Assignment 5

CS 432

Spring 2017

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Question 1

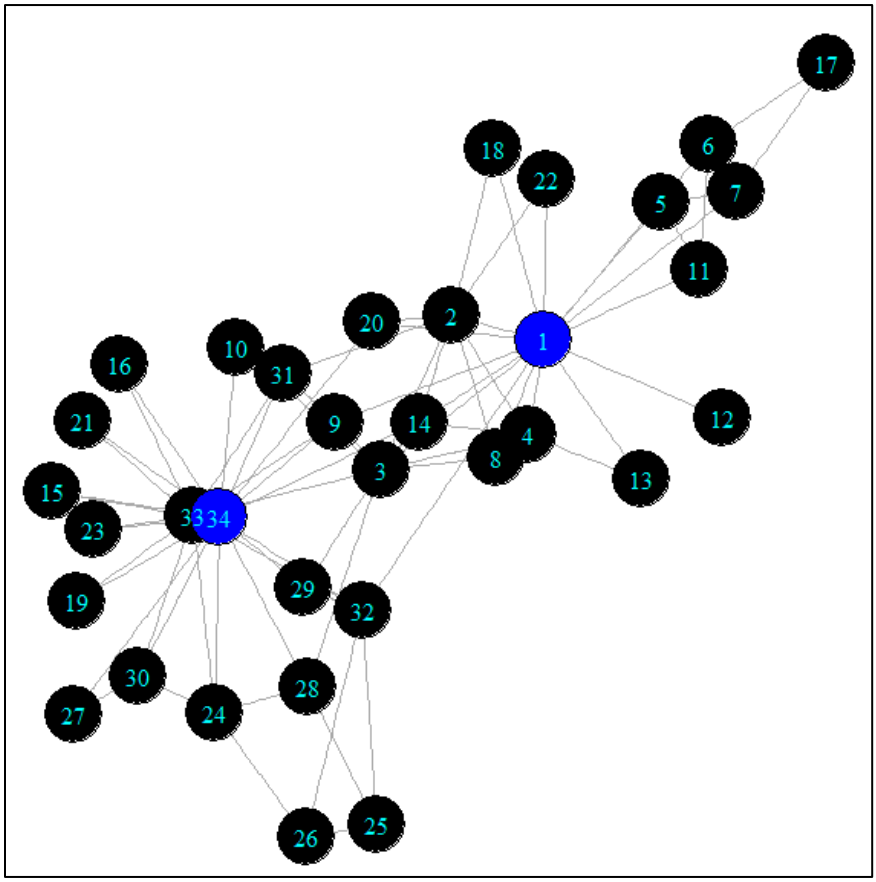
Zachary's Karate Club consisted of 34 members. There was a split in the group that was almost identical to Wayne Zachary's analysis/ prediction, with about 97% accuracy. To model this, I decided to use RStudio. The "igraph" package in RStudio is very useful for analyzing the data from Zachary's Karate Club. Before I began, I came across an excellent article about the study found here: https://milesott.com/2016/08/26/karate-club-network-club/ It provided a link to a dataset in gml format. I used this as a starting point for my analysis. To begin, I read the data into a graph in RStudio. Then, I created a variable to house the edge betweenness. According to Girvan and Newman, edge betweenness centrality is "the number of shortest paths that go through an edge in a network graph." This is found by examining all the edges in a graph to determine which edge has the highest betweenness. Then, deleting that edge until a cluster or module is formed. The "edge.bewteenness.community" algorithm is the Girvan-Newman algorithm. To handle edge removal and determine modularity, I used most of the code in this **example**:

```
# Now we have the merges/splits and we need to calculate the modularity
# for each merge for this we'll use a function that for each edge
# removed will create a second graph, check for its membership and use
# that membership to calculate the modularity
mods <- sapply(0:ecount(g), function(i){
  g2 <- delete.edges(g, ebc$removed.edges[seq(length=i)])
  cl <- clusters(g2)$membership
# March 13, 2014 - compute modularity on the original graph g
# (Thank you to Augustin Luna for detecting this typo) and not on the induced one g2.
  modularity(g,cl)
})
```

Before the Split:

```
library(igraph)

#undirected graph
g <- read.graph("C:/CS432/A5/karate.gml", format="gml")

#find the edge betweenness
ebc <-edge.betweenness.community(g)

#color corresponds with membership
#V(g)$color <- ebc$membership + 5

V(g)$color[1] <- "blue"
V(g)$color[2:33] <- "black"
V(g)$color[34] <- "blue"

plot(g,  layout = layout.fruchterman.reingold, vertex.label.color = "cyan", vertex.size = 15)
```

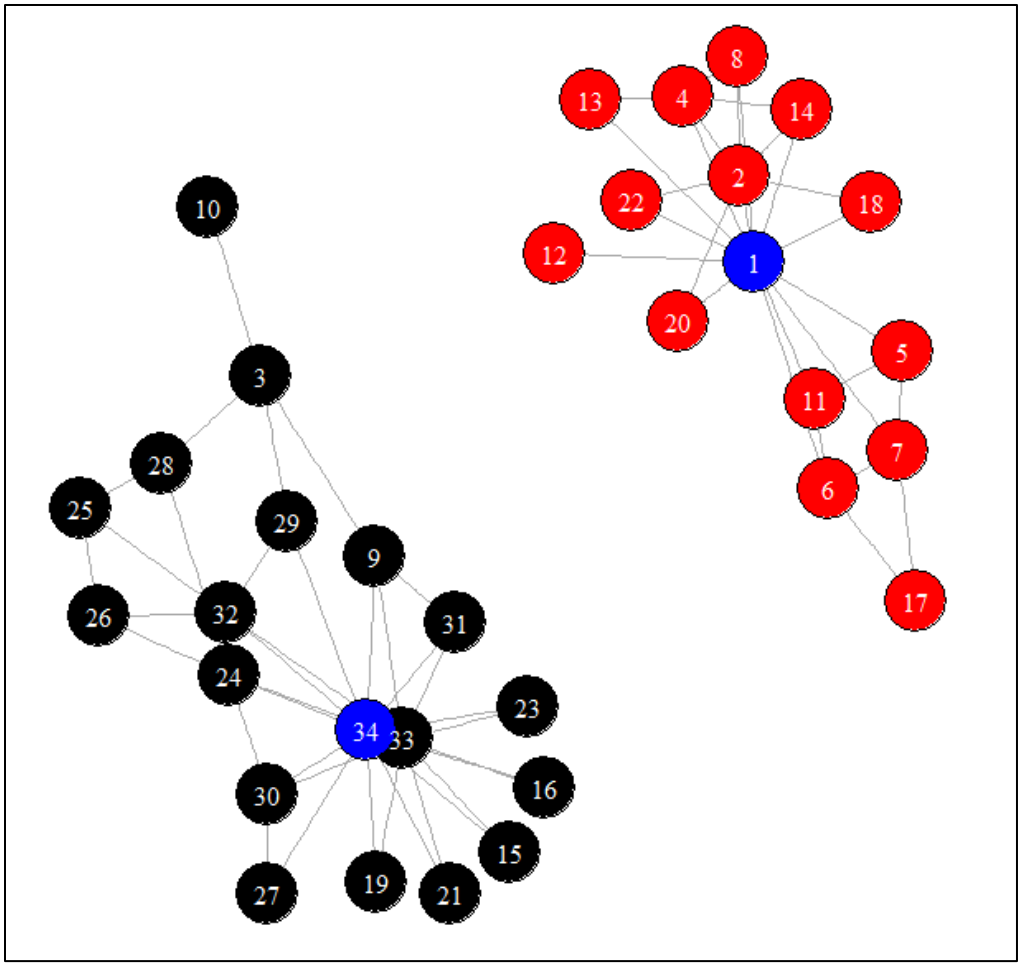
Note: I have indicated which nodes belong to “Mr. Hi” (1) and “John A.” (34).



Two Clusters:

```
library(igraph)

#undirected graph
g <- read.graph("C:/CS432/A5/karate.gml", format="gml")

#find the edge betweenness
ebc <-edge.betweenness.community(g)
```

```
v(g)$color[1] <- "blue"
v(g)$color[22] <- "red"
v(g)$color[20] <- "red"
v(g)$color[8] <- "red"
v(g)$color[2] <- "red"
v(g)$color[4] <- "red"
v(g)$color[11] <- "red"
v(g)$color[14] <- "red"
v(g)$color[13] <- "red"
v(g)$color[18] <- "red"
v(g)$color[12] <- "red"
v(g)$color[5] <- "red"
v(g)$color[6] <- "red"
v(g)$color[7] <- "red"
v(g)$color[17] <- "red"
v(g)$color[34] <- "blue"

#plot(g,  layout = layout.fruchterman.reingold, vertex.label.color = "cyan", vertex.size = 15)


#delete edges to find the remaining components that make up the communities
mods <- sapply(
0:ecount(g), function(i){
g2 <- delete.edges(g, ebc$removed.edges[seq(length=i)])
cl <- clusters(g2)$membership
if(no.clusters(g2)==2){
    plot(g2, layout = layout.fruchterman.reingold, vertex.label.color = "white", vertex.size = 15)
    }
  }
```



Results:

Group 1 consists of 15 members including- 1, 2, 4, 5, 6, 7, 8, 11, 12, 13, 14, 17, 18, 20, and 22. Group 2 consists of 19 members including- 3, 9, 10, 15, 16, 19, 21, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, and 34. This is almost identical with Zachary's prediction, as the only deficiency results from individuals 3 and 9. Therefore, I would venture to say that the mathematical model accurately represents reality.

After the Split:

Mr. Hi	John A.
1	3
2	9
4	10
5	15
6	16
7	19
8	21
11	23
12	24
13	25
14	26
17	27
18	28
20	29
22	30
	31
	32
	33
	34

Actual Split:

Mr. Hi	John A.
1	10
2	15
3	16
4	19
5	21
6	23
7	24
8	25
9	26
11	27
12	28
13	29
14	30
17	31
18	32
20	33
22	34

Zachary's Split:

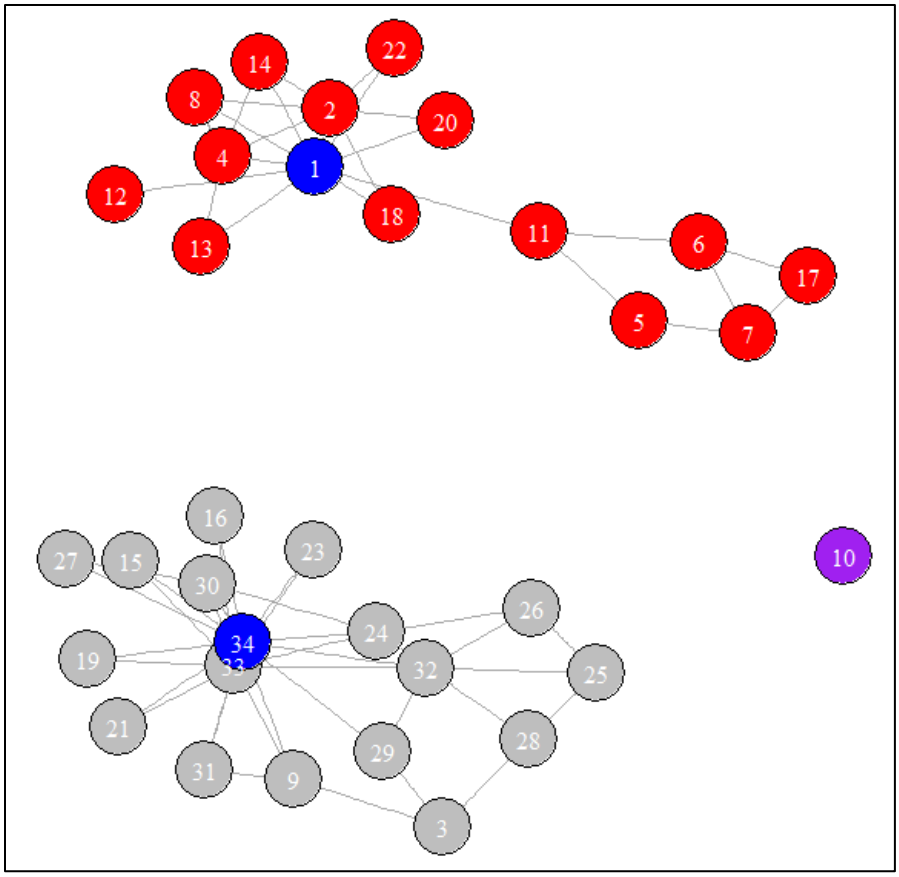
Mr. Hi	John A.
1	9
2	10
3	15
4	16
5	19
6	21
7	23
8	24
11	25
12	26
13	27
14	28
17	29
18	30
20	31
22	32
	33
	34

Question 2

In order to obtain a cluster level of 3, 4, and 5, the “no.clusters,” or number of clusters, was set to each corresponding number. Some slight changes were made to help distinguish between each cluster for readability.

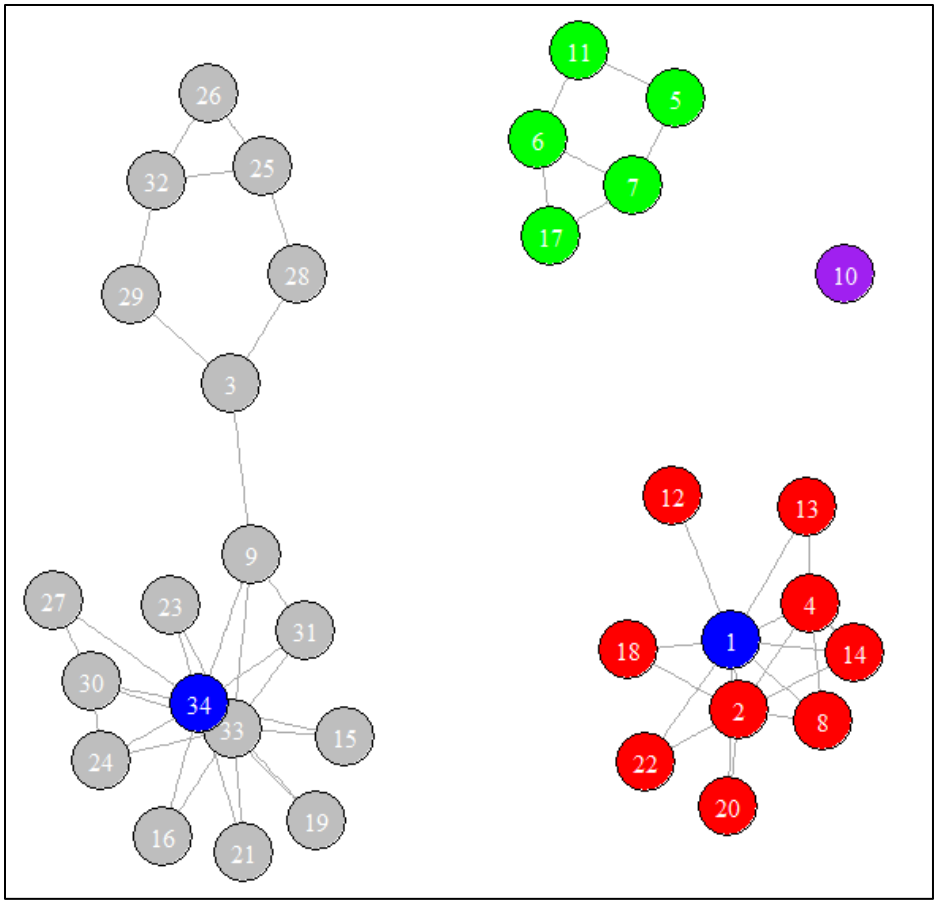
Three Clusters:

```
library(igraph)

#undirected graph
g <- read.graph("C:/CS432/A5/karate.gml", format="gml")

#find the edge betweenness
ebc <-edge.betweenness.community(g)

#color corresponds with membership; for 5 clusters
#V(g)$color <- ebc$membership + 5

V(g)$color <- "gray"
V(g)$color[1] <- "blue"
V(g)$color[34] <- "blue"


# for two clusters
# V(g)$color[22] <- "red"
# V(g)$color[20] <- "red"
# V(g)$color[8] <- "red"
# V(g)$color[2] <- "red"
# V(g)$color[4] <- "red"
# V(g)$color[11] <- "red"
# V(g)$color[14] <- "red"
# V(g)$color[13] <- "red"
# V(g)$color[18] <- "red"
# V(g)$color[12] <- "red"
# V(g)$color[5] <- "red"
# V(g)$color[6] <- "red"
# V(g)$color[7] <- "red"
# V(g)$color[17] <- "red"

# for three clusters
V(g)$color[10] <- "purple"

V(g)$color[2] <- "red"
V(g)$color[4] <- "red"
V(g)$color[5:8] <- "red"
V(g)$color[11:14] <- "red"
V(g)$color[17:18] <- "red"
V(g)$color[20] <- "red"
V(g)$color[22] <- "red"



#plot(g,  layout = layout.fruchterman.reingold, vertex.label.color = "cyan", vertex.size = 15)


#delete edges to find the remaining components that make up the communities
mods <- sapply(
0:ecount(g), function(i){
g2 <- delete.edges(g, ebc$removed.edges[seq(length=i)])
cl <- clusters(g2)$membership
if(no.clusters(g2)==3){
    plot(g2, layout = layout.fruchterman.reingold, vertex.label.color = "white", vertex.size = 15)
    }
  }
)
```


22
14
8
2
20
4
1
12
18
11
6
17
13
5
7
16
27
15
23
10
30
26
24
34
19
32
25
21
28
29
31
9
3

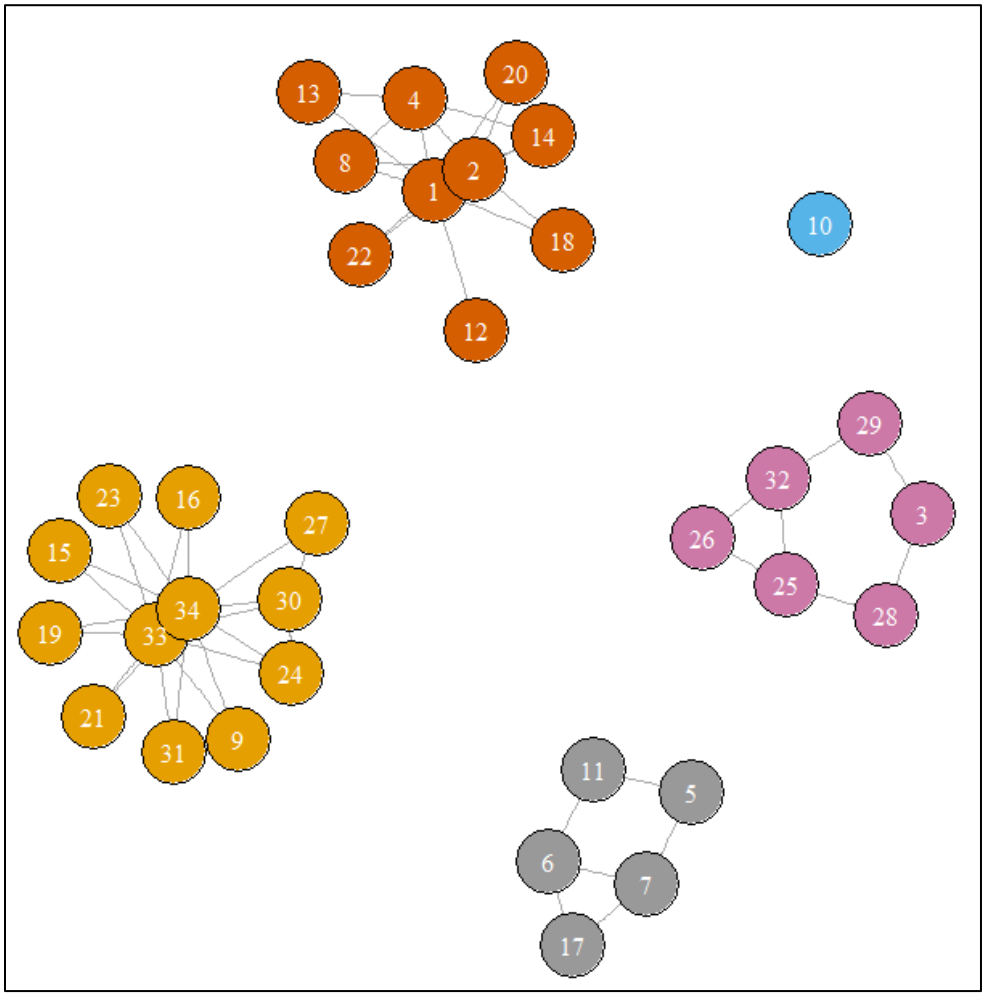
Four Clusters:

```
library(igraph)

#undirected graph
g <- read.graph("C:/CS432/A5/karate.gml", format="gml")

#find the edge betweenness
ebc <-edge.betweenness.community(g)

#color corresponds with membership; for 5 clusters
#V(g)$color <- ebc$membership + 5

V(g)$color <- "gray"
V(g)$color[1] <- "blue"
V(g)$color[34] <- "blue"

# for three clusters
V(g)$color[10] <- "purple"

V(g)$color[2] <- "red"
V(g)$color[4] <- "red"
V(g)$color[8] <- "red"
V(g)$color[12:14] <- "red"
V(g)$color[18] <- "red"
V(g)$color[20] <- "red"
V(g)$color[22] <- "red"

V(g)$color[5:7] <- "green"
V(g)$color[11] <- "green"
V(g)$color[17] <- "green"



#plot(g,  layout = layout.fruchterman.reingold, vertex.label.color = "cyan", vertex.size = 15)


#delete edges to find the remaining components that make up the communities
mods <- sapply(
0:ecount(g), function(i){
g2 <- delete.edges(g, ebc$removed.edges[seq(length=i)])
cl <- clusters(g2)$membership
if(no.clusters(g2)==4){
    plot(g2, layout = layout.fruchterman.reingold, vertex.label.color = "white", vertex.size = 15)
    }
  }
)
```


11
5
6
7
17
26
32
25
29
28
3
10
12
13
4
18
1
14
2
8
22
20
9
27
23
31
30
34
33
15
24
16
21
19

Five Clusters:

```
library(igraph)

#undirected graph
g <- read.graph("C:/CS432/A5/karate.gml", format="gml")

#find the edge betweenness
ebc <-edge.betweenness.community(g)

#color correspongs with membership
V(g)$color <- ebc$membership + 5

#delete edges to find the remaining components that make up the communities
mods <- sapply(
0:ecount(g), function(i){
g2 <- delete.edges(g, ebc$removed.edges[seq(length=i)])
cl <- clusters(g2)$membership
if(no.clusters(g2)==5){
    plot(g2, layout = layout.fruchterman.reingold, vertex.label.color = "white", vertex.size = 15)
    }
  }
)
```



Resources

http://www1.ind.ku.dk/complexLearning/zachary1977.pdf

http://aris.ss.uci.edu/~lin/76.pdf

https://link.springer.com/referenceworkentry/10.1007%2F978-1-4419-9863-7_874

http://igraph.org/r/doc/betweenness.html

http://www.sixhat.net/finding-communities-in-networks-with-r-and-igraph.html

http://stackoverflow.com/questions/9876267/r-igraph-community-detection-edge-betweenness-method-count-list-members-of-e

https://en.wikipedia.org/wiki/Girvan%E2%80%93Newman_algorithm

https://www.r-bloggers.com/going-viral-with-rs-igraph-package/

http://www.shizukalab.com/toolkits/sna/plotting-networks-pt-2

https://www.r-bloggers.com/going-viral-with-rs-igraph-package/

http://rstudio-pubs-static.s3.amazonaws.com/5014_4e3001382f7442629c0760f373cdadd4.html

http://stackoverflow.com/questions/31992685/colour-specific-node-in-igraph

http://stackoverflow.com/questions/14164887/change-the-font-and-colour-of-the-title-of-the-igraph