Institute of Distance and Open Learning

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Subject Name – Social Network Analysis

BY

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Institute of Distance and Open Learning

(IDOL)

University of Mumbai

Certificate

This is to certify that **Mr Mohammed Maaz Shaikh** student of Masters of Computer Science, Part 2, Semester 3 has completed the specified term work in the subject of **Social Network Analysis** in satisfactorily manner within this institute as laid down by University of Mumbai during the academic year 2024 to 2025.

M.Sc. - CS Coordinator

Examiner

Date:

Guide

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Practical No 1

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

(i) number of edges,

(ii) number of nodes;

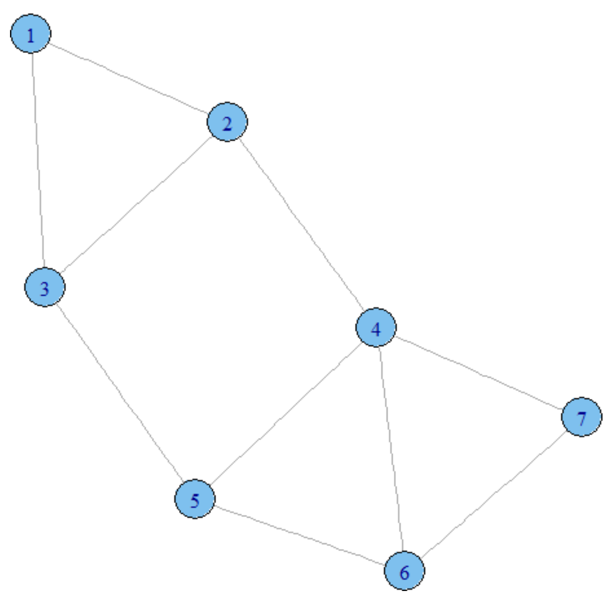
(iii) degree of node;

(iv) node with lowest degree;

(v)the adjacency list;

(vi) matrix of the graph

```
>library(igraph)
>g <- graph.formula(1-2, 1-3, 2-3, 2-4, 3-5, 4-5, 4-6,4-7, 5-6, 6-7)
>plot(g)
```



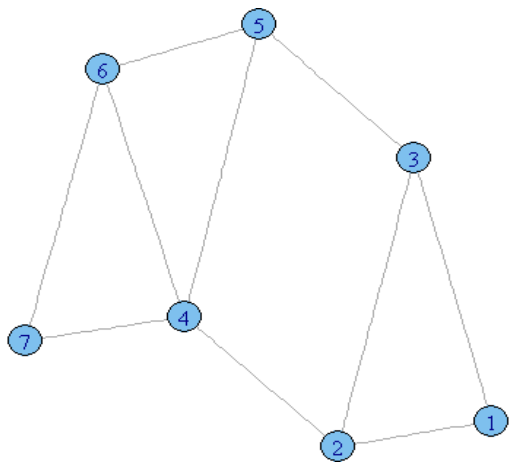
1) <u>Number of edges</u>

```
>ecount(g)
[1] 10
```

2) <u>No of nodes</u>

```
>vcount(g)
[1] 7
```

3) <u>Degree of nodes</u>



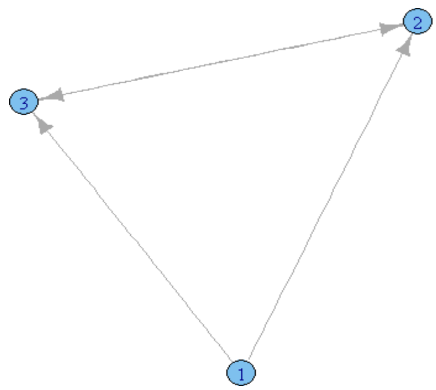
>degree(g)

1 2 3 4 5 6 7

2 3 3 4 3 3 2

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

>plot(dg)



>degree(dg, mode="in")

1 2 3

0 2 2

>degree(dg, mode="out")

1 2 3

2 1 1

4)<u>Node with lowest degree</u>

>V(dg)$name[degree(dg)==min(degree(dg))]

[1] "1"

<u>Node with highest degree</u>

>V(dg)$name[degree(dg)==max(degree(dg))]

[1] "2" "3"

5)<u>To find neighbors / adjacency list:</u>

>neighbors(g,5)

[1] 3 4 6

>neighbors(g,2)

[1] 1 3 4

>get.adjlist(dg)

$`1`

[1] 2 3

$`2`

[1] 1 3 3

$`3`

[1] 1 2 2

6) <u>Adjacency Matrix</u>

>get.adjacency(g)

7 x 7 sparse Matrix of class "dgCMatrix"

```
  1 2 3 4 5 6 7
1 . 1 1 . . . .
  2 1 . 1 1 . . .
  3 1 1 . . 1 . .
4 .1 . . 1 1 1
5 . . 1 1 .1 .
  6 . . . 1 1 . 1
  7 . . . 1 .1 .
```

Practical No 2

Perform following tasks:

(i) View data collection forms and/or import one-mode/ two-mode datasets;

(ii) Basic Networks matrices transformations.

(i) View data collection forms and/or import one-mode/ two-mode datasets.

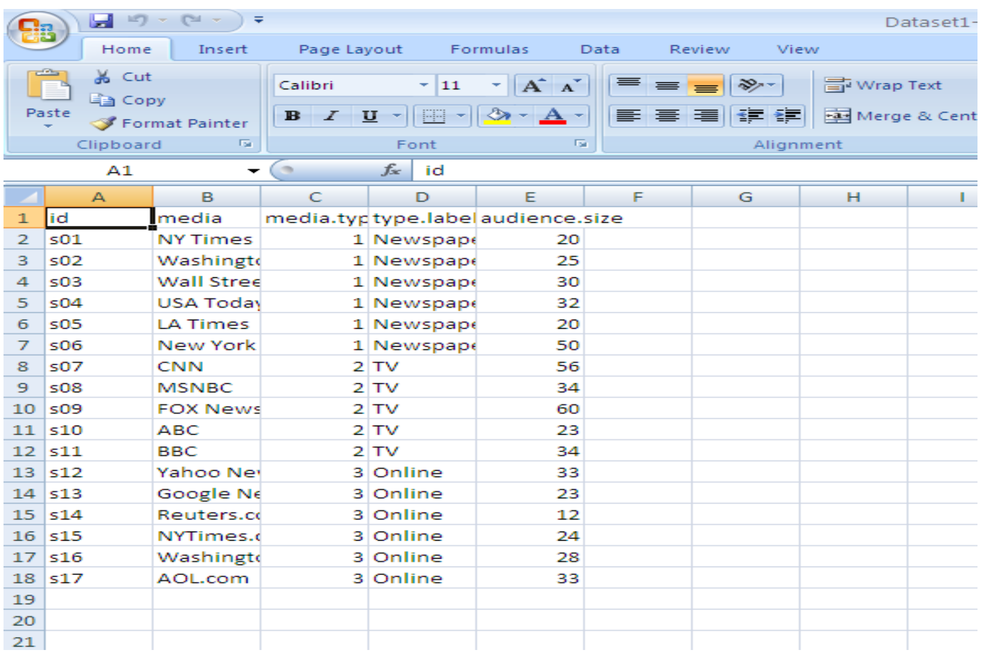
getwd()

[1] "C:/Users/admin/Documents"

>setwd("d:/sam")

Reading data from a csv file

>nodes<- read.csv("Dataset1-Media-Example-NODES.csv", header=T, , as.is=T)



	A	B	C	D	E
1	id	media	media.typ	type.label	audience.size
2	s01	NY Times	1	Newspape	20
3	s02	Washingto	1	Newspape	25
4	s03	Wall Stree	1	Newspape	30
5	s04	USA Today	1	Newspape	32
6	s05	LA Times	1	Newspape	20
7	s06	New York	1	Newspape	50
8	s07	CNN	2	TV	56
9	s08	MSNBC	2	TV	34
10	s09	FOX News	2	TV	60
11	s10	ABC	2	TV	23
12	s11	BBC	2	TV	34
13	s12	Yahoo Ne	3	Online	33
14	s13	Google Ne	3	Online	23
15	s14	Reuters.c	3	Online	12
16	s15	NYTimes.c	3	Online	24
17	s16	Washingto	3	Online	28
18	s17	AOL.com	3	Online	33

>head(nodes)

Output:-

id media media.typetype.labelaudience.size

1 s01 NY Times 1 Newspaper 20

2 s02 Washington Post 1 Newspaper 25

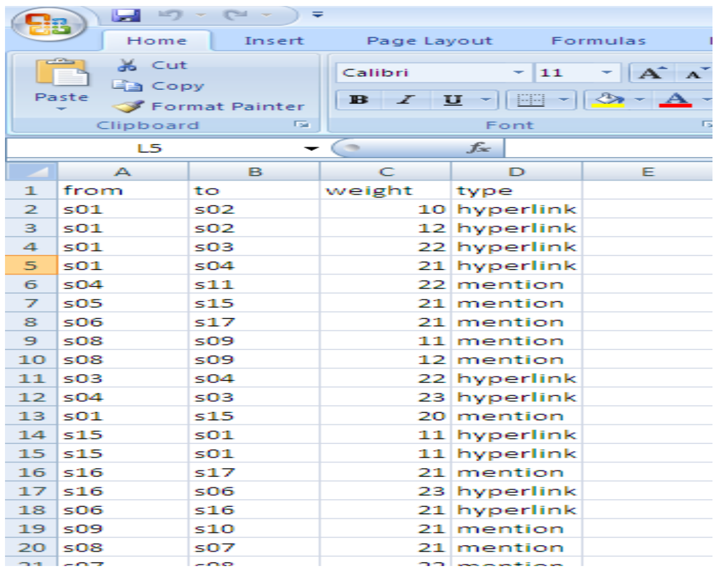
3 s03 Wall Street Journal 1 Newspaper 30

4 s04 USA Today 1 Newspaper 32

5 s05 LA Times 1 Newspaper 20

6 s06 New York Post 1 Newspaper 50

>links<- read.csv(“Dataset1-Media-Example-EDGES.csv", header=T, as.is=T)



	A	B	C	D
1	from	to	weight	type
2	s01	s02	10	hyperlink
3	s01	s02	12	hyperlink
4	s01	s03	22	hyperlink
5	s01	s04	21	hyperlink
6	s04	s11	22	mention
7	s05	s15	21	mention
8	s06	s17	21	mention
9	s08	s09	11	mention
10	s08	s09	12	mention
11	s03	s04	22	hyperlink
12	s04	s03	23	hyperlink
13	s01	s15	20	mention
14	s15	s01	11	hyperlink
15	s15	s01	11	hyperlink
16	s16	s17	21	mention
17	s16	s06	23	hyperlink
18	s06	s16	21	hyperlink
19	s09	s10	21	mention
20	s08	s07	21	mention

>head(links)

<u>Output:-</u>

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

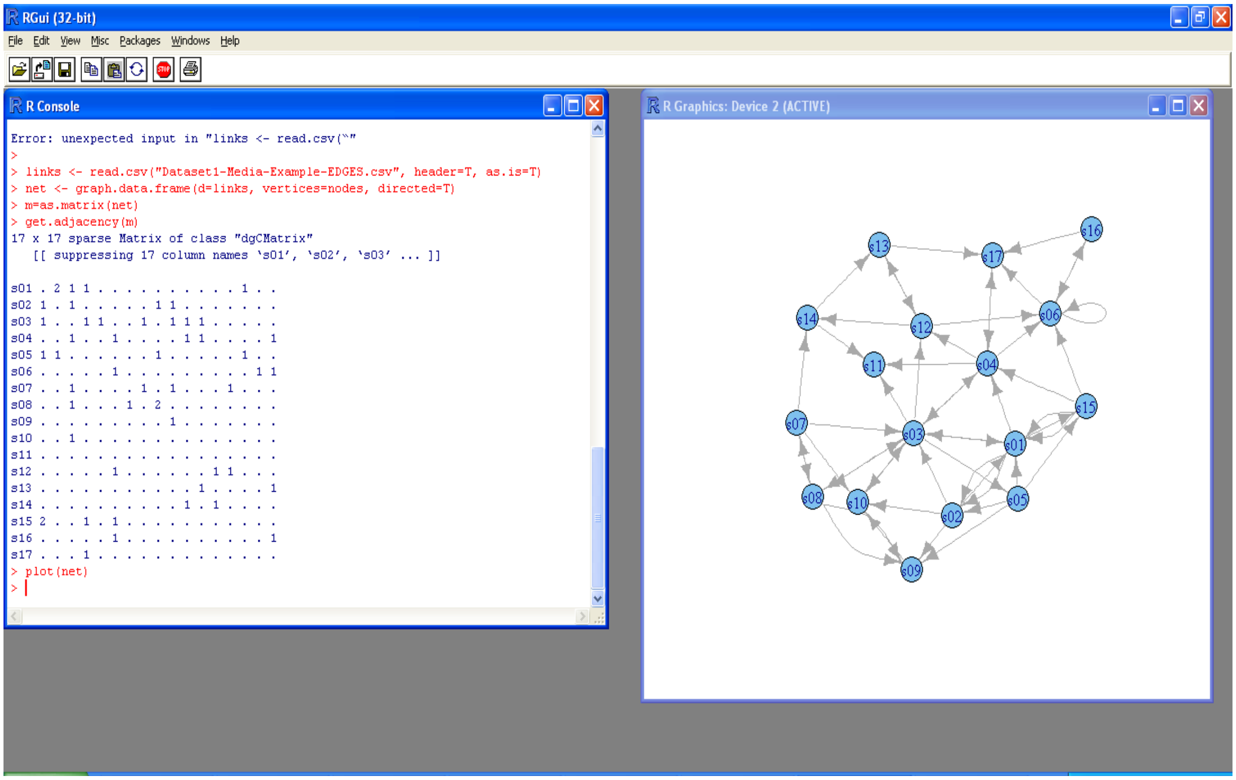
(ii) Basic Networks matrices transformations

>net<- graph.data.frame(d=links, vertices=nodes, directed=T)

> m=as.matrix(net)

>get.adjacency(m)

>plot(net)


RGui (32-bit)
File Edit View Misc Packages Windows Help
R Console
Error: unexpected input in "links <- read.csv(“"
>
> links <- read.csv("Dataset1-Media-Example-EDGES.csv", header=T, as.is=T)
> net <- graph.data.frame(d=links, vertices=nodes, directed=T)
> m=as.matrix(net)
> get.adjacency(m)
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(net)
>
R Graphics: Device 2 (ACTIVE)

Practical No 3

Compute the following node level measures:

(i) Density;

(ii) Degree;

(iii) Reciprocity;

(iv) Transitivity;

(v) Centralization;

(vi) Clustering.

1) Density

>vcount(g)

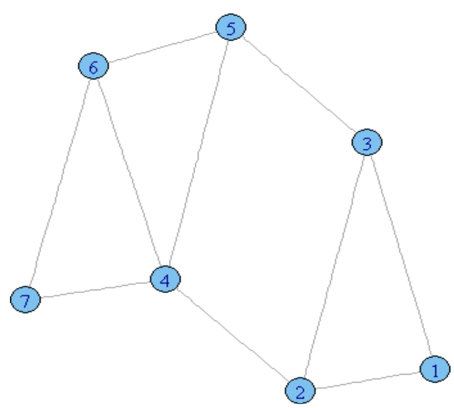
[1] 7

>ecount(g)

[1] 10

>ecount(g)/(vcount(g)*(vcount(g)-1)/2)

[1] 0.4719



2) Degree

>degree(net)

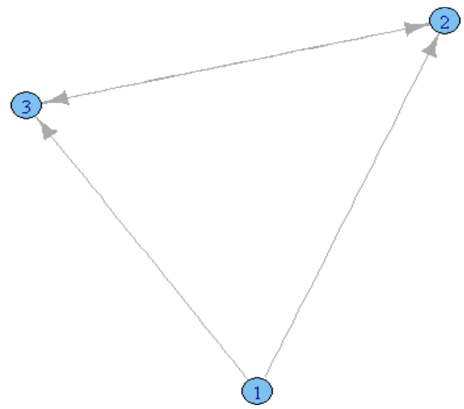
s01 s02 s03 s04 s05 s06 s07 s08 s09 s10 s11 s12

10 7 13 9 5 8 5 6 5 5 3 6

s13 s14 s15 s16 s17

4 4 6 3 5

3) Reciprocity:



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

>plot(dg)

>reciprocity(dg)

[1] 0.5

- **Formula**

>dyad.census(dg)

$mut

[1] 1

$asym

[1] 2

$null

[1] 0

> 2*dyad.census(dg)$mut/ecount(dg)

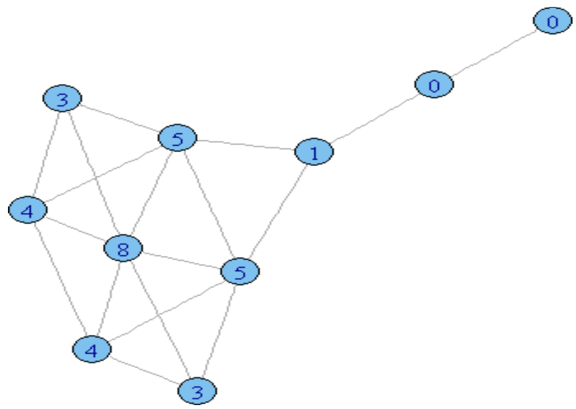
[1] 0.5

4) Transitivity

>kite<- graph.famous("Krackhardt_Kite")

>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

[7] 0.5000000 0.3333333 0.0000000 NaN

<u>Formula</u>

>adjacent.triangles(kite) / (degree(kite) * (degree(kite)-1)/2)

[1] 0.6666667 0.6666667 1.0000000 0.5333333 1.0000000 0.5000000

[7] 0.5000000 0.3333333 0.0000000 NaN

5) Centralization

- **<u>Degree of centrality</u>**

>centralization.degree(net, mode="in", normalized=T)

$res

[1] 5 3 6 4 1 5 1 2 4 4 3 3 2 2 2 1 4

$centralization

[1] 0.1838235

$theoretical_max

[1] 272

- **<u>Closeness Centralization</u>**

>closeness(net, mode="all", weights=NA)

s01 s02 s03 s04 s05 s06 s07

0.03333333 0.03030303 0.04166667 0.03846154 0.03225806 0.03125000 0.03030303

s08 s09 s10 s11 s12 s13 s14

```
0.02857143 0.02564103 0.02941176 0.03225806 0.03571429 0.02702703 0.02941176
       s15        s16        s17
0.03030303 0.02222222 0.02857143
>centralization.closeness(net, mode="all", normalized=T)
$res
 [1] 0.5333333 0.4848485 0.6666667 0.6153846 0.5161290 0.5000000 0.4848485
 [8] 0.4571429 0.4102564 0.4705882 0.5161290 0.5714286 0.4324324 0.4705882
[15] 0.4848485 0.3555556 0.4571429

$centralization
[1] 0.3753596

$theoretical_max
[1] 7.741935
```

- **Betweeness Centrality**

```
>betweenness(net, directed=T, weights=NA)
       s01        s02        s03        s04        s05        s06        s07
 26.857143   6.238095 126.511905  92.642857  13.000000  20.333333   1.750000
       s08        s09        s10        s11        s12        s13        s14
 21.000000   1.000000  15.000000   0.000000  33.500000  20.000000   4.000000
       s15        s16        s17
  5.666667   0.000000  58.500000
>edge.betweenness(net, directed=T, weights=NA)
[1]  6.619048  6.619048 11.785714  8.333333  6.500000 11.166667 21.333333
 [8]  4.250000  4.250000 16.000000 64.476190  9.500000  3.261905  3.261905
[15] 15.000000  1.000000 15.000000 17.000000 16.750000  2.000000  1.250000
[22] 8.000000 12.500000  4.000000 26.000000 18.000000 14.500000 17.000000
[29] 7.500000  4.500000  2.738095 23.000000 11.000000 31.000000   9.011905
[36] 18.000000 28.500000  0.000000  3.000000  6.500000 17.000000  8.666667
[43] 74.500000 11.750000 34.000000  4.500000  6.333333  8.809524  5.333333
[50] 3.000000 28.000000 10.000000
```

```
>centralization.betweenness(net, directed=T, normalized=T)

$res

 [1] 26.857143   6.238095 126.511905  92.642857  13.000000  20.333333

 [7]  1.750000  21.000000   1.000000  15.000000   0.000000  33.500000

[13] 20.000000   4.000000   5.666667   0.000000  58.500000

$centralization

[1] 0.4439329

$theoretical_max

[1] 3840
```

- **Eigenvector centrality**

```
>centralization.evcent(net, directed=T, normalized=T)

$vector

 [1] 0.7694528 0.5623895 1.0000000 0.8569443 0.3049992 0.9285033 0.1025656

 [8] 0.3362816 0.4696841 0.6510633 0.6361813 0.6479337 0.2674341 0.2289017

[15] 0.3277070 0.2831928 0.7125008

$value

[1] 3.278697

$options

$options$bmat

[1] "I"

$options$n

[1] 17

$options$which
[1] "LR"


$options$nev

[1] 1

$options$tol
```

```
$options$ncv

[1] 0

$options$ldv

[1] 0

$options$ishift

[1] 1

$options$maxiter

[1] 3000

$options$nb

[1] 1

$options$mode

[1] 1

$options$start

[1] 1

$options$sigma
[1] 0

$options$sigmai
[1] 0

$options$info
[1] 0

$options$iter
[1] 7

$options$nconv

[1] 1

$options$numop

[1] 31

$options$numopb
```

$options$numreo

[1] 18

$centralization

[1] 0.4946416

$theoretical_max

[1] 16

6) <u>Clustering</u>

>library(igraph)

 # let's generate two networks and merge them into one graph.

>g2 <- barabasi.game(50, p=2, directed=F)

>g1 <- watts.strogatz.game(1, size=100, nei=5, p=0.05)

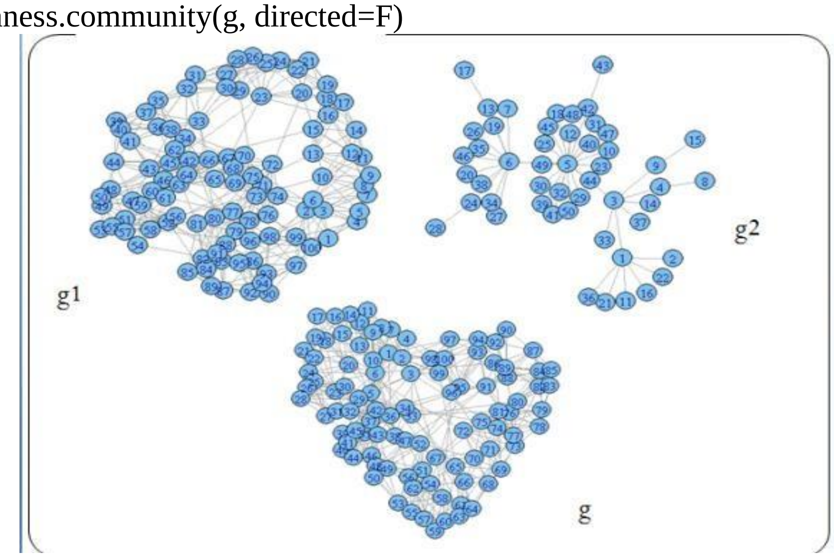
>g <- graph.union(g1,g2)

#Let's remove multi-edges and loops

>g <- simplify(g)

1st we calculate the edge betweenness,

>ebc<- edge.betweenness.community(g, directed=F)

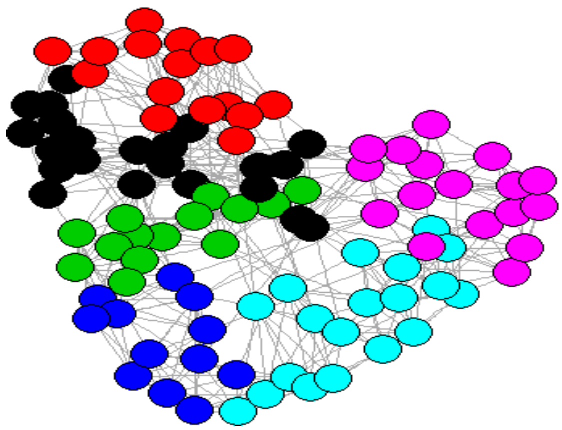


>mods<- sapply(0:ecount(g), function(i)

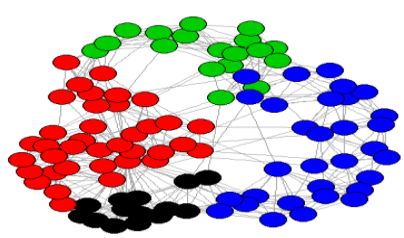
{

[1] 0

```
g2 <- delete.edges(g, ebc$removed.edges[seq(length=i)])
cl<- clusters(g2)$membership
modularity(g,cl)
    })
# Now, let's color the nodes according to their membership
>g2<-delete.edges(g, ebc$removed.edges[seq(length=which.max(mods)-1)])
>V(g)$color=clusters(g2)$membership
# Let's choose a layout for the graph
>g$layout<- layout.fruchterman.reingold
# plot it
>plot(g, vertex.label=NA)
```



```
# fastgreedy.communityagorithm
>fc<- fastgreedy.community(g)
>com<-community.to.membership(g, fc$merges, steps= which.max(fc$modularity)-1)
>V(g)$color <- com$membership+1
>g$layout<- layout.fruchterman.reingold
>plot(g, vertex.label=NA)
```



FASTGREEDY ALGORITHM

[1] 0

PRACTICAL NO 4

For a given network find the following:

(i) Length of the shortest path from a given node to another node;

(ii) The density of the graph;

(iii) Draw egocentric network of node G with chosen configuration parameters.

(i) Length of the shortest path from a given node to another node;

>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]

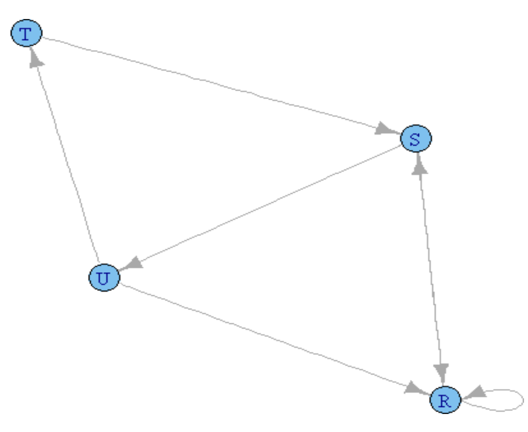
>matt<- matt[, -1]

>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)

[1] 0

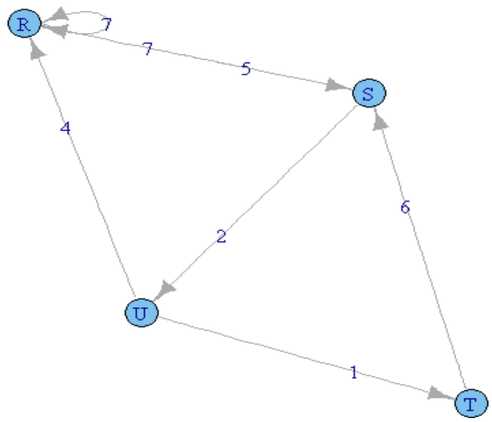
  R S T U

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

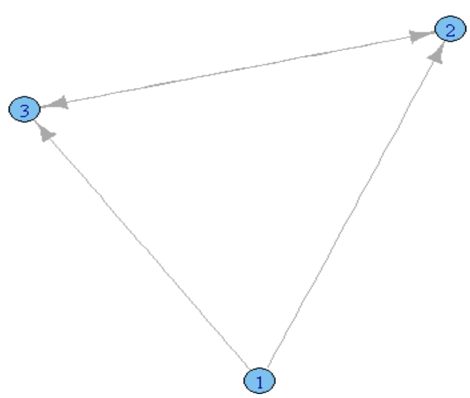
>plot(g, edge.label=E(g)$weight)

(ii) The density of the graph;

>library(igraph)

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

>plot(dg)



[1] 0

```
>graph.density(dg, loops=TRUE)
[1] 0.4444444
```

- Without considering loops

```
>graph.density(simplify(dg), loops=FALSE)
[1] 0.6666667
```

[1] 0

Practical No 5

Write a program to distinguish between:

i) a network as a sociogram (or “network graph”)

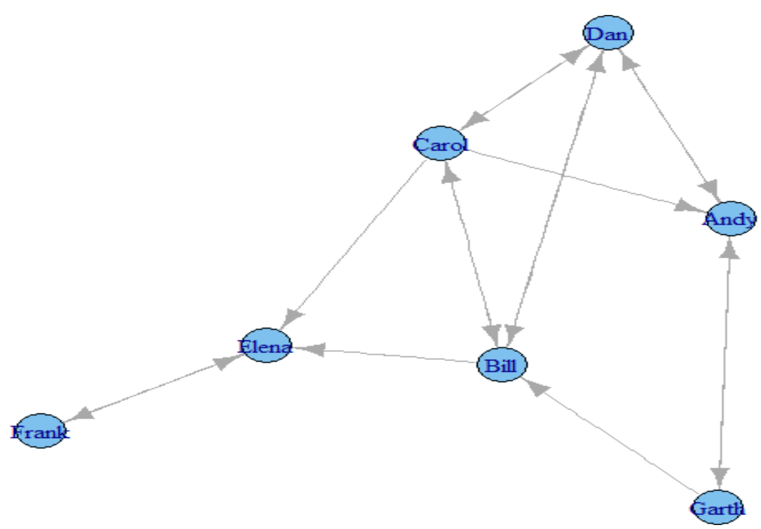
ii) a network as a matrix,&

iii) a network as an edge list.

Using 3 distinct networks representatives of each.

1) a network as a sociogram (or “network graph”)

```
>library(igraph)

> ng<-graph.formula(Andy++Garth,Garth-+Bill,Bill-+Elena,Elena++Frank,Carol-+Andy,Carol-
+Elena,Carol++Dan,Carol++Bill,Dan++Andy,Dan++Bill)

>plot(ng)
```



2) a network as a matrix,

```
>get.adjacency(ng)

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   .   .
```

[1] 0

Frank . . . 1 . . .

Carol 1 .1 1 . . 1

Dan 1 . 1 . . 1 .

3) a network as an edge list.

>E(ng)

Edge sequence:

[1] Andy -> Garth

[2] Andy -> Dan

[3] Garth -> Andy

[4] Garth -> Bill

[5] Bill -> Elena

[6] Bill -> Carol

[7] Bill -> Dan

[8] Elena -> Frank

[9] Frank -> Elena

[10] Carol -> Andy

[11] Carol -> Bill

[12] Carol -> Elena

[13] Carol -> Dan

[14] Dan -> Andy

[15] Dan -> Bill

[16] Dan -> Carol

>get.adjedgelist(ng,mode="in")

$Andy

[1] 3 10 14

$Garth

[1] 1

$Bill

[1] 0

```
[1] 4 11 15

$Elena
[1] 5  9 12

$Frank
[1] 8

$Carol
[1]  6 16

$Dan
[1] 2  7 13
```

```
[1] 0
```

Practical No 6

Write a program to exhibit

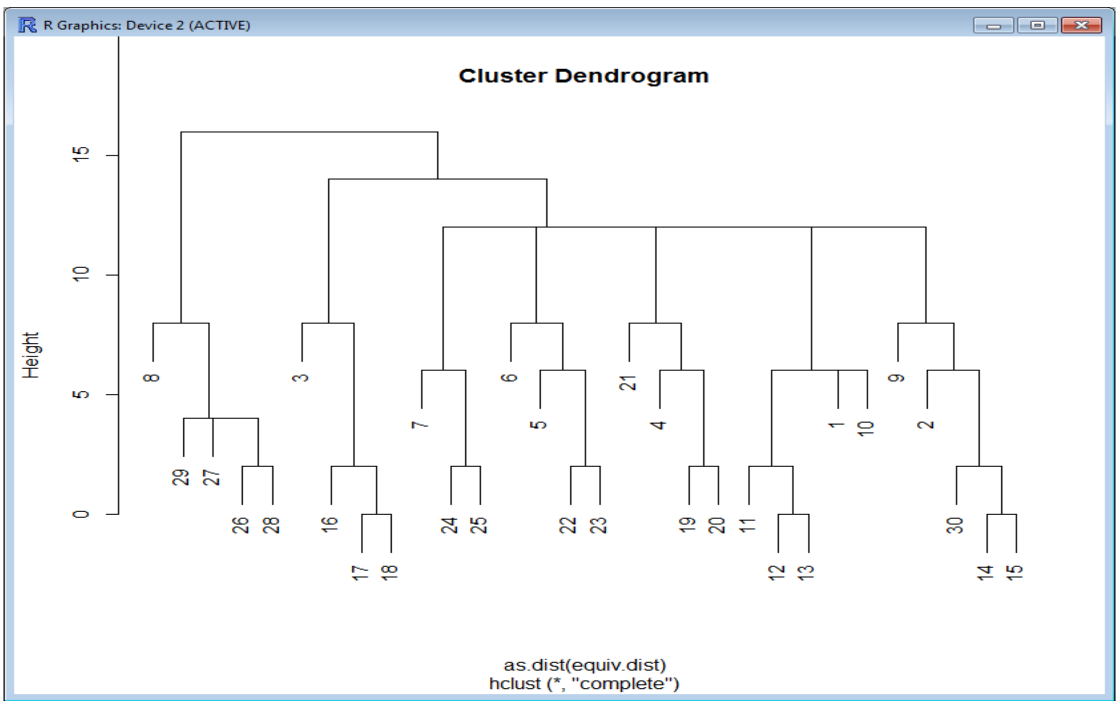
i) structural equivalence,

ii) automatic equivalence,

iii) regular equivalence from a network.

i) structural equivalence

```
>library(sna)

>library(igraph)

> links2 <- read.csv("Dataset2-Media-User-Example-EDGES.csv", header=T, row.names=1)

>eq<-equiv.clust(links2)

>plot(eq)
```



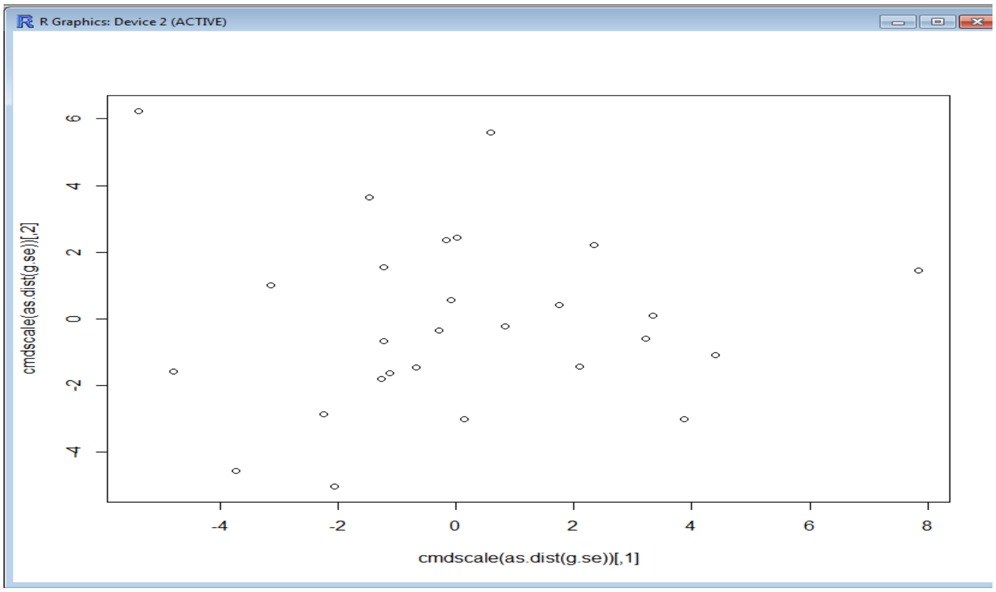
ii) automatic equivalence,

```
>g.se<-sedist(links2)
```

<u>Plot a metric MDS of vertex positions in two dimensions</u>

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

[1] 0

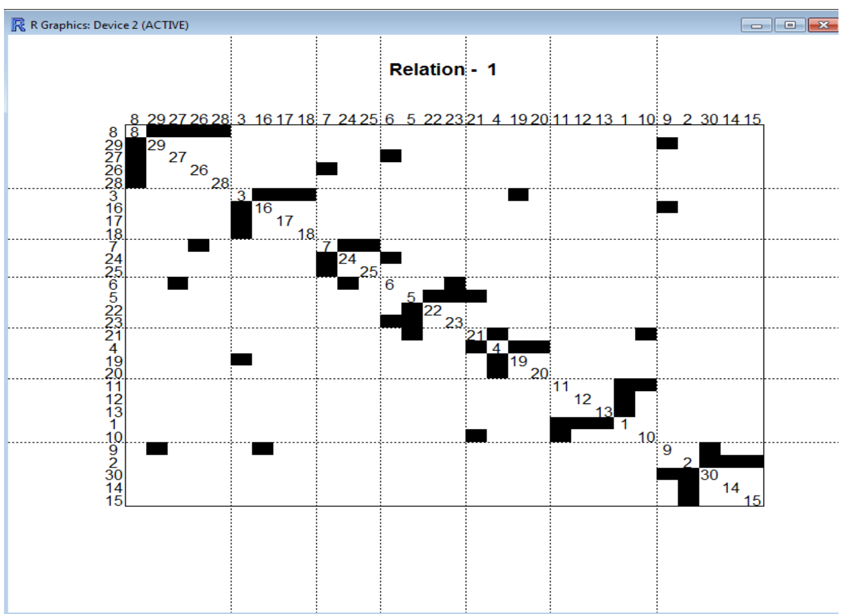


iii) regular equivalence from a network.

<u>Blockmodeling</u>

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

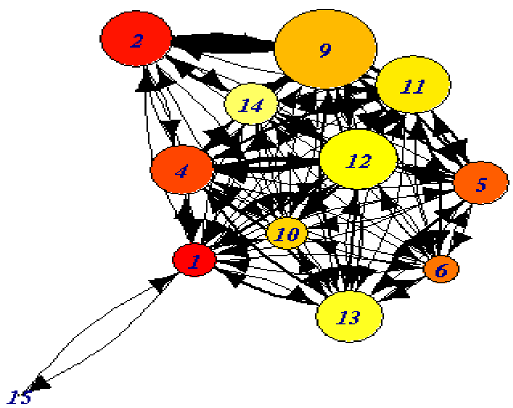
>plot(b)

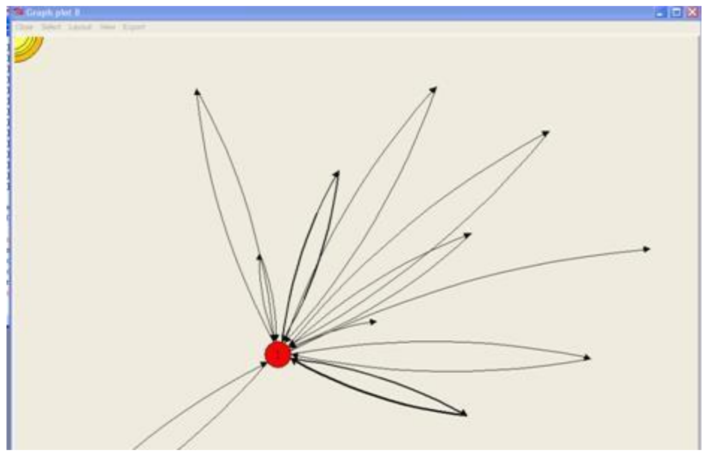


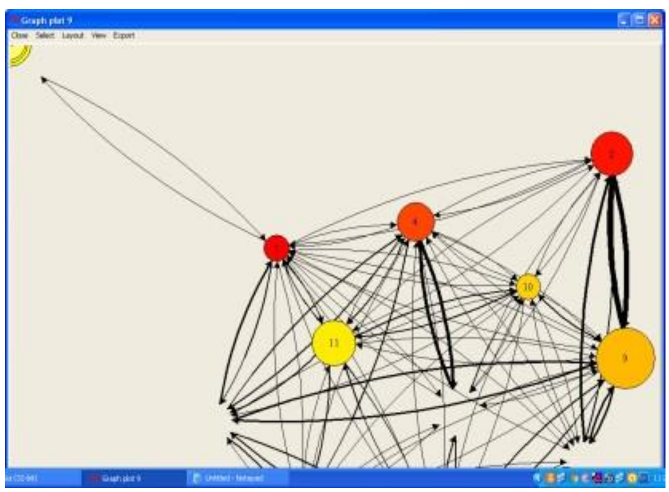
Practical No 7

Create sociograms for the persons-by-persons network and the committee-bycommittee network for a given relevant problem. Create one-mode network and two-node network for the same.

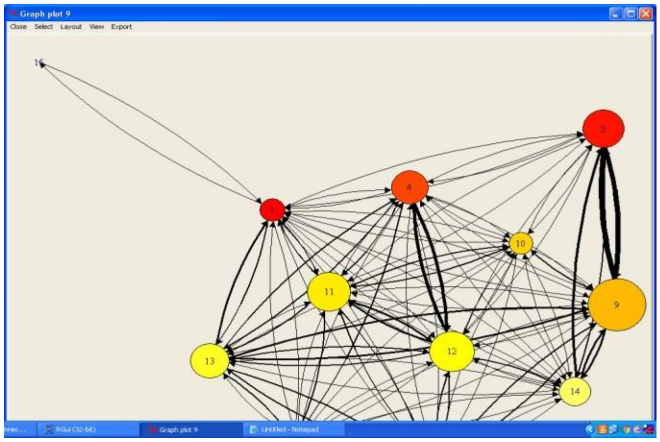
```
>library(Dominance)

>data(data_Network_1)

 ## set 1 for action you want to show

>bytes= "00111111111000000000"

>Sociogram(data_Network_1,bytes)
```

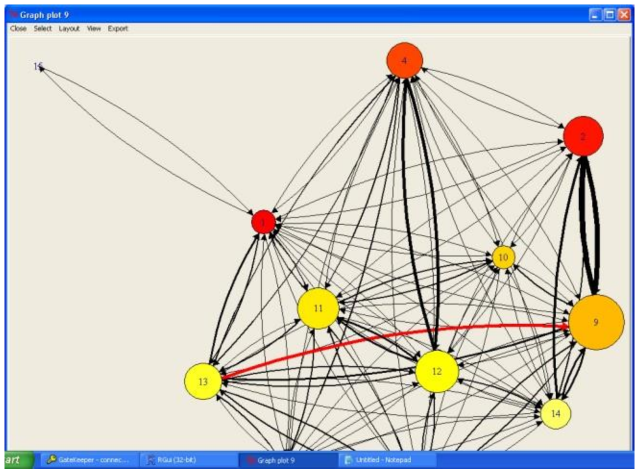






[1] 0





```
> print(data_Network_1)
  Name Beschreibung item.number dominance.order age  sex action.from.
1    1       Pferd1           1               1  NA    2            4
2    2       Pferd2           2               2  NA    1            9
3    3       Pferd3           3              NA  NA    1            4
4    4       Pferd4           4               5  NA    1           12
5    5       Pferd5           5              10  NA    1            5
6    6       Pferd6           6               3  NA    1            9
7    7       Pferd7           7               6  NA    1            5
8    8       Pferd8           8              NA  NA    1            9
```

```
  action.to kind.of.action                time test.2.kind.of.action
1         9             11                <NA>                     3
2         4             11 2009-06-07 03:30:00                     3
3        12             11                <NA>                     3
4         4             11                <NA>                     3
5         9             11                <NA>                     3
6         5             11                <NA>                     3
```

```
  test.3.kind.of.acttion           name.of.action action.number classification
1                      3                  leading             1              1
2                      3                following             2              2
3                      3                 approach             3              1
4                      3                     bite             4              1
5                      3            threat to bite            5              1
6                      3                     kick             6              1
```

[1] 0

	weighting
1	1
2	-1
3	1
4	1
5	1
6	1

[1] 0

Practical No 8

Perform SVD analysis of a network.

```
>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 9.687693e-17
 $u
           [,1]       [,2]        [,3]          [,4]
 [1,] -0.3333333  0.4687136  0.05029703  3.375152e-01
 [2,] -0.3333333  0.4687136  0.05029703 -8.126230e-01
 [3,] -0.3333333  0.4687136  0.05029703  4.751078e-01
 [4,] -0.3333333 -0.2779153  0.38076936  1.160461e-16
 [5,] -0.3333333 -0.2779153  0.38076936  1.160461e-16
 [6,] -0.3333333 -0.2779153  0.38076936  1.160461e-16
 [7,] -0.3333333 -0.1907983 -0.43106639 -7.755807e-17
 [8,] -0.3333333 -0.1907983 -0.43106639 -7.755807e-17
```

```
 [9,] -0.3333333 -0.1907983 -0.43106639 -7.755807e-17

$v
           [,1]          [,2]        [,3] [,4]
[1,] -0.8660254 -2.464364e-17  0.00000000  0.5
[2,] -0.2886751  8.118358e-01  0.08711702 -0.5
[3,] -0.2886751 -4.813634e-01  0.65951188 -0.5
[4,] -0.2886751 -3.304723e-01 -0.74662890 -0.5
```

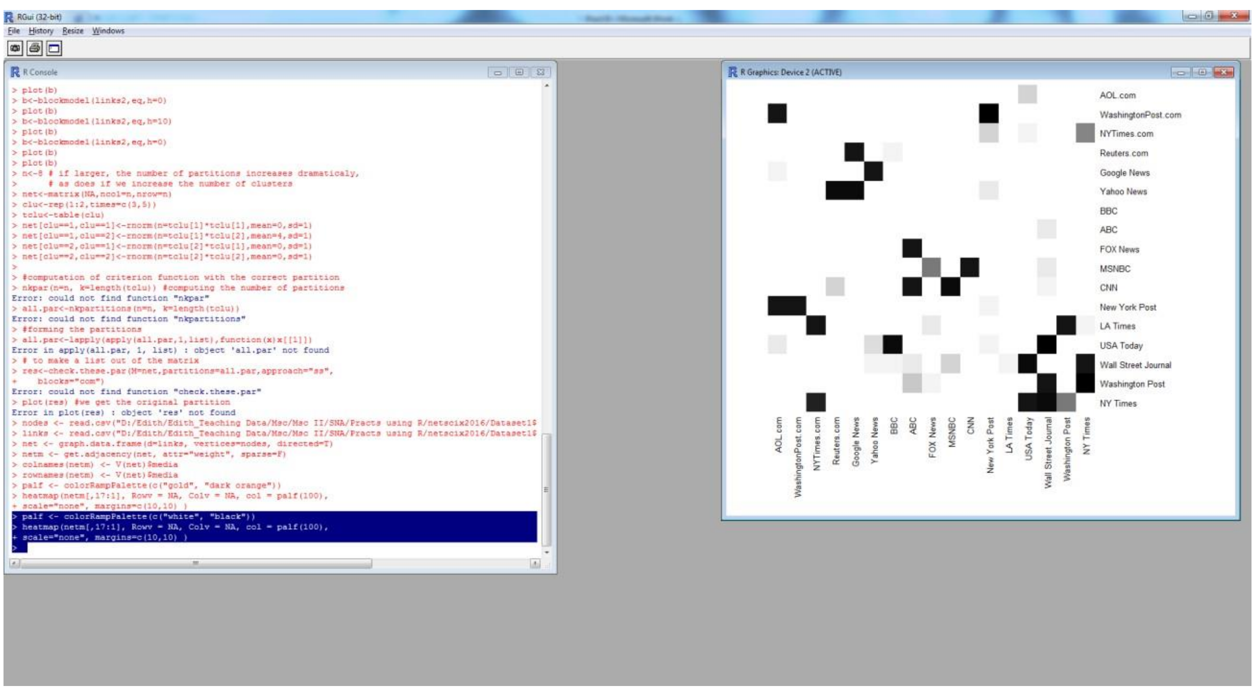
```
[1] 0
```

Practical 9

Identify ties within the network using two-mode core periphery analysis

<u>File name:</u> "Media-Example-NODES.csv" and "Media-Example-EDGES.csv"

```
nodes<- read.csv("Dataset1-Media-Example-NODES.csv", header=T, as.is=T)

links<- read.csv("Dataset1-Media-Example-EDGES.csv", header=T, as.is=T)

net<- graph.data.frame(d=links, vertices=nodes, directed=T)

netm<- get.adjacency(net, attr="weight", sparse=F)

colnames(netm) <- V(net)$media

rownames(netm) <- V(net)$media

palf<- colorRampPalette(c("white", "black"))

heatmap(netm[,17:1], Rowv = NA, Colv = NA, col = palf(100),

+ scale="none", margins=c(10,10) )
```



[1] 0

Practical 10

Find “factions” in the network using two-mode faction analysis.

>library(igraphdata)

Warning message:

package ‘igraphdata’ was built under R version 3.0.3

>data(karate)

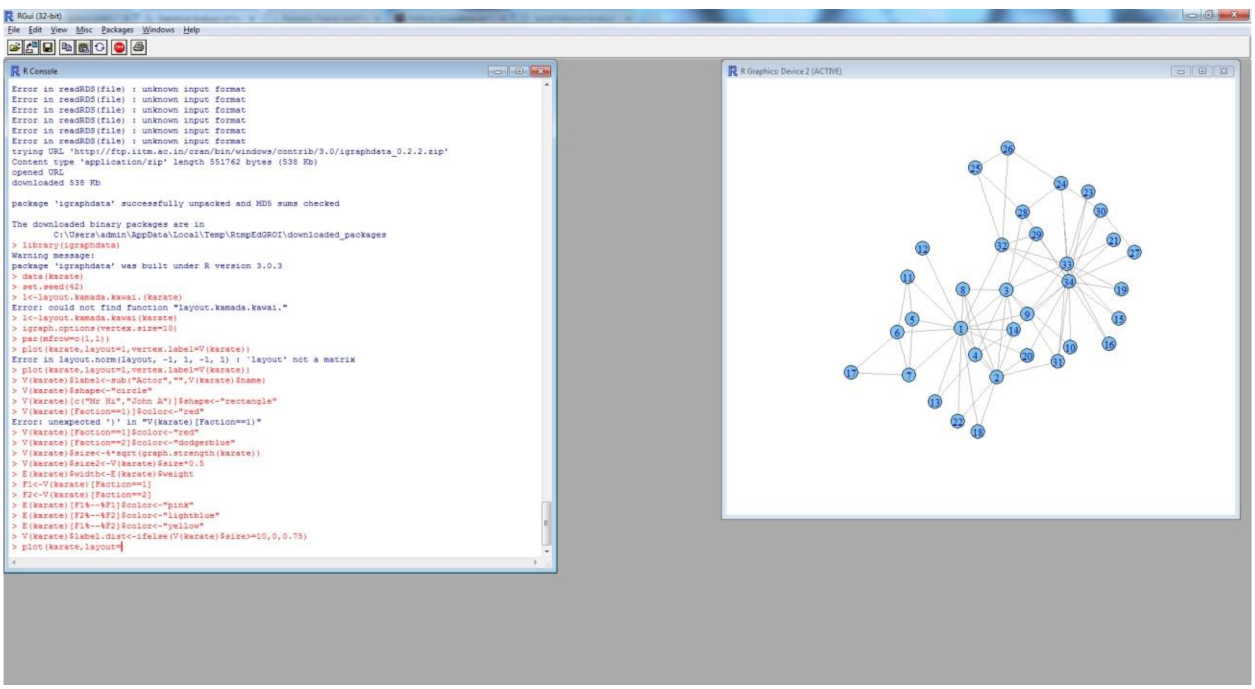
>set.seed(42)

> l<-layout.kamada.kawai(karate)

>igraph.options(vertex.size=10)

>par(mfrow=c(1,1))

>plot(karate,layout=l,vertex.label=V(karate))



>V(karate)$label<-sub("Actor","",V(karate)$name)

>V(karate)$shape<-"circle"

>V(karate)[c("MrHi","John A")]$shape<-"rectangle"

[1] 0

>V(karate)[Faction==1]$color<-"red"

>V(karate)[Faction==2]$color<-"dodgerblue"

>V(karate)$size<-4*sqrt(graph.strength(karate))

>V(karate)$size2<-V(karate)$size*0.5

>E(karate)$width<-E(karate)$weight

> F1<-V(karate)[Faction==1]

> F2<-V(karate)[Faction==2]

>E(karate)[F1%--%F1]$color<-"pink"

>E(karate)[F2%--%F2]$color<-"lightblue"

>E(karate)[F1%--%F2]$color<-"yellow"

>V(karate)$label.dist<-ifelse(V(karate)$size>=10,0,0.75)

>plot(karate,layout=l)