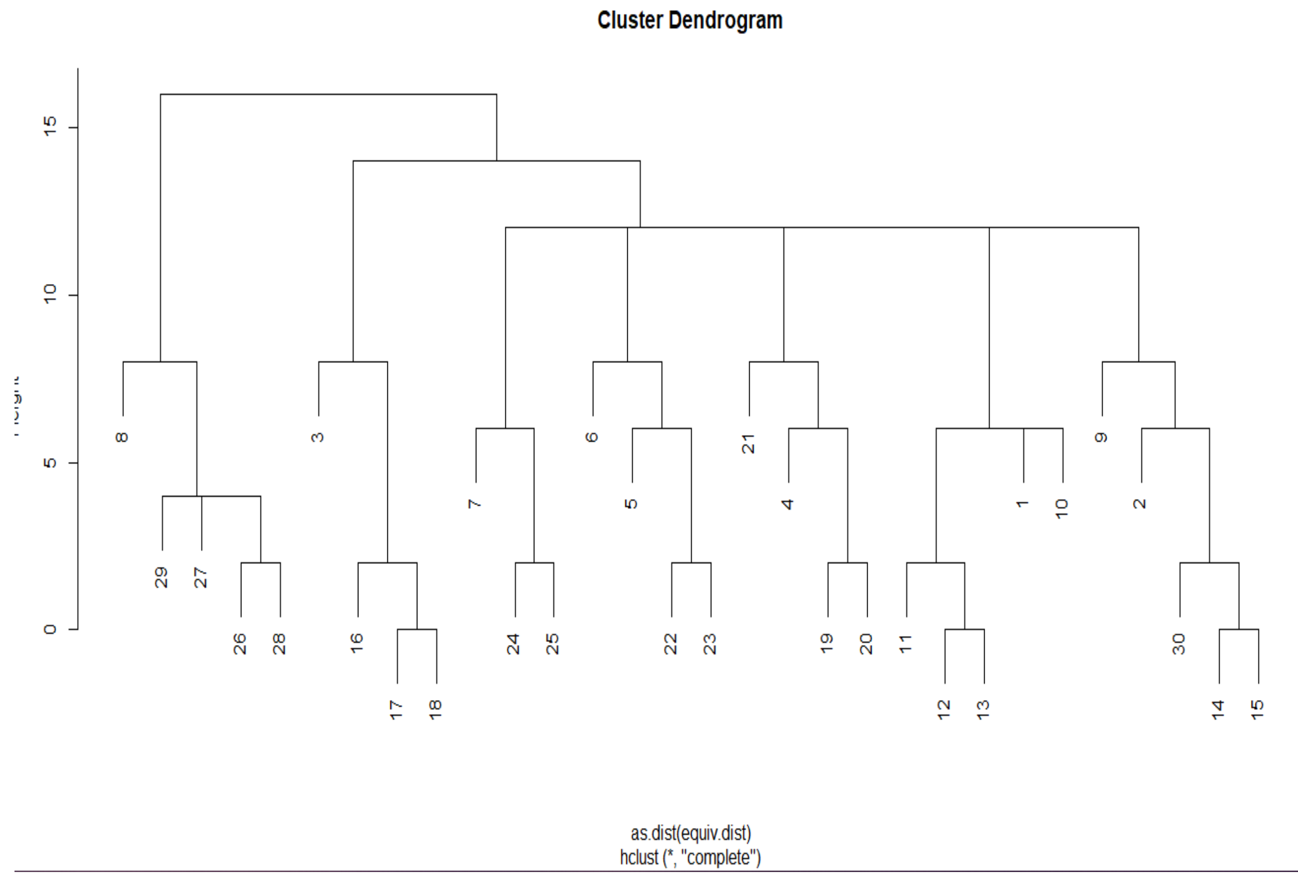
- **library():** library() and require() load and attach add-on packages.
- **read.csv():** Reads a file in table format and creates a data frame from it, with cases corresponding to lines and variables to fields in the file.
- **equiv.clust():** equiv.clust() uses a definition of approximate equivalence (equiv.fun()) to form a hierarchical clustering of network positions.
- **plot():** Draw a scatter plot with decorations such as axes and titles in the active graphics window.
- **sedist():** sedist() uses the graphs indicated by g in the arguments to assess the extent to which each vertex is structurally equivalent.
- **cmdscale():** Classical multidimensional scaling (MDS) of a data matrix.
- **as.dist():** This function computes and returns the distance matrix computed by using the specified distance measure to compute the distances between the rows of a data matrix.
- **blockmodel():** Given a set of equivalence classes and one or more graphs, blockmodel will form a blockmodel of the input graph(s) based on the classes in question

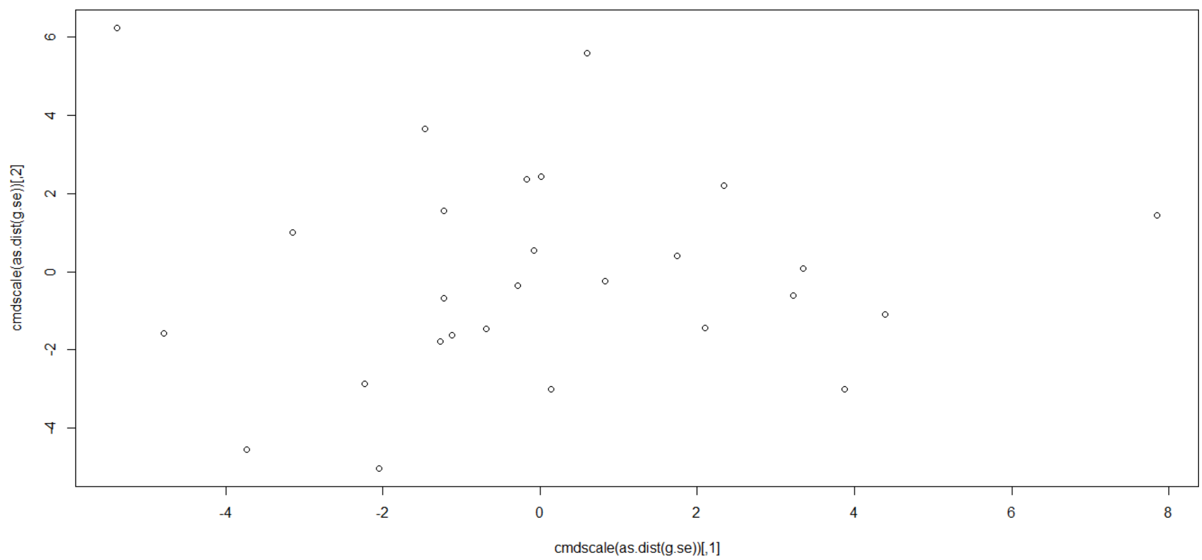
Source Code:

```
library(sna)

library(igrap

h)

links2   - read.csv(”C:/Temp/input_files/edges1.csv”,
header=T, row.names=1)

eq  -equiv.clust(links2)

plot(eq)


g.se -sedist(links2)


plot(cmdscale(as.dist(g.se)))

b -blockmodel(links2,eq,h=10)

plot(b)
```

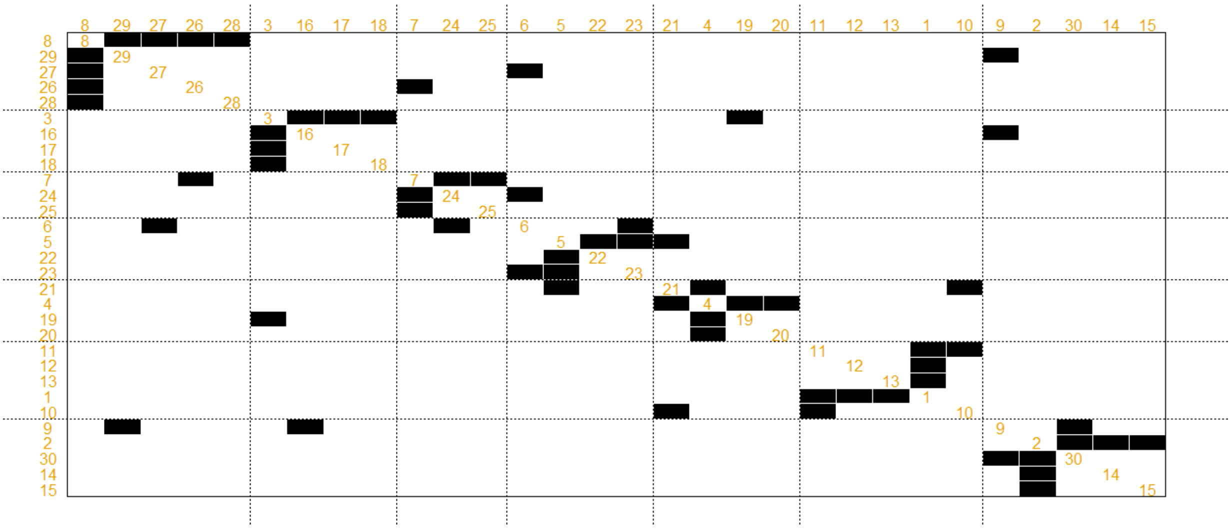
Output:

```
> library(sna)
> library(igraph)
> links2 <- read.csv("C:/Temp/input_files/edges1.csv", header=T, row.names=1)
> eq<-equiv.clust(links2)
> plot(eq)
>
> g.se<-sedist(links2)
>
> plot(cmdscale(as.dist(g.se)))
> b<-blockmodel(links2,eq,h=10)
> plot(b)
>
```


Cluster Dendrogram
as.dist(equiv.dist)
hclust (*, "complete")


cmdscale(as.dist(g.se))[,2]
cmdscale(as.dist(g.se))[,1]

Relation - 1



Practical 7

Aim: **Perform SVD analysis of a network.**

Software(s) used:

- **R ver.** 4.1.3
- **RStudio ver.** 2022.02.0+433

External packages required:

- **igraph**

Description:

- **The igraph package: igraph is a library and R package for network analysis.**
  The main goals of the igraph library is to provide a set of data types and functions for:
  - **pain-free implementation of graph algorithms,**
  - **fast handling of large graphs, with millions of vertices and edges, allowing rapid prototyping via high level languages like R.**

- **matrix(): matrix() creates a matrix from the given set of values.**

- **c(): Combines values into a vector or list.**

- **print(): print() prints its argument and returns it invisibly.**

- **svd(): Compute the singular-value decomposition of a rectangular matrix.**

Source Code:

```
library(igraph)
a - matrix(c(1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 0, 0, 0, 0,
    0, 0, 0, 0, 0, 1, 1, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1,
    1), 9, 4)
print(a)
svd(a)
```

Output:

```
> library(igraph)
> a<- matrix(c(1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 0, 0, 0, 0, 0,
+             0, 0, 0, 0, 1, 1, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 1), 9, 4)
> print(a)
      [,1] [,2] [,3] [,4]
 [1,]    1    1    0    0
 [2,]    1    1    0    0
 [3,]    1    1    0    0
 [4,]    1    0    1    0
 [5,]    1    0    1    0
 [6,]    1    0    1    0
 [7,]    1    0    0    1
 [8,]    1    0    0    1
 [9,]    1    0    0    1
```

```
> svd(a)
$d
[1] 3.464102e+00 1.732051e+00 1.732051e+00 1.922963e-16

$u
            [,1]       [,2]          [,3]          [,4]
 [1,] -0.3333333  0.4714045 -1.741269e-16  7.760882e-01
 [2,] -0.3333333  0.4714045 -3.692621e-16 -1.683504e-01
 [3,] -0.3333333  0.4714045 -5.301858e-17 -6.077378e-01
 [4,] -0.3333333 -0.2357023 -4.082483e-01  6.774193e-17
 [5,] -0.3333333 -0.2357023 -4.082483e-01  6.774193e-17
 [6,] -0.3333333 -0.2357023 -4.082483e-01  6.774193e-17
 [7,] -0.3333333 -0.2357023  4.082483e-01  5.194768e-17
 [8,] -0.3333333 -0.2357023  4.082483e-01  5.194768e-17
 [9,] -0.3333333 -0.2357023  4.082483e-01  5.194768e-17

$v
           [,1]       [,2]          [,3] [,4]
[1,] -0.8660254  0.0000000 -4.378026e-17  0.5
[2,] -0.2886751  0.8164966 -2.509507e-16 -0.5
[3,] -0.2886751 -0.4082483 -7.071068e-01 -0.5
[4,] -0.2886751 -0.4082483  7.071068e-01 -0.5
```