Bryan Carey
CS432 Assignment 5
Due March 16, 2017

1) We know the result of the Karate Club (Zachary, 1977) split. Prove or disprove that the result of the split could have been predicted by the weighted graph of social interactions. How well does the mathematical model represent reality?

Generously document your answer with all supporting equations, code, graphs, and arguments.

Solution: I did not know of Karate Club until Dr. Nelson brought it up and I read about it. When he asked what was the first rule of Karate Club was, I assumed it was the same as Fight Club- don't talk about Fight Club. I read the report provided by Dr. Nelson on the prompt, http://aris.ss.uci.edu/~lin/76.pdf , the source detailed the split of a university karate club, that was followed by W. W. Zachary, over the course of three years due to difference in opinions on the matter of price of lessons. The group split into two unofficial factions, led by Club President John A.(wanted to stabilize prices), and the instructor Mr. Hi(wanted to raise prices). Eventually the club would become two separate clubs headed by the aforementioned parties. The paper states that "the model allows the locus of fission within the group to be accurately predicted (greater than 97% accuracy for the data reported here)".

A graph of the club, pre-split was found on another site- https://milesott.com/2016/08/26/karate-club-network-club/

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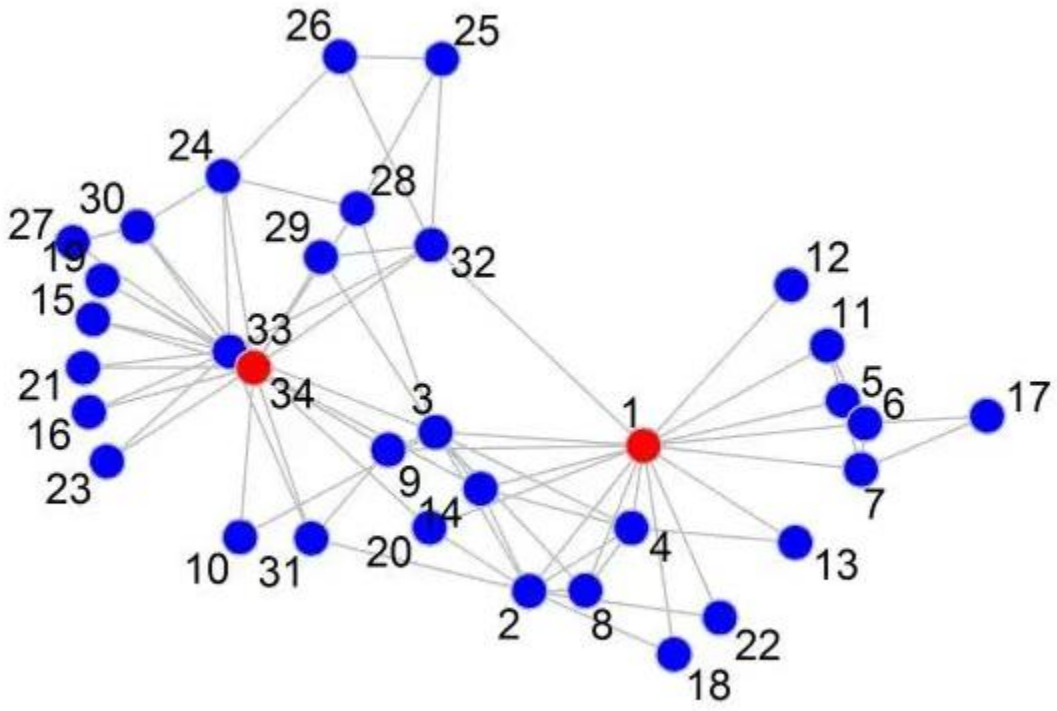

I looked to recreate this graph in myself, so I could manipulate it and recreate the split. In speaking with a classmate I was informed that R was capable of solving this problem, as it had access to the igraph library referenced in the provided readings multiple times. I read up on igraph and the tutorials provided at http://igraph.org/r/ . https://github.com/igraph/igraph/commit/ad7a64d69f5f964721d22ccd0eda96f30549b0f3 was also helpful in creating my graphs. I read it into RStudio using the g = portion of the following code from http://stackoverflow.com/questions/14066700/about-community-to-membership-function .

```
library(igraph)
g=graph.famous("Zachary")
c=walktrap.community(g)
a=community.to.membership(g,c$merges,steps=2)
b=a$membership
modularity(g,b)
```

The initial graph was created using Q1_one.R

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```r
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library(igraph)

#Reading in from .gml file
karateclub <- graph.famous("Zachary")

#Coloring of nodes, denoting Mr. Hi & John A., and the students
V(karateclub)$color[1] <- "red"
V(karateclub)$color[34] <- "red"
V(karateclub)$color[2:33] <- "blue"

```

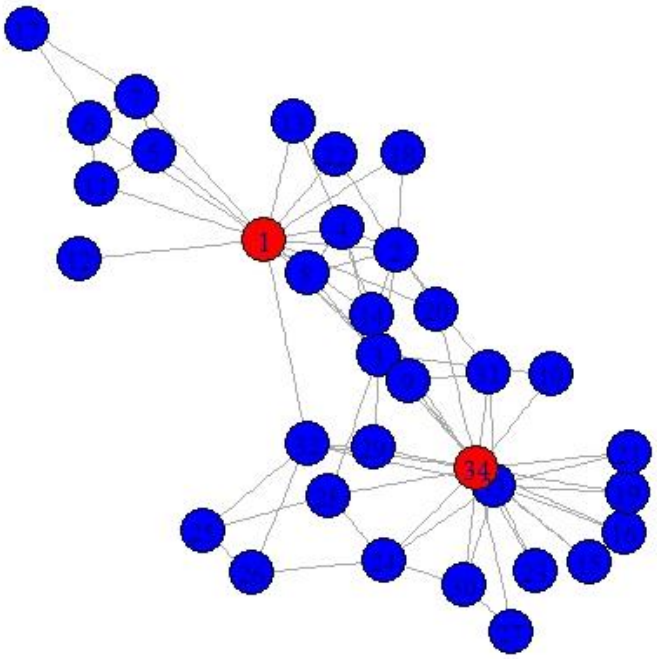

The graph, post-split was created using Q1_two.R

I referenced http://stackoverflow.com/questions/33005510/algorithm-of-community-edge-betweenness-in-python-igraph-implementation, http://igraph.org/r/doc/betweenness.html

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```r
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library(igraph)

#Reading in from .gml file
karateclub <- graph.famous("Zachary")

#Coloring of nodes, denoting Mr. Hi & John A., and the students
V(karateclub)$color[1] <- "red"
V(karateclub)$color[34] <- "red"
V(karateclub)$color[2:33] <- "blue"

#edge betweenness
karateclubsplit <-edge.betweenness.community(karateclub)

#found from
mods <- sapply(
  0:ecount(karateclub), function(i){
    karateclub2 <- delete.edges(karateclub, karateclubsplit$removed.edges[seq(length=i)])
    cl <- clusters(karateclub2)$membership
    if(no.clusters(karateclub2)==2){
      plot(karateclub2,)}})
```

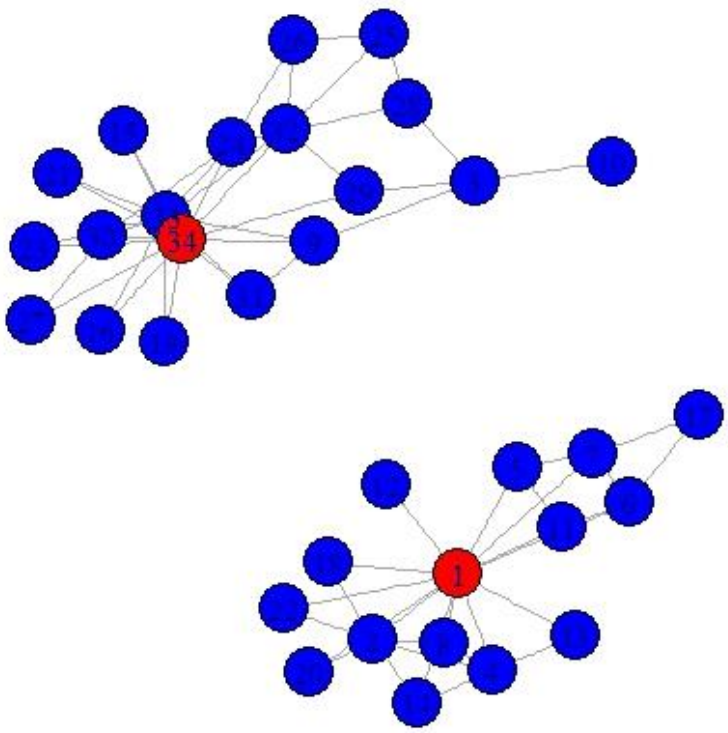

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The ‘mods’ portion of the code was found at this link, http://www.sixhat.net/finding-communities-in-networks-with-r-and-igraph.html , which was sent to me by another student.

```
# First we load the ipgrah package
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)

# let's see if we have communities here using the
# Grivan-Newman algorithm
# 1st we calculate the edge betweenness, merges, etc...
ebc <- edge.betweenness.community(g, directed=F)

# 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)
})
```

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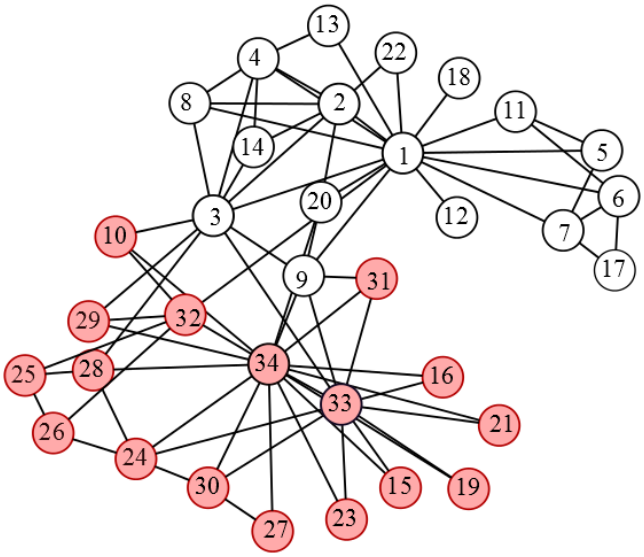
I checked my results against the graph of the actual results, found at https://en.wikipedia.org/wiki/Zachary%27s_karate_club .



The simulation I ran was able to accurately reproduce the results of the split almost exactly with the exception of number 3, which sided with 34 as opposed to 1. This leads me to believe that yes, the split could have been predicted based upon analysis of the relationships between each of the individuals.

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2) We know the group split in two different groups. Suppose the disagreements in the group were more nuanced – what would the clubs look like if they had split into groups of 3, 4, and 5?

Solution: Using my code from Q1_two.R, I was able to simulate the split into 3, 4, and 5 factions simply by changing the value in place of the two located here. Another classmate informed me of how to do so with ease.

```
mods <- sapply(
  0:ecount(karateclub), function(i){
    karateclub2 <- delete.edges(karateclub, karateclubsplit$removed.edges[seq(length=i)])
    cl <- clusters(karateclub2)$membership
    if(no.clusters(karateclub2)==2){
      plot(karateclub2,)}})
```

The results were as follows-

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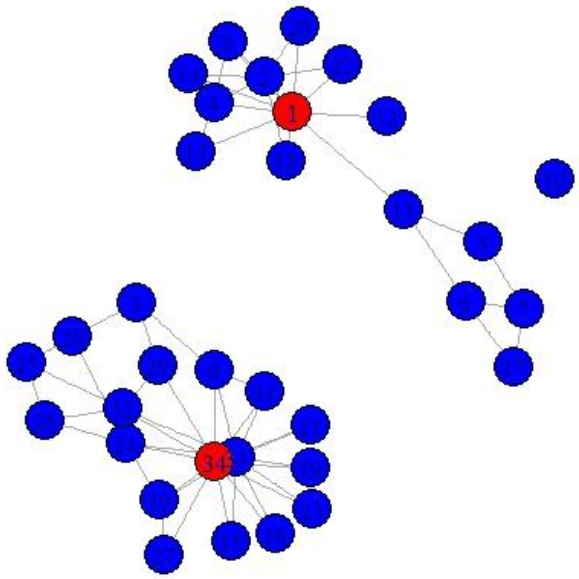

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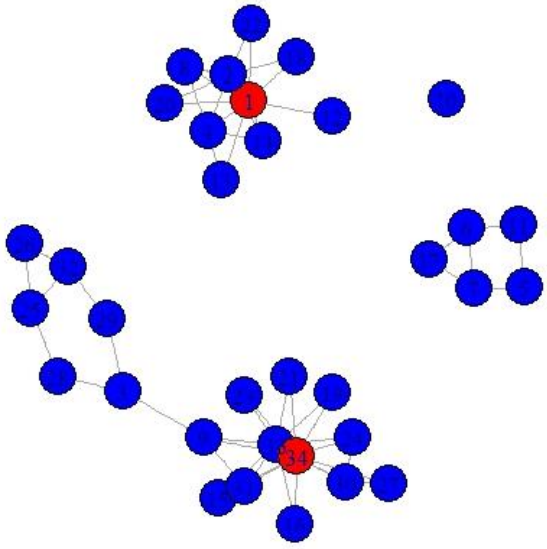

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5.