Statistical Computing with R: Masters in Data Science 503 (S15) First Batch, SMS, TU, 2021

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Review Preview

- Social Networks:
  - Nodes/Vertices
  - Edges/Connection
  - Degree
  - Edge density
  - Closeness (centrality)
  - Betweenness (centrality)
  - Edge_betweenness etc.
- Social Network Analysis:
  - Hubs
  - Authorities
  - Community detection

Social Networks:

https://study.com/academy/lesson/what-are-social-networks-types-examples-quiz.html

- **Social networks** are simply networks of social interactions and personal relationships. Think about your group of friends and how you got to know them.
- Maybe you met them in elementary school, or maybe you met them through a hobby or through your community.
- Either way, you were exposed to social networks: **meeting other individuals in a social situation, while developing strong personal bonds over time**.

- If you're on Facebook, keep in mind that so are 1.15 billion? other people throughout the world.
- In fact, 72% of all Internet users are active on social media today, indulging in social interactions and developing personal relationships.
- **But you don't always have to go online to be exposed to social networks, as they come in a multitude of formats.**

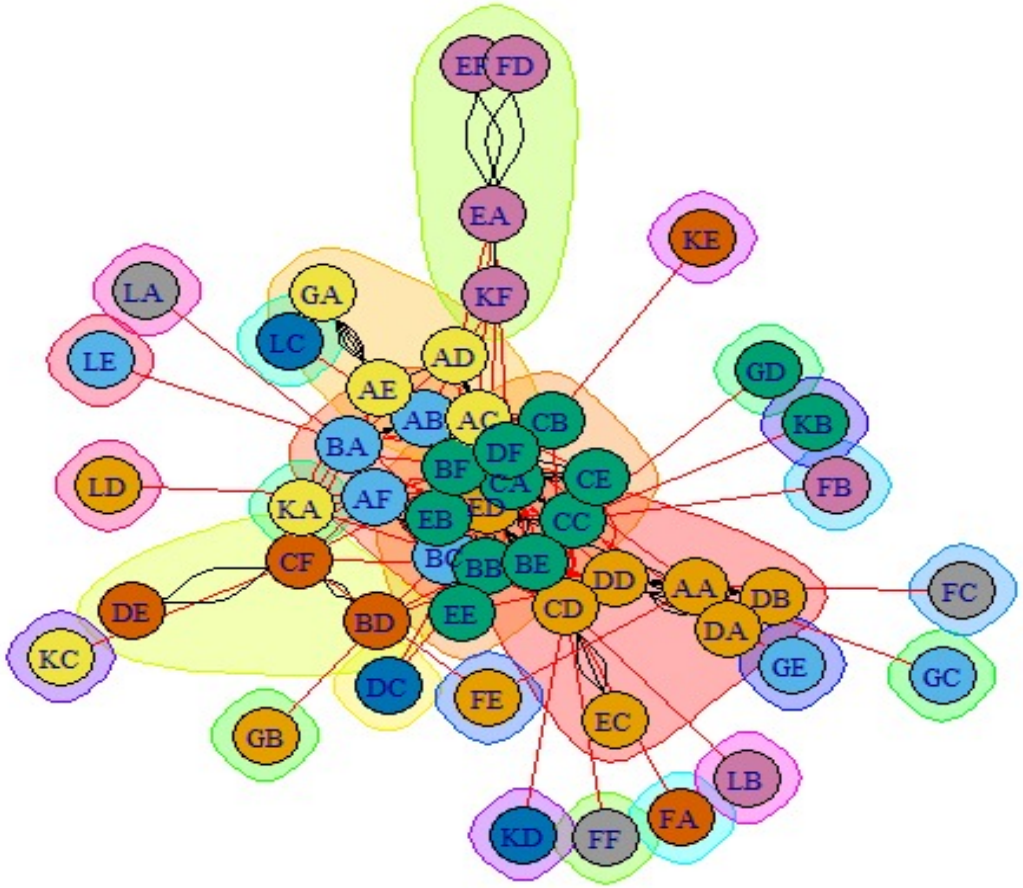
Why Should I Care About Social Network Analysis?

https://towardsdatascience.com/how-to-get-started-with-social-network-analysis-6d527685d374

- Social network analysis (SNA), also known as network science, is a field of data analytics that uses networks and graph theory to understand social structures.
- SNA techniques can also be applied to networks outside of the societal realm.
- Networks are all around us — such as road networks, internet networks, and online social networks like Facebook, Twitter …
- Learning SNA and its techniques will give you valuable tools to provide insight on a variety of data sources.
- In order to build SNA graphs, two key components are required: **actors and relationships**.

SNA graph:

- A social network graph contains both points and lines connecting those dots — similar to a connect-the-dot puzzle.
- The points represent the actors and the **lines** represent the **relationships**.
- The shaded area is “community”



SNA: Networks and Graph theory

https://en.wikipedia.org/wiki/Social_network_analysis

- **Social network analysis** (**SNA**) is the process of investigating social structures through the use of networks and graph theory.
- It characterizes networked structures in terms of *nodes* (individual actors, people, or things within the network) and the *ties*, *edges*, or *links* (relationships or interactions) that connect them.
- The advantages of SNA are twofold. Firstly, it can process a large amount of relational data and describe the overall relational network structure.
- It can also select term and parameter to confirm the influential nodes in the network, such as in-degree and out-degree centrality.
- Through analyzing nodes, clusters and relations, the communication structure and position of individuals can be clearly described

Discussion on “How to do SNA Guide?”

https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/491572/socnet_howto.pdf

- The aim of social network analysis is to understand a community by mapping the relationships that connect them as a network, **and then trying to draw out** key individuals, groups within the network (‘components’), and/or associations between the individuals.

- A network is simply a number of points (or ‘nodes’) that are connected by links.
- Generally in social network analysis, the nodes are people and the links are any social connection between them – for example, friendship, marital/family ties, or financial ties.
- **SNA for detecting network of gangs (of criminals)**

How SNA is used to analyze “gang” network?

https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/491572/socnet_howto.pdf

- Social network analysis can provide information about the **reach of gangs, the impact of gangs, and gang activity**.
- The approach may also allow you to identify those who may be at risk of gang-association and/or being exploited by gangs.
- The technique will generate diagrams that will show the relationships between individuals that are contained in your data, this could include: criminal links, social links, potential feuds, etc.
- SNA diagrams can include names, pictures and further details of individuals as required.

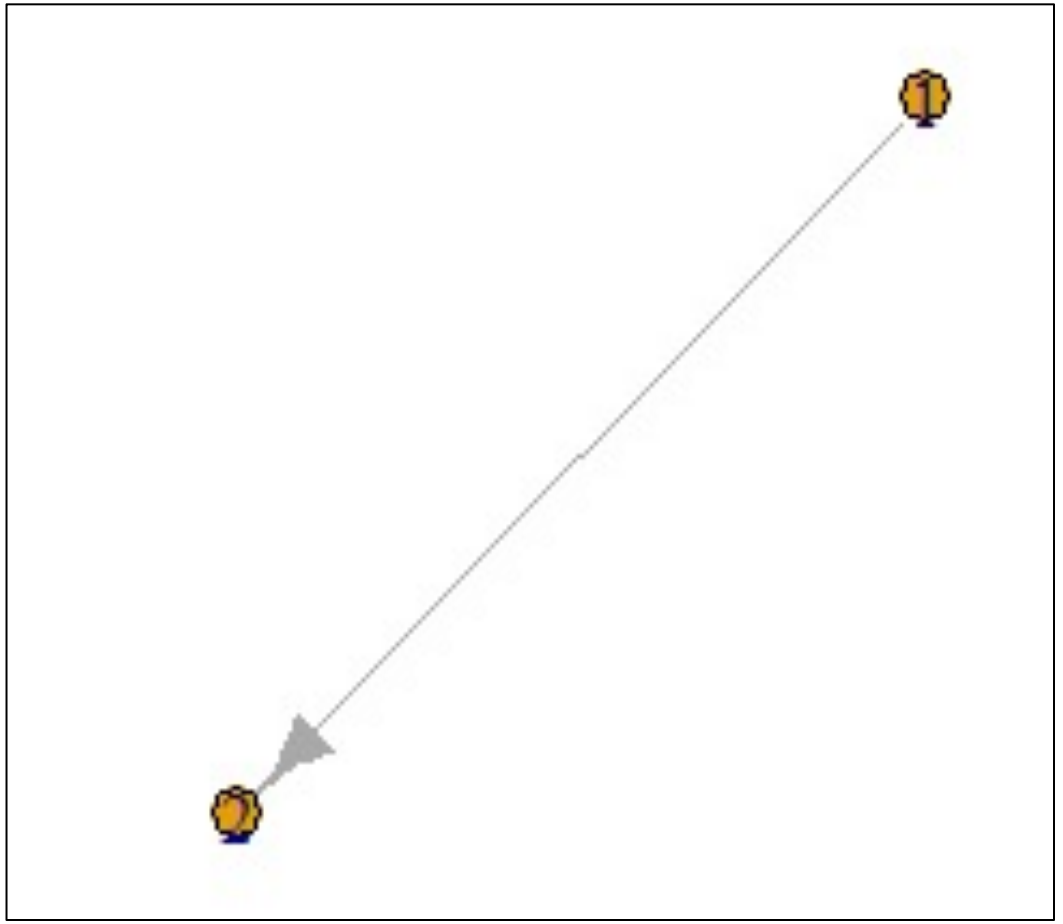
SNA Basics:

https://www.youtube.com/watch?v=0xsM0MbRPGE

```
library(igraph)
g <- graph(c(1,2))
plot(g)
```

- First **node** contains 1
- Second **node** contains 2

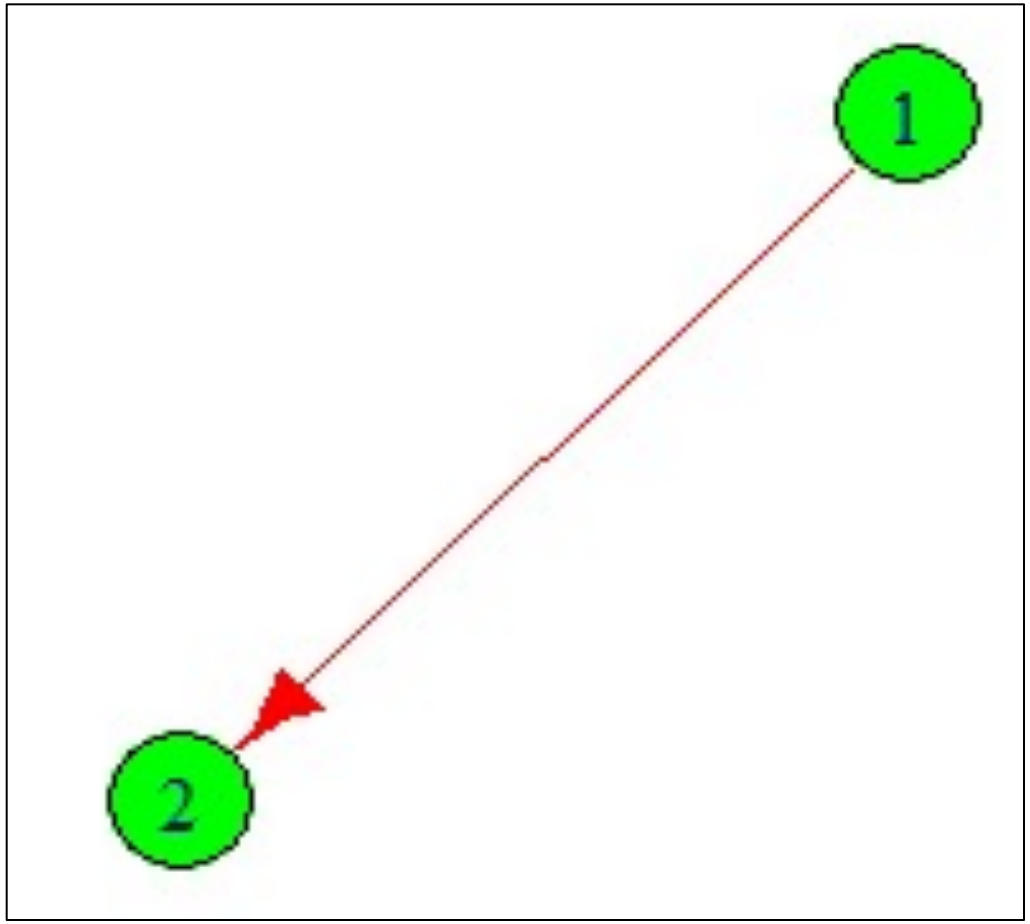
- The arrow (**edge**) goes from 1 to 2 as we defined that way in g!



SNA Basics: Changing size and color of node (vertex) and edge

```
plot(g,
        vertex.color = “green”,
        vertex.size = 40,
        edge.color = “red”,
        edge.size = 20)
```

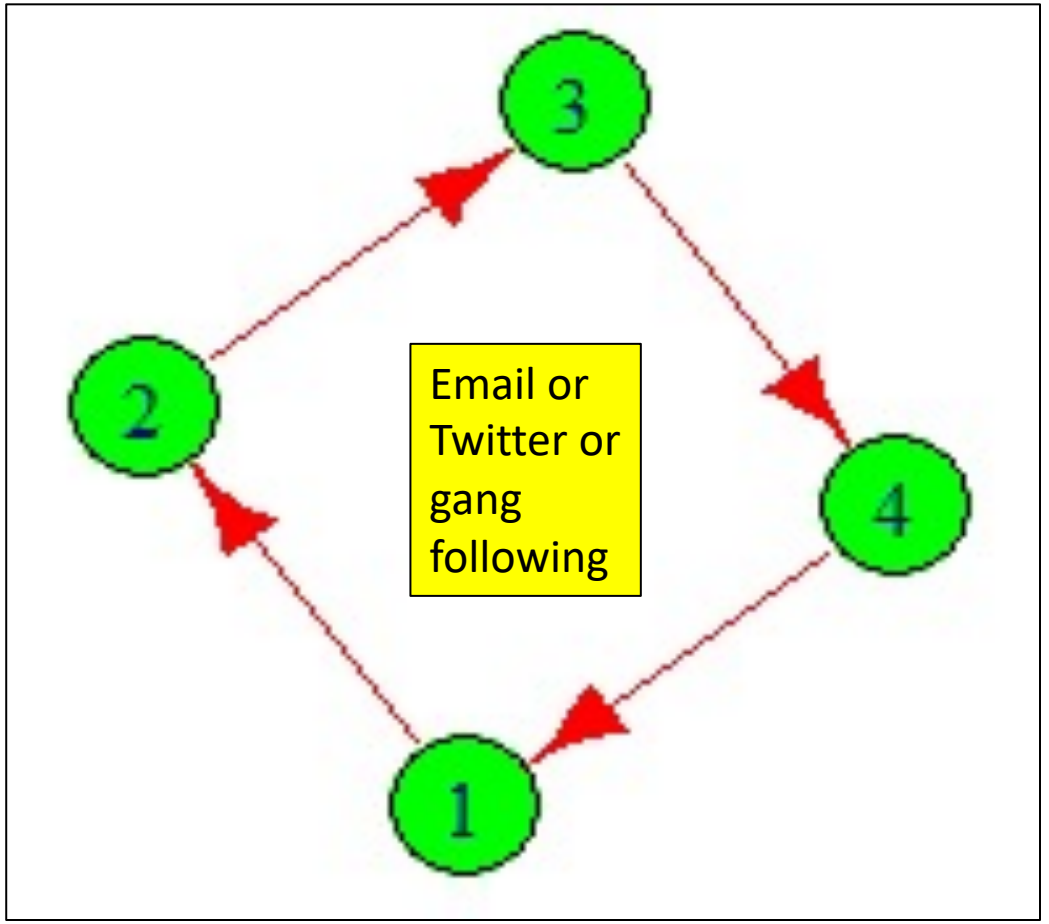
Note: Here information (email, twitter following, gang following) is flowing from 1 to 2!



SNA Basics: Adding more data points

```
g <- graph(c(1,2,2,3,3,4,4,1)
plot(g,
        vertex.color = “green”,
        vertex.size = 40,
        edge.color = “red”,
        edge.size = 20)
```

Note: This is a directed graph as we can see “arrow” here.

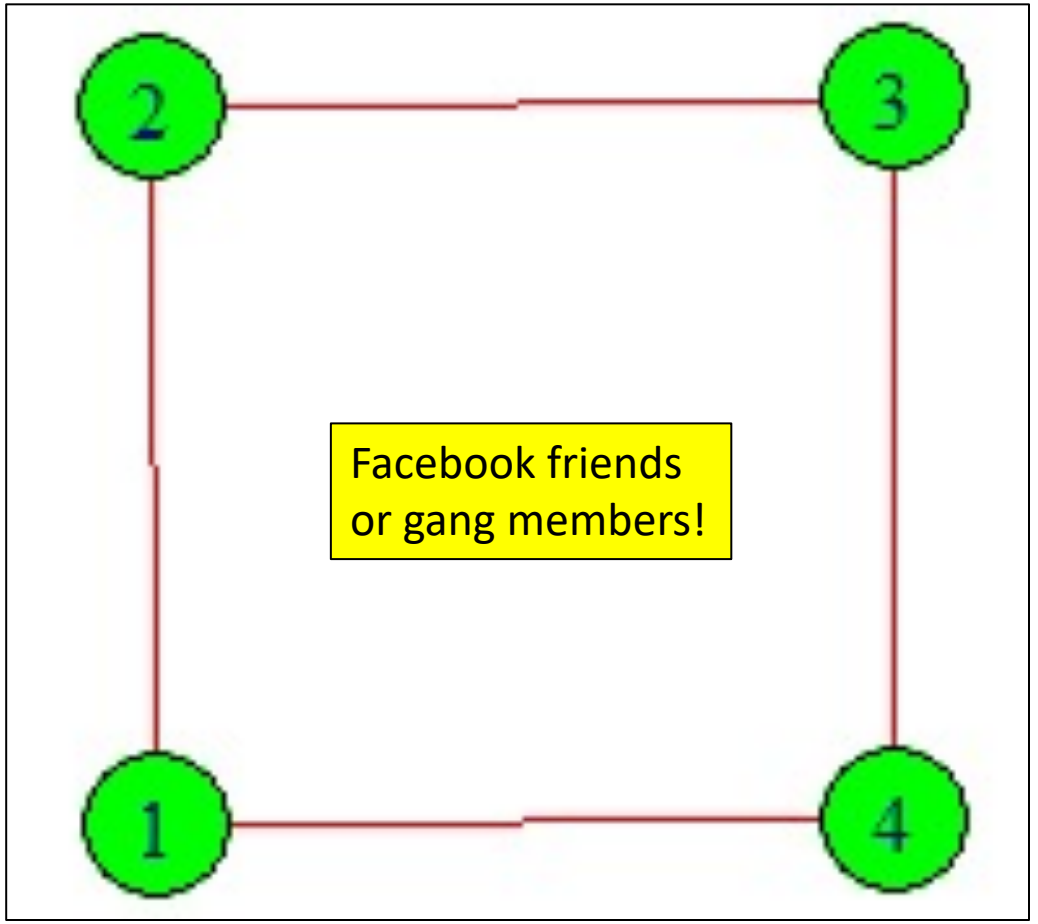


SNA Basics: Undirected data points

```
g <- graph(c(1,2,2,3,3,4,4,1),
directed = F)

plot(g,
        vertex.color = “green”,
        vertex.size = 40,
        edge.color = “red”,
        edge.size = 20)
```

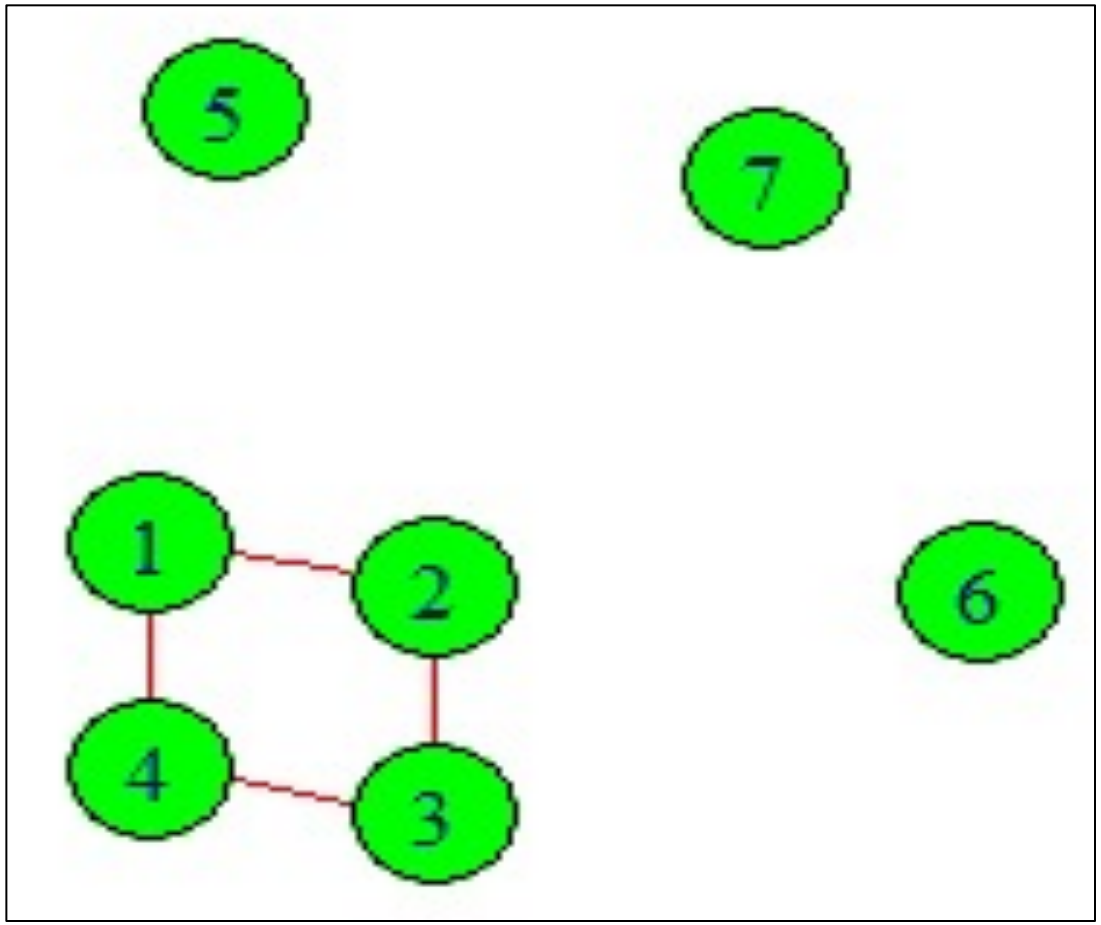
Note: This is not a directed graph as we cannot see “arrow” here.



SNA Basics: Adding related & unrelated nodes

```
g <- graph(c(1,2,2,3,3,4,4,1),
directed = F, n=7)
plot(g,
        vertex.color = “green”,
        vertex.size = 40,
        edge.color = “red”,
        edge.size = 20)
```

Note: This is not a directed graph as we cannot see “arrow” here.



SNA Basics: Adding related & unrelated nodes

g[]

This will give us the matrix used to produce the earlier graph

The dimension of this matrix is 7x7

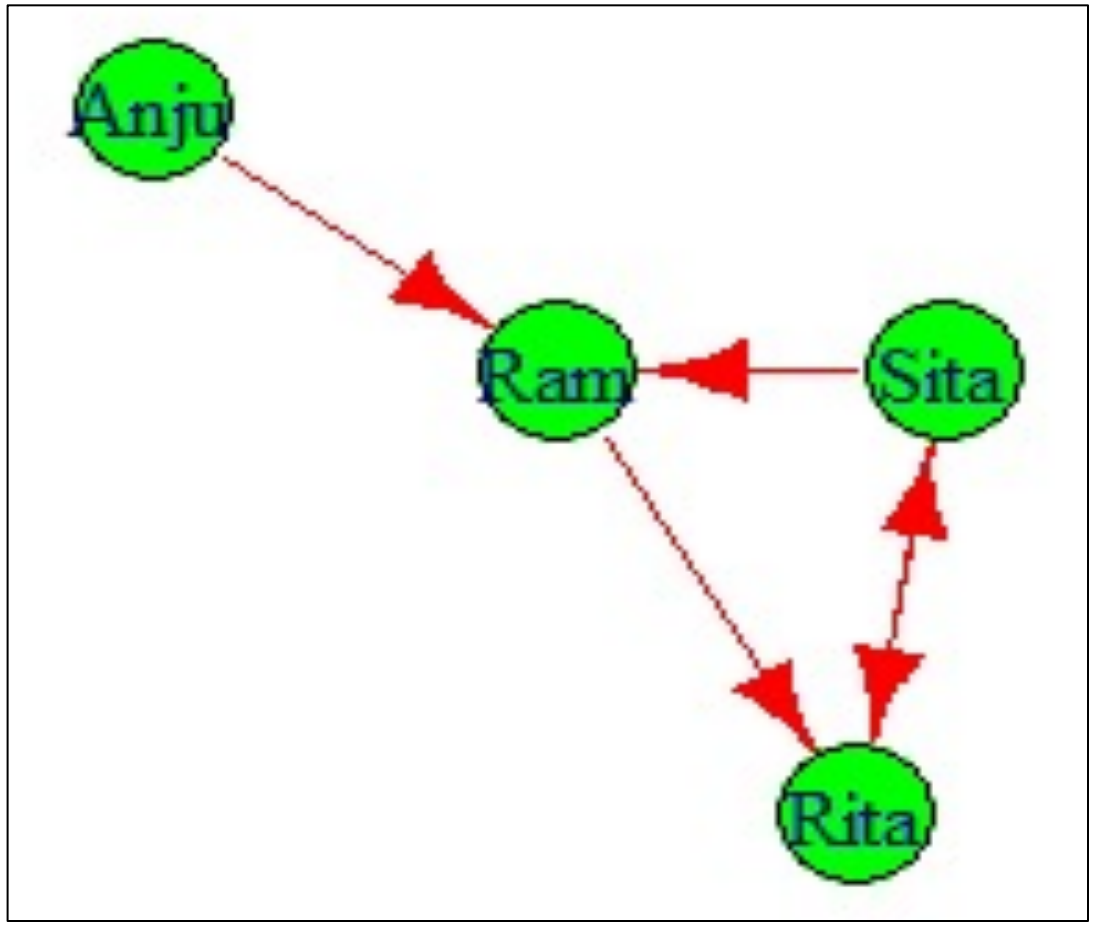
The dot(.) means no relation (connection) and 1 mean the connection with the nodes e.g. 1 has connection with 2 and 4

7 x 7 sparse Matrix of class "dgCMatrix"

[1,] . 1 . 1 . . .
[2,] 1 . 1 . . . .
[3,] . 1 . 1 . . .
[4,] 1 . 1 . . . .
[5,] . . . . . .
[6,] . . . . . .
[7,] . . . . . .

SNA Basics: Defining nodes with text data

```
g1 <-
graph(c("Sita","Ram","Ram","Rita"
,"Rita","Sita","Sita","Rita", "Anju",
"Ram"))
plot(g1,
    vertex.color = "green",
    vertex.size = 40,
    edge.color = "red",
    edge.size = 5)
```



SNA Basics: Getting info of “g1”

g1

D=Directed, N=Names
4 = Four vertices (nodes)
5 = Five edges (lines)

Pairs: Sita->Ram
Ram->Rita
Rita->Sita
Sita->Rita
Anju->Ram

Output in R:

IGRAPH 0adac86 DN-- 4 5 --
+ attr: name (v/c)
+ edges from 0adac86 (vertex names):
[1] Sita->Ram Ram ->Rita Rita->Sita Sita->Rita Anju->Ram

SNA Basics: Getting degrees of “g1”

degree(g1) or degree(g1, mode=“all”)

Sita Ram Rita Anju

3 3 3 1

degree(g1, mode=“in”)

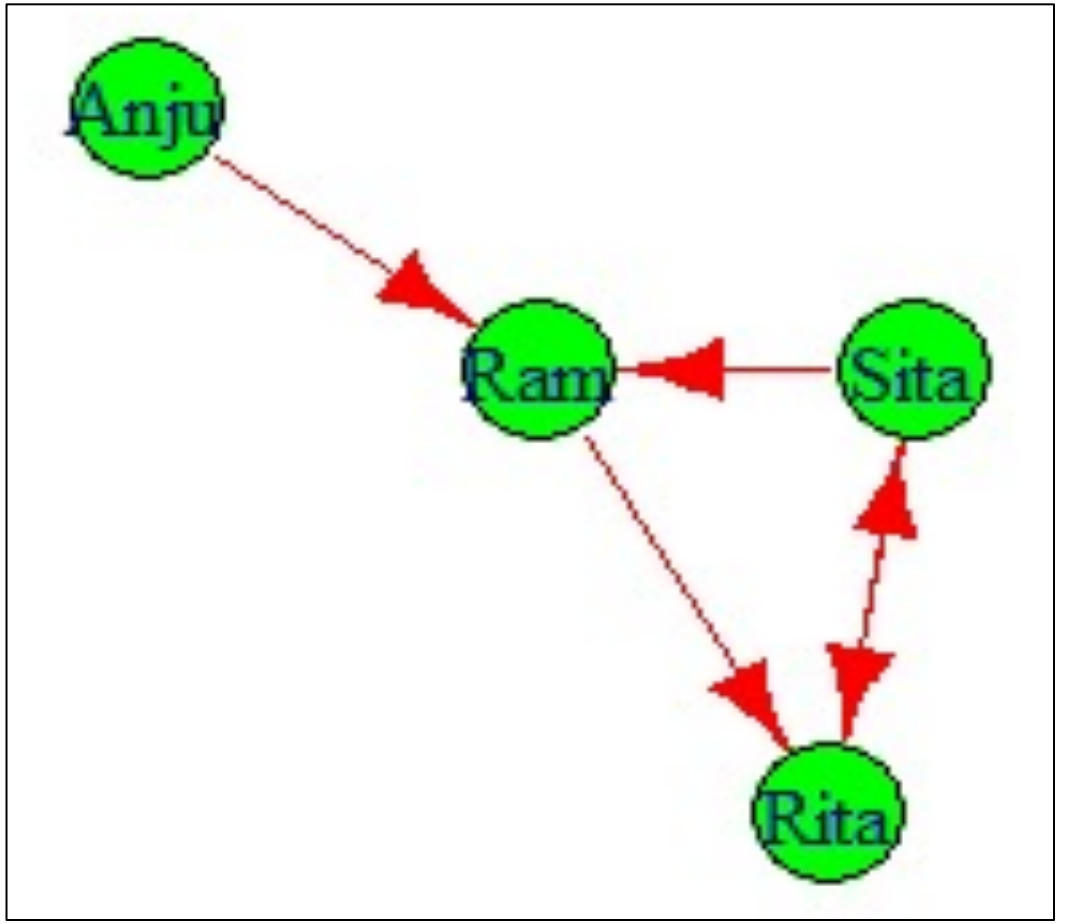
Sita Ram Rita Anju

1 2 2 0

degree(g1, mode=“out”)

2 1 1 1

“degree” means = Number of connections for each node



SNA Basics: Getting diameter of “g1”

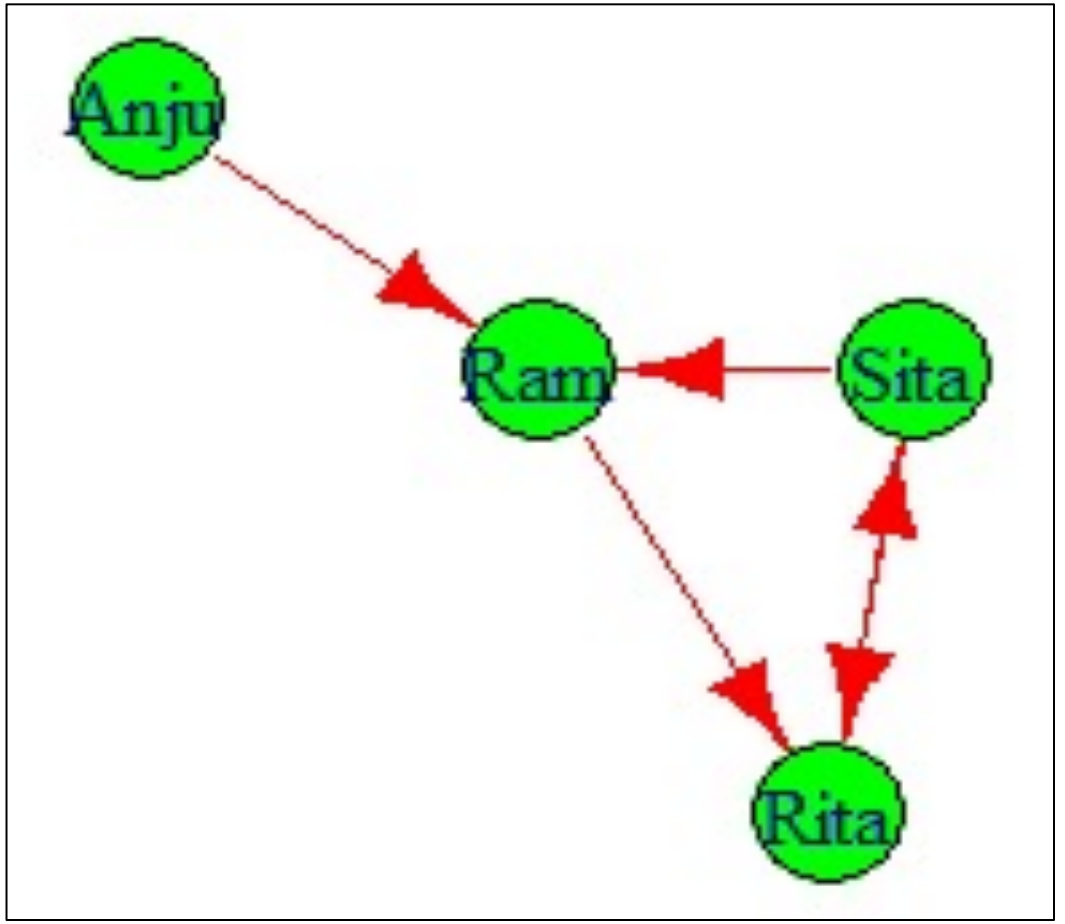
#Diameter

diameter(g1, directed = F, weights = NA)

[1] 2

“diameter” means = number of edged inside and outside of SND
i.e. Anju -> Ram and Ram -> Rita

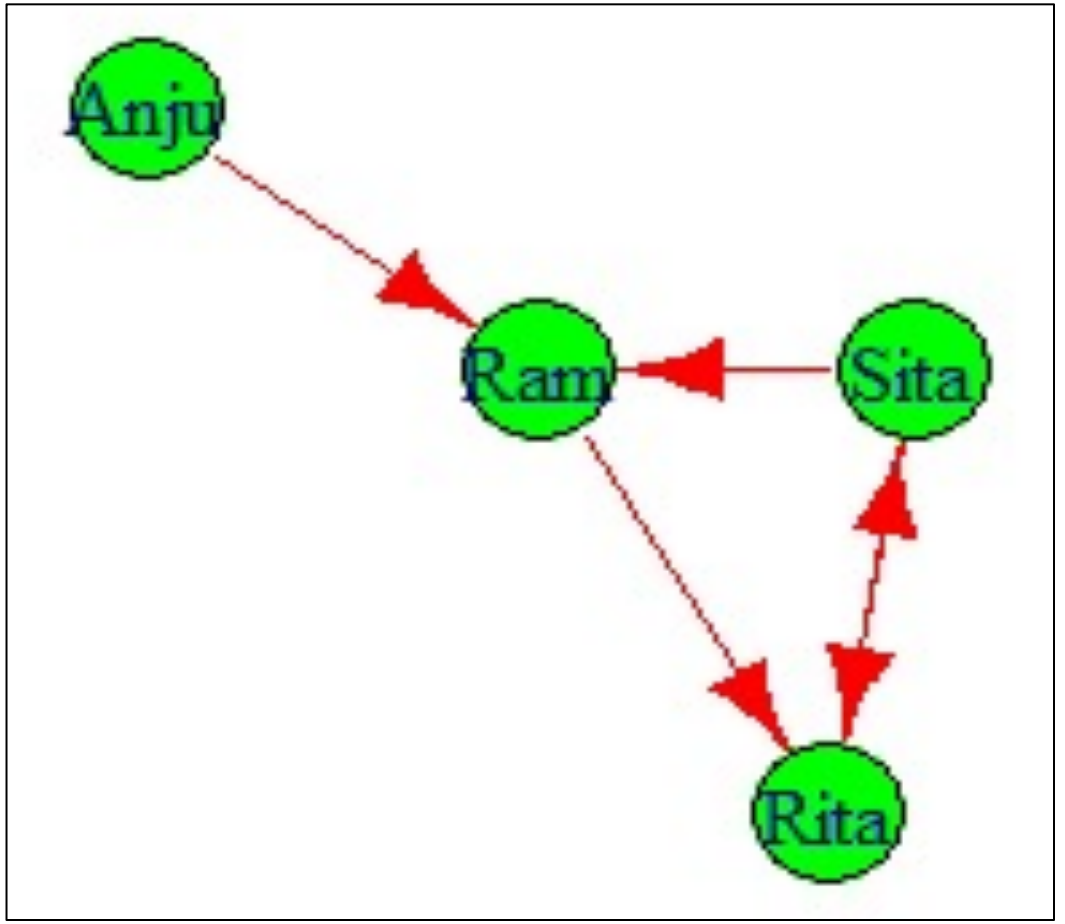
Or Anju -> Ram and Ram -> Sita



SNA Basics: Getting edge density of “g1”

```
#Edge density
edge_density(g1, loops = F)
[1] 0.4166667


#Edge density
ecount(g1)/(vcount(g1)*(vcount(g1)-1))
5/4*(4-1)
[1] 0.4166667
```



SNA Basics: Getting reciprocity of “g1”

#Reciprocity of directed graph

#Percentage reciprocated ties

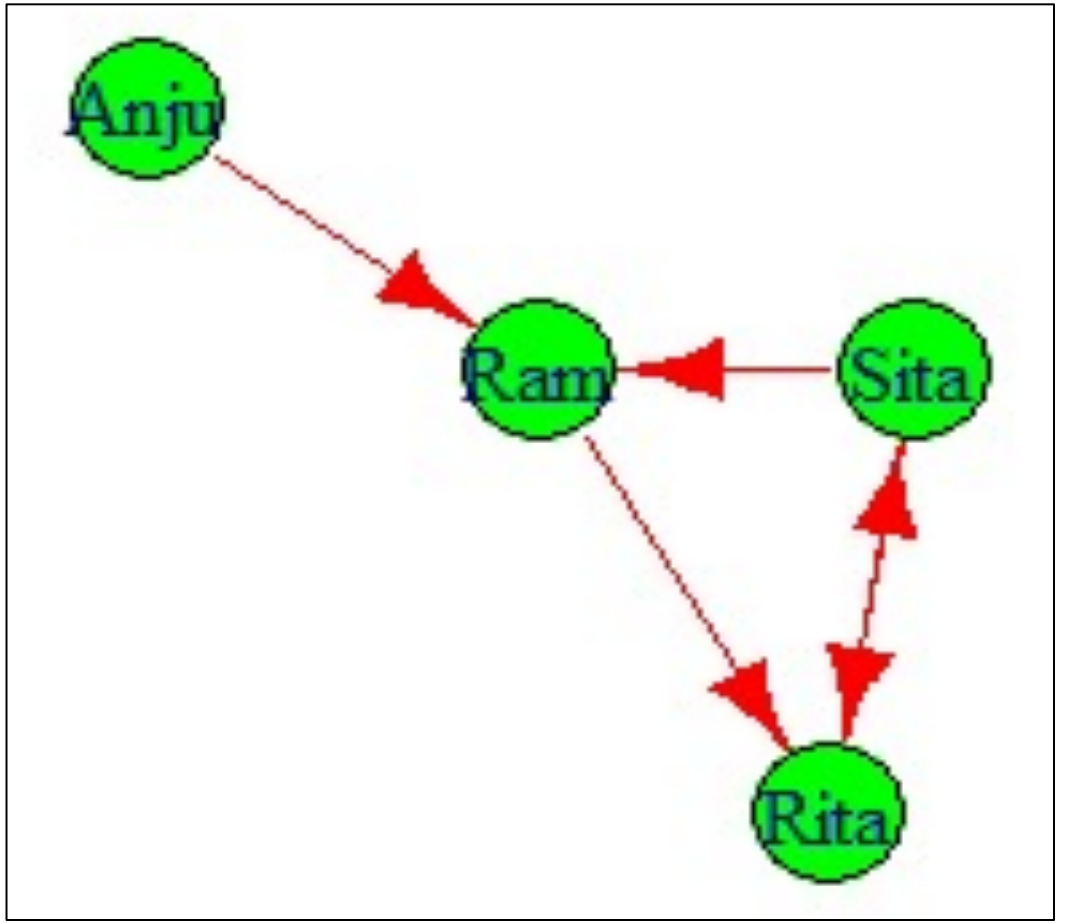
reciprocity(g1)

[1] 0.4

Total edges = 5

Tied edges = 2

Reciprocity = 2/5 = 0.4



SNA Basics: Getting closeness of “g1”

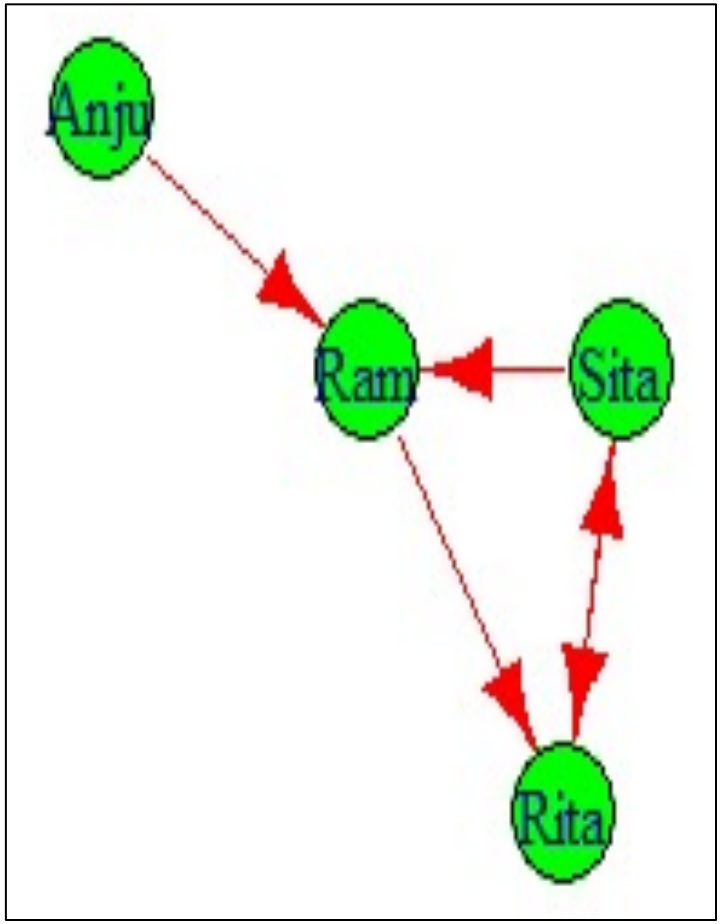
#Closeness

closeness(g1, mode = "all", weights = NA)

Sita	Ram	Rita	Anju
0.2500000	0.3333333	0.2500000	0.2000000

Ram is closest to other three persons

Anju is farthest to other three persons



SNA Basics: Getting betweenness of “g1”

#Betweenness

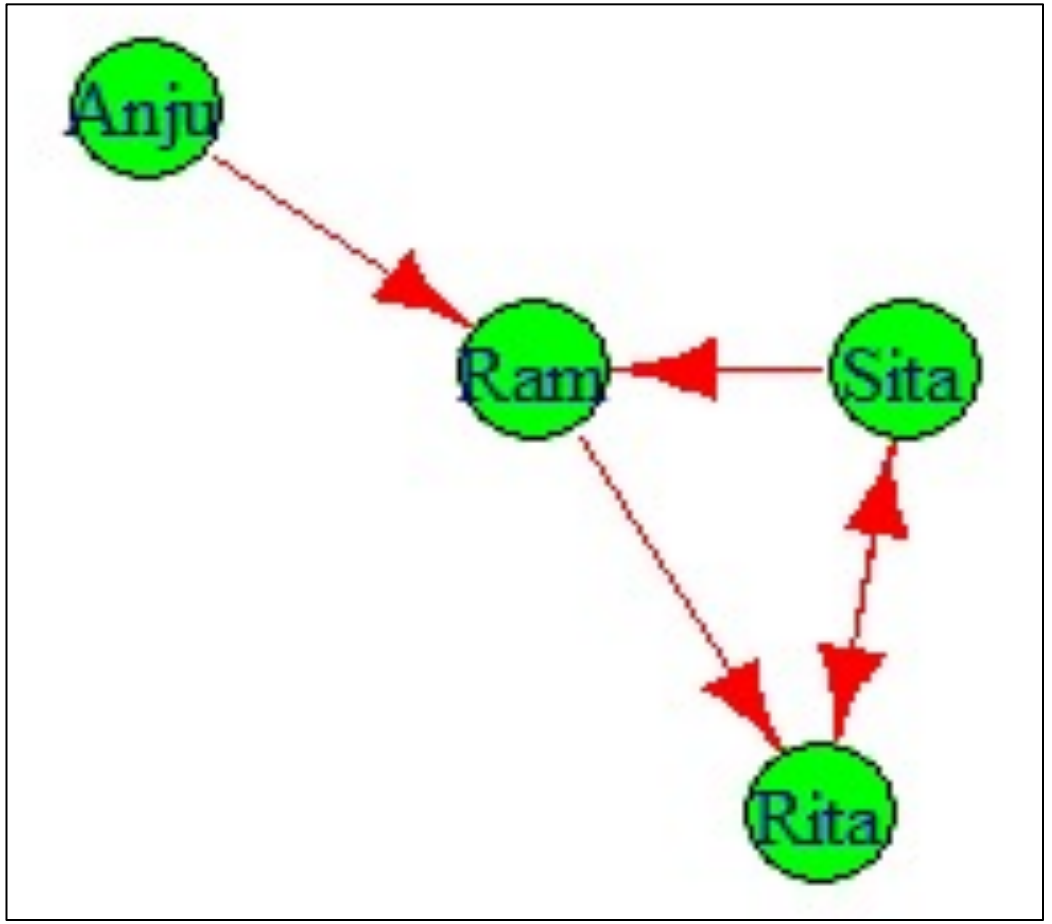
betweenness(g1, directed = T, weights = NA)

Sita	Ram	Rita	Anju
1	2	2	0

Ram and Rita have two “inner” edges, Sita has 1 and Anju has 0!

edge_betweenness(g1, directed = T, weights = NA)

2 4 4 1 3 **#Learn on your own!**



Question/queries so far?

- More are here: https://igraph.org/r/html/latest/

SNA with a data file: networkdata.csv

https://www.youtube.com/watch?v=0xsM0MbRPGE

```
#Read the data in R

data <- read.csv(file.choose(), header=T)

#Save the first two columns as y

y <- data.frame(data$first, data$second)

#Save it as network graph data

net <- graph.data.frame(y, directed=T)
```

first	second	grade	spec
AA	DD	6	Y
AB	DD	6	R
AF	BA	6	Q
DD	DA	6	Q
CD	EC	6	X
DD	CE	6	Y
CD	FA	6	X
CD	CC	6	W
BA	AF	6	R
CB	CA	6	T
CC	CA	6	U
CD	CA	6	Q
BC	CA	6	U
DD	DA	6	Y
ED	AD	6	R
AE	AC	6	Z
AB	BA	6	Y
CD	EC	6	X
CA	CC	6	U

SNA with a data file: networkdata.csv

#Vertices – 52 unique vertices

V(net)

#Edges – 290 edges

E(net)

#Names as labels

V(net)$label #Result = NULL

#Define the labels

V(net)$label <- V(net)$name

V(net)$label # 52 vertices as labels

- + 52/52 vertices, named, from 58abab2:
- [1] AA AB AF DD CD BA CB CC BC ED AE CA EB BF BB AC DC BD DB CF DF BE EA CE EE EF
- [27] FF FD GB GC GD AD KA KF LC DA EC FA FB DE FC FE GA GE KB KC KD KE LB LA LD LE

SNA with a data file: networkdata.csv

#Define degree

V(net)$degree #Result = NULL

V(net)$degree <- degree(net)

V(net)$degree

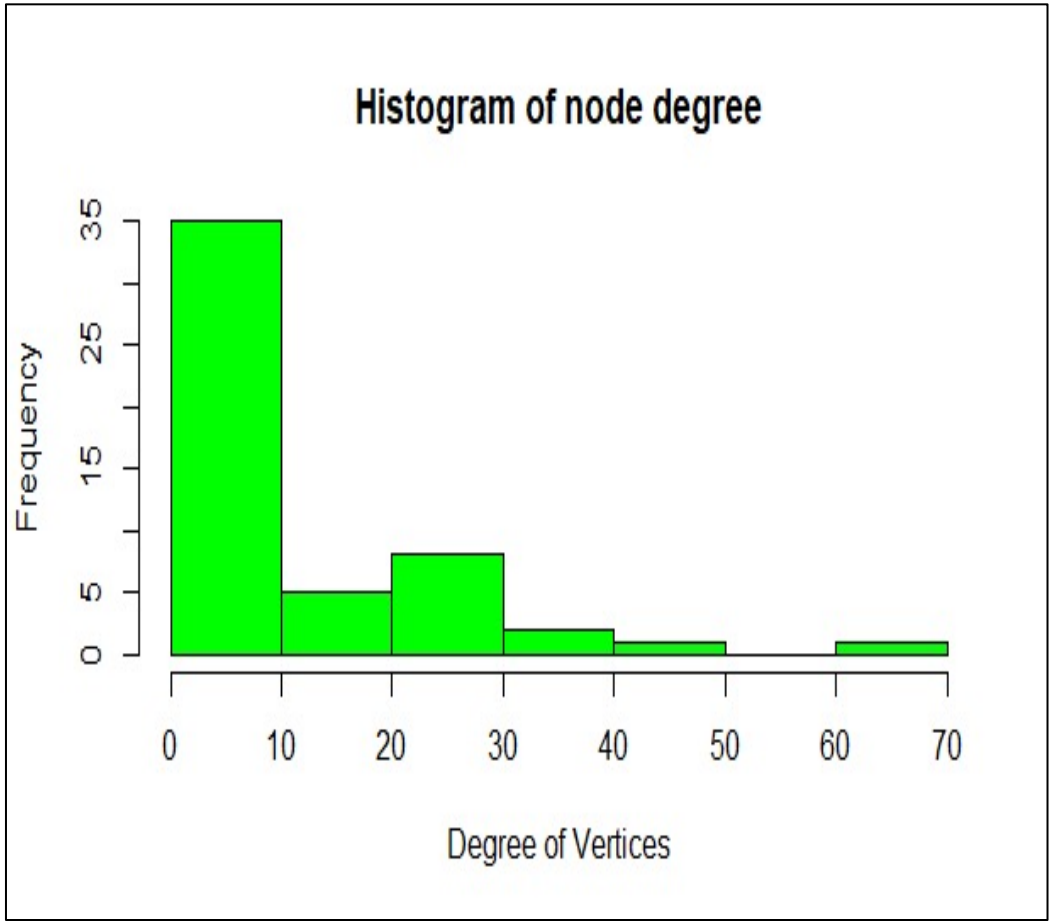
What does it means here?

Number of connections for each nodes (vertices)

- [1] 18 9 23 36 40 26 24 50 21 27 15 62 7 12 23 27 2 4 8 12 23 20 8 10 6 8
- [27] 1 8 1 1 1 9 3 3 1 7 3 1 1 2 1 2 5 1 1 1 1 1 1 1 1 1
- [1] "AA" "AB" "AF" "DD" "CD" "BA" "CB" "CC" "BC" "ED" "AE" "CA" "EB" "BF" "BB" "AC" "DC" "BD" "DB" "CF" "DF" "BE" "EA" "CE" "EE" "EF"
- [27] "FF" "FD" "GB" "GC" "GD" "AD" "KA" "KF" "LC" "DA" "EC" "FA" "FB" "DE" "FC" "FE" "GA" "GE" "KB" "KC" "KD" "KE" "LB" "LA" "LD" "LE"

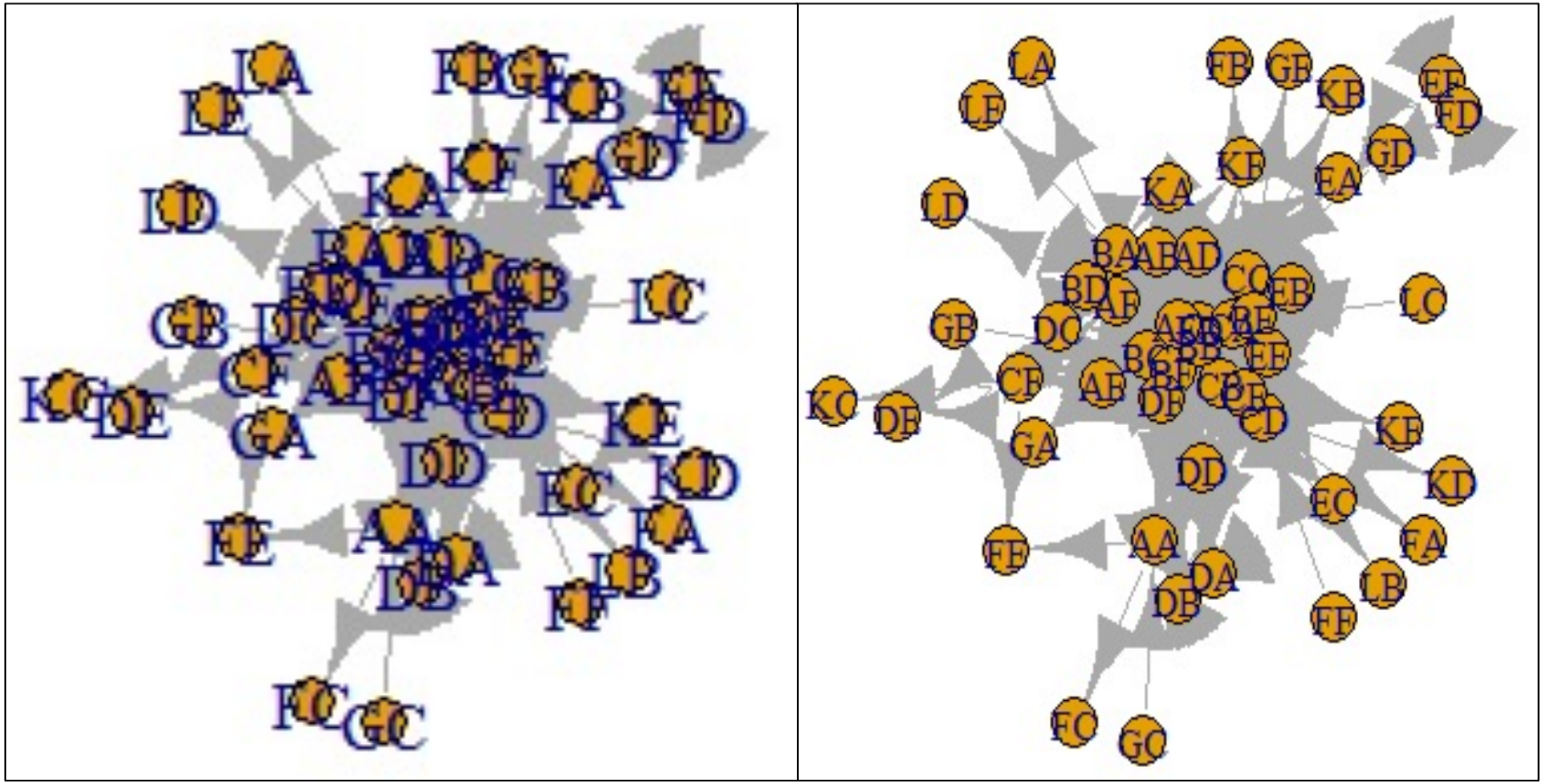
Histogram of node degree i.e. connections

- #Histogram of node degree
- hist(V(net)$degree,
  col = "green",
  main = "Histogram of node degree",
  ylab = "Frequency",
  xlab = "Degree of Vertices")



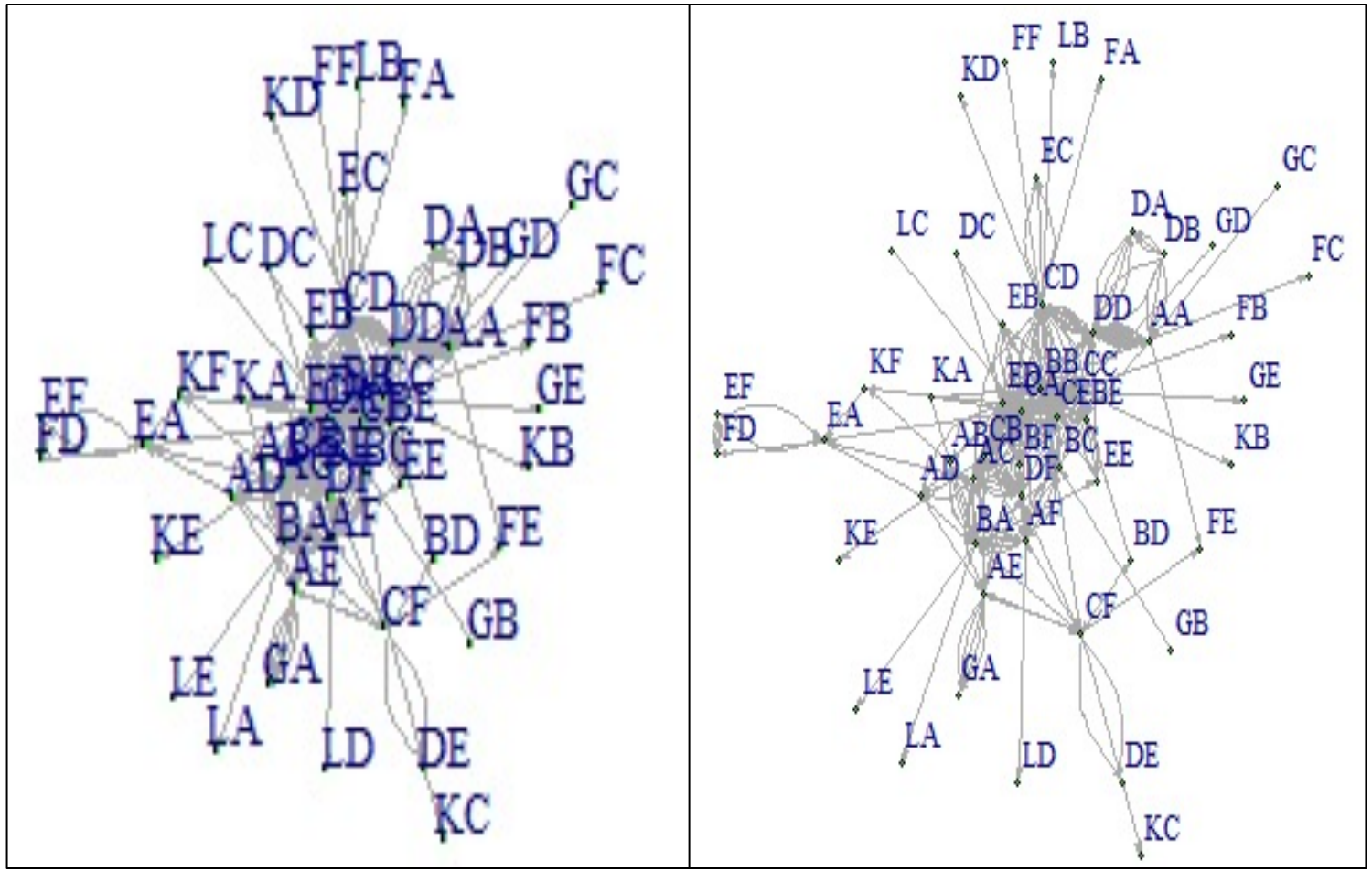
Network diagram:

- set.seed(222)
- plot(net)



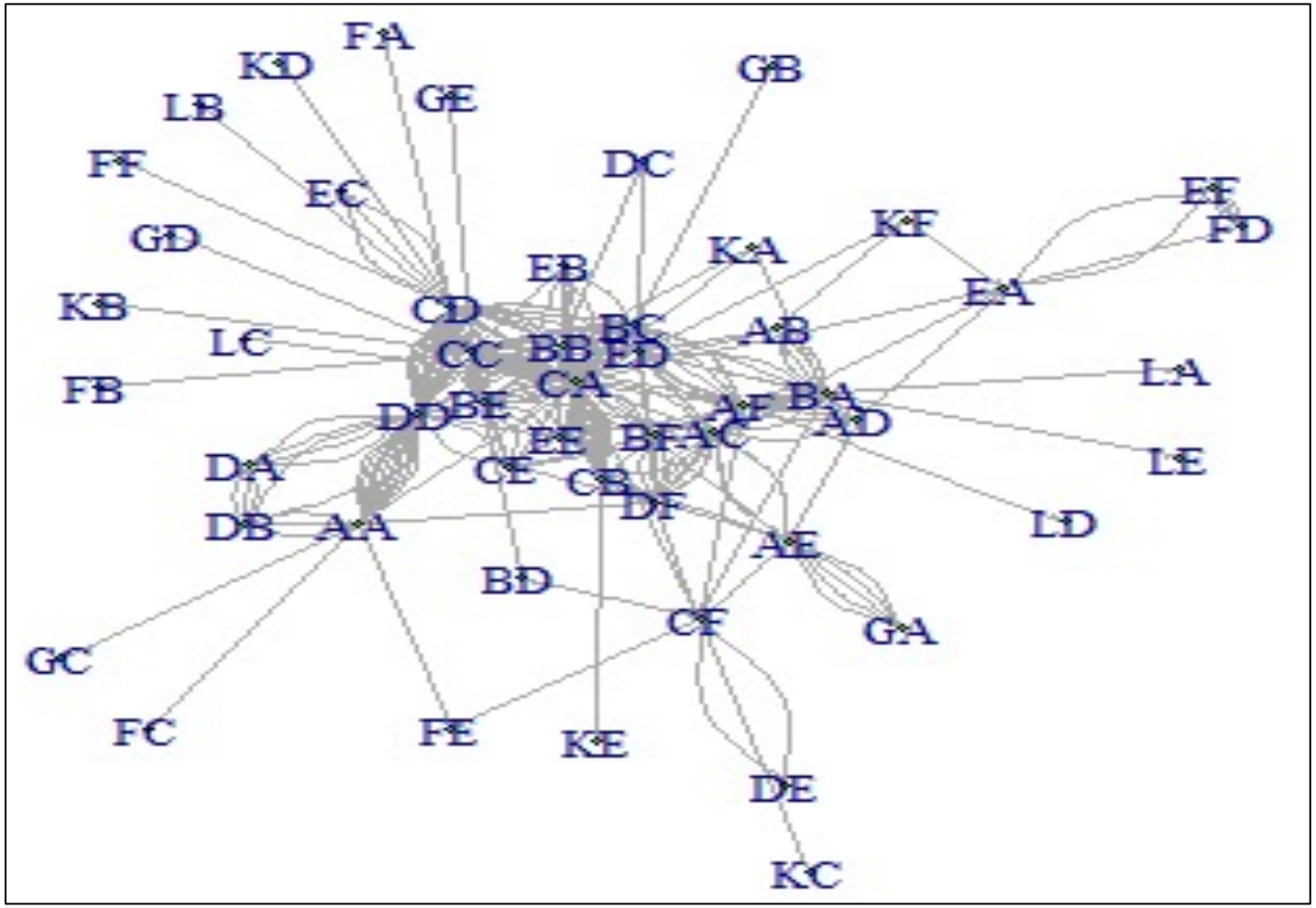
Network diagram: A bit of tweaking!

- plot(net,
- vertex.color = "green",
- vertex.size = 2,
- vertex.label.dist = 1.5,
- edge.arrow.size = 0.1,
- vertex.label.cex = 0.8)



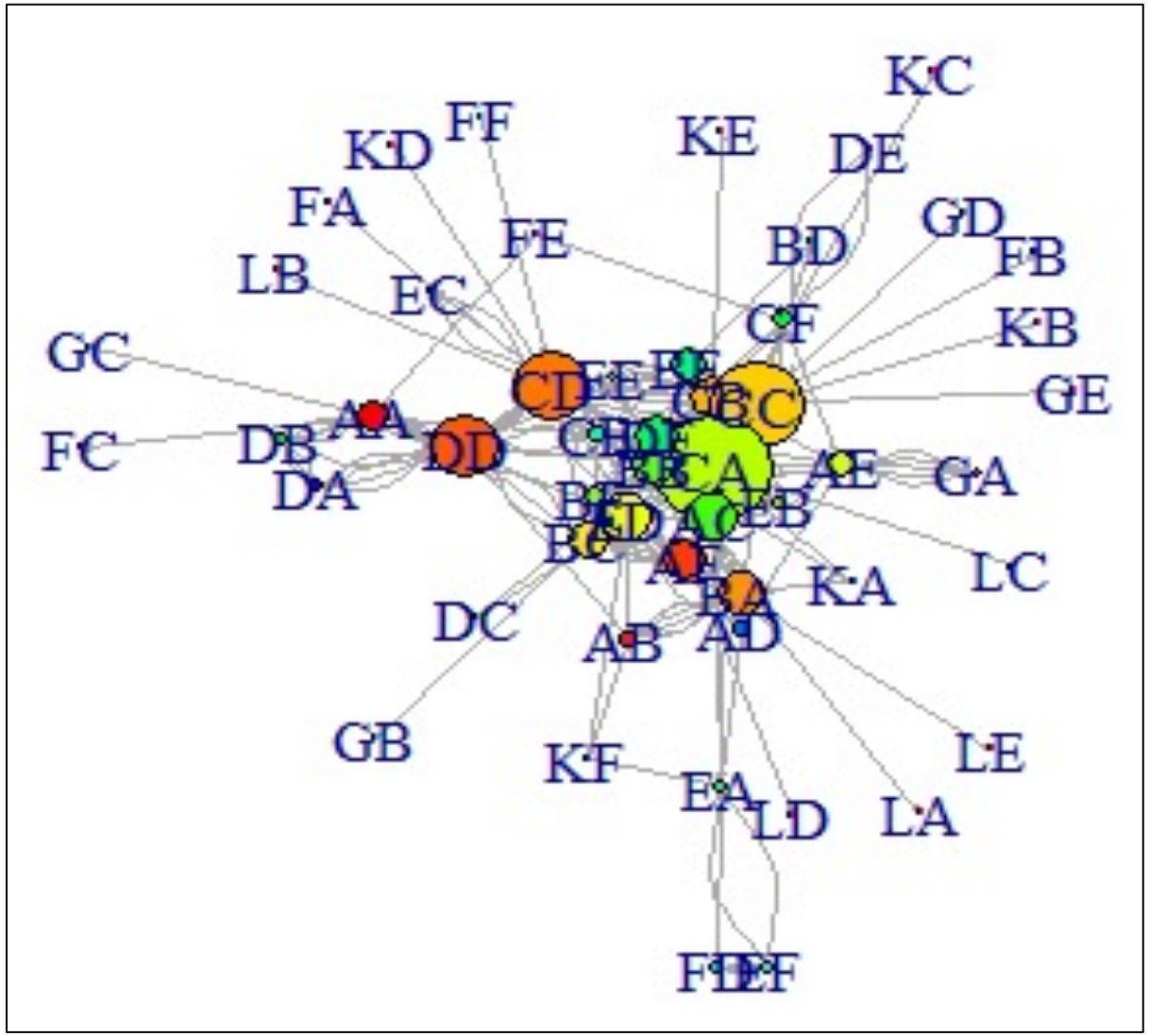
Network diagram: A little bit of tweaking!

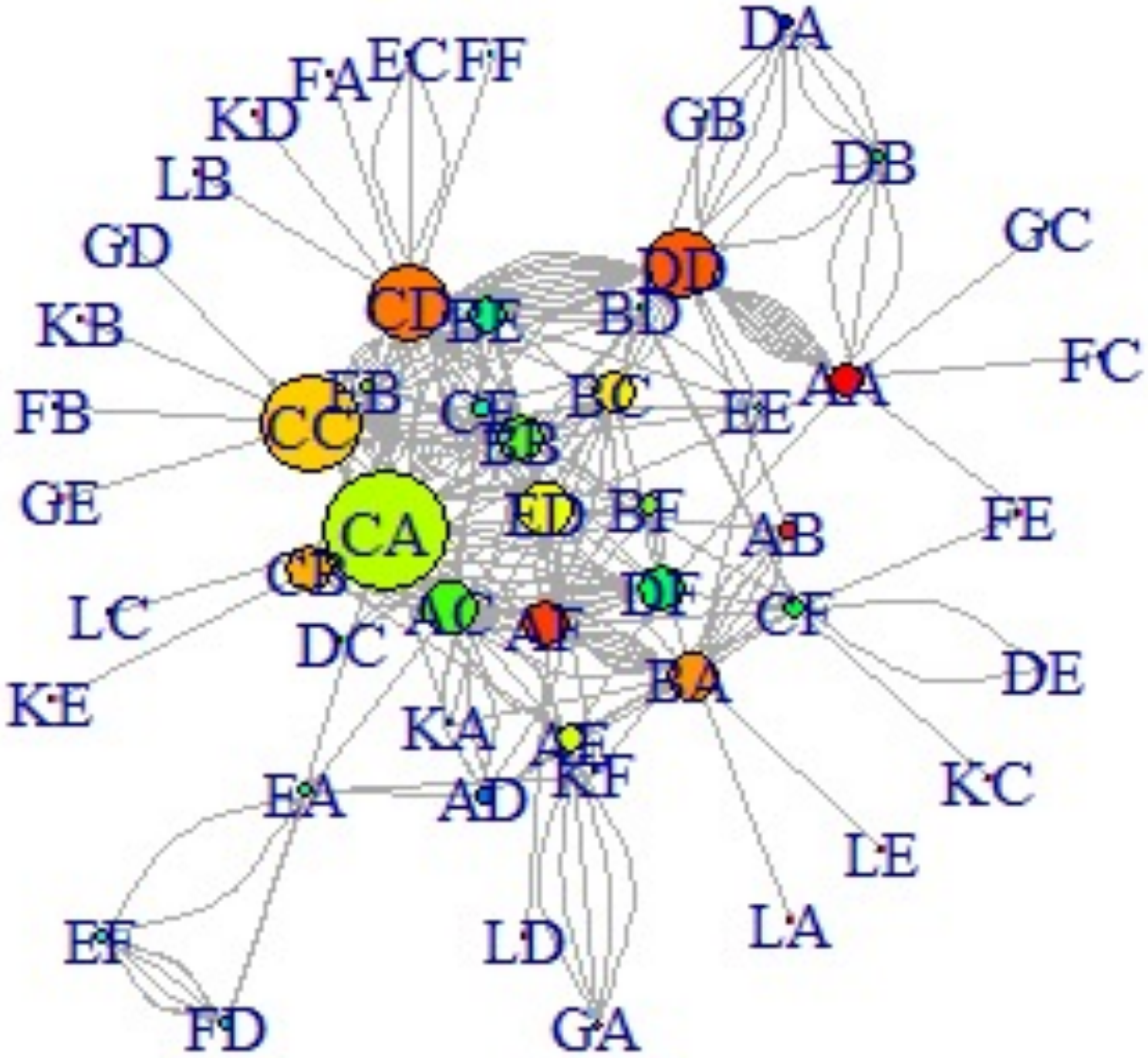
- plot(net,
- vertex.color = "green",
- vertex.size = 2,
- edge.arrow.size = 0.1,
- vertex.label.cex = 0.8)



Network diagram: layout 1!

```
plot(net,
vertex.color = rainbow(52),
vertex.size = V(net)$degree*0.4,
edge.arrow.size = 0.1,
layout=layout.fruchterman.reingold)
```





#Next layout i.e. layout 2

```
plot(net,
    vertex.color = rainbow(52),
    vertex.size = V(net)$degree*0.4,
    edge.arrow.size = 0.1,
    layout=layout.kamada.kawai)
```

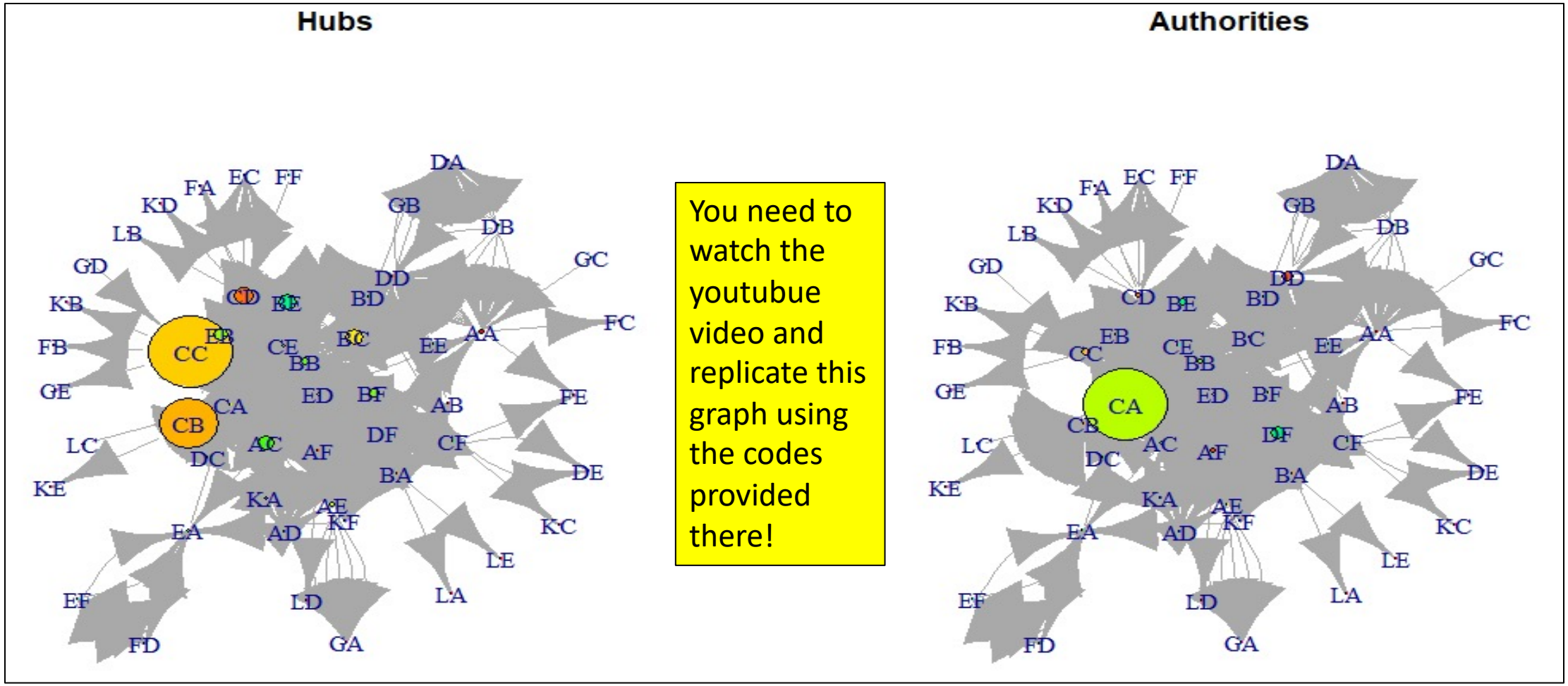
Which nodes are “hubs”?

- **Nodes with most outer edges**
- **We need “hub score”**

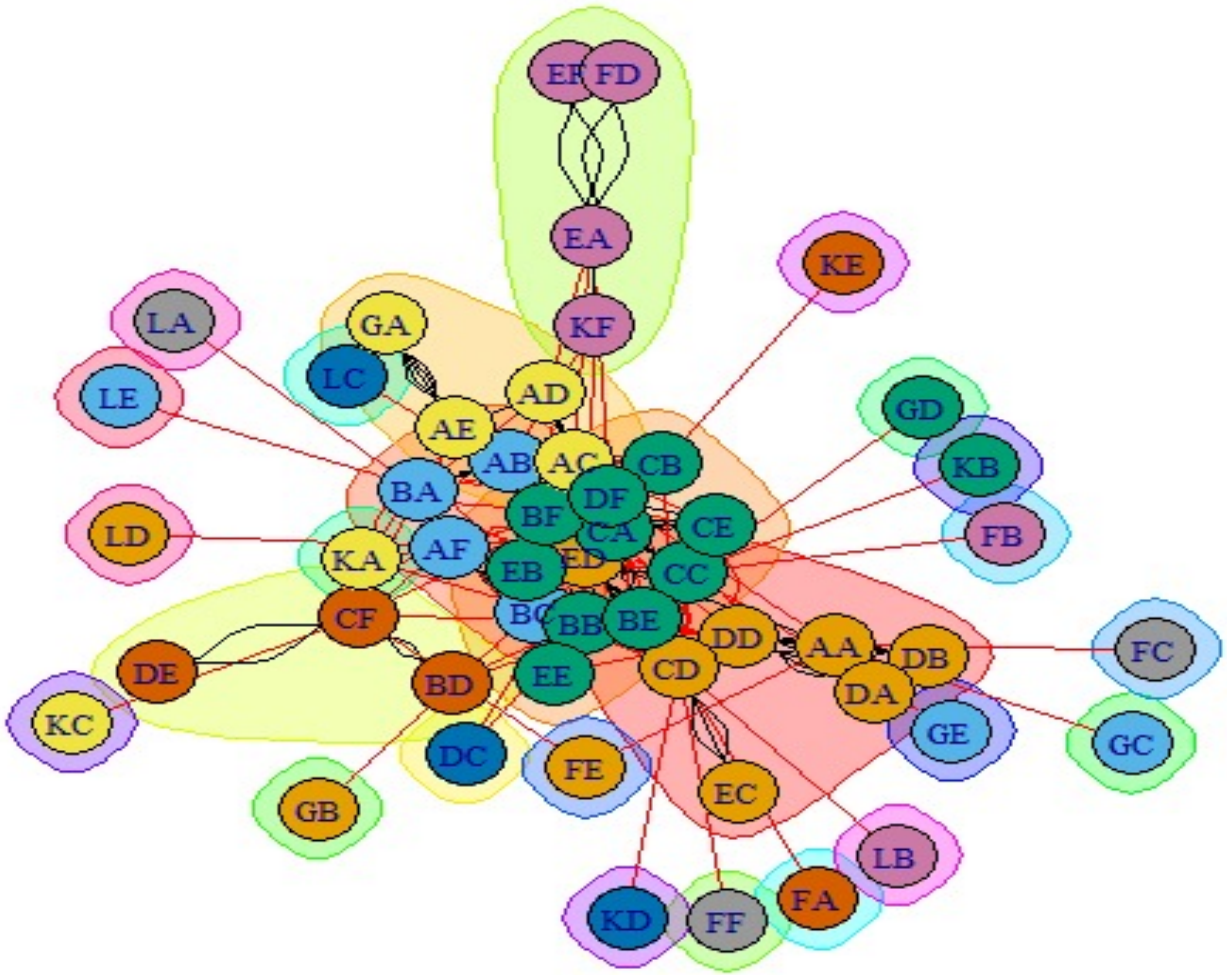
Which nodes are “authorities”?

- **Nodes with most inner edges**
- **We need “authority score”**

Hubs and authorities: With hub score & authority scores of the network data



Community (cluster) detection:




```
#Community detection
net <- graph.data.frame(y, directed = F)
cnet <- cluster_edge_betweenness(net)
plot(cnet,
    net,
    vetex.size = 10,
    vertex.label.cex = 0.8)
```

Question/Queries?

- **Read and learn about “sna” package on your own!**

Assignment (MS Teams):

- Follow this link and replicate the SNA done with Twitter Data provided there and prepare a report with all the explanations

- https://www.rdatamining.com/examples/social-network-analysis

Next class:

- **Grammar of graphics**
- ggplot2 packages and its use in R
- **Read Chapter 1: Data Visualization with ggplot2 of your course text book carefully before coming to the next class**
- Next class is on Friday 19 November 2021 in the SMSTU classroom

ggplot2 Book and Tutorial

- Book:

https://ggplot2-book.org/index.html

- Tutorial:

https://www.tutorialspoint.com/ggplot2/ggplot2_tutorial.pdf

More resources for ggplot2:

- https://ggplot2.tidyverse.org/
- https://cfss.uchicago.edu/notes/grammar-of-graphics/
- https://andrewirwin.github.io/data-visualization/index.html
- https://www.researchgate.net/publication/5142951_The_Grammar_of_Graphics

Thank you!

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