INFX 576: Problem Set 4 - Core/Periphery Structure[*]

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Due: Thursday, February 9, 2017

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Instructions:

Before beginning this assignment, please ensure you have access to R and RStudio.

1. Download the `problemset4.Rmd` file from Canvas. You will also need the data contained in `problemset4_data.Rdata` and the `block.fit` function we used in class.

2. Replace the "Insert Your Name Here" text in the `author:` field with your own full name. Any collaborators must be listed on the top of your assignment.

3. Be sure to include well-documented (e.g. commented) code chucks, figures and clearly written text chunk explanations as necessary. Any figures should be clearly labeled and appropriately referenced within the text.

4. Collaboration on problem sets is acceptable, and even encouraged, but each student must turn in an individual write-up in his or her own words and his or her own work. The names of all collaborators must be listed on each assignment. Do not copy-and-paste from other students' responses or code.

5. When you have completed the assignment and have **checked** that your code both runs in the Console and knits correctly when you click `Knit PDF`, rename the R Markdown file to `YourLastName_YourFirstName_ps4.Rmd`, knit a PDF and submit the PDF file on Canvas.

Setup:

In this problem set you will need, at minimum, the following R packages.

```
# Load standard libraries
library(statnet)
load("problemset4_data.Rdata")
load("block.fit.Rdata")
```

Problem 1: Core/Periphery Structure

In this problem we will use data from a famous series of studies by Bernard, Killworth, and Sailer[1] on the relationship between observed interaction and informants self-reports of interaction. The specific networks we will use here are from the "behavioral" side, meaning that the i, j cell corresponds to the number of times i and j were *observed* to interact during the data collection period. All interaction is these studies is interpersonal; the study contexts are: (1) communication among radio operators (`bfham`), (2) face-to-face interactions among members of a fraternity (`bkfrat`), (3) face-to-face interactions in a university research group (`bktec`), and (4) face-to-face interactions in a small business (`bkoff`). Here we investigate the possibility of latent two-class structure in these interation networks.

[*]Problems originally written by C.T. Butts (2009)

[1]Bernard H, Killworth P and Sailer L. (1982). Informant accuracy in social network data V. Social Science Research, 11, 30-66.

(a) Network Visualization

To begin visualize each network. You might find it helpful to use transparency when displaying edges using the `edge.col=rgb(0,0,0,0.5)` option of the `gplot` function. Based on each visualization, indicate whether there appears to be a two-class block structure present, and if so what it might be.
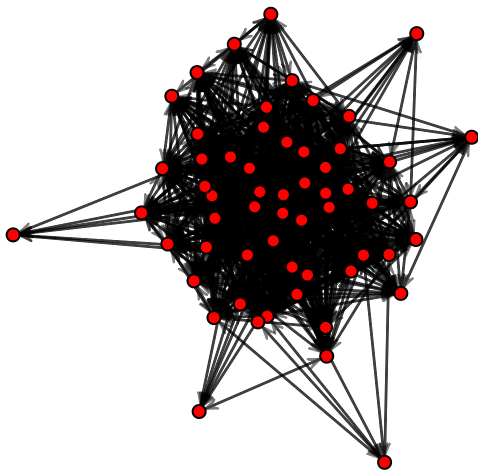
```
#plot the networks BKHAM
gplot(bkham,edge.col=rgb(0,0,0,0.5), main="BKHAM")
```
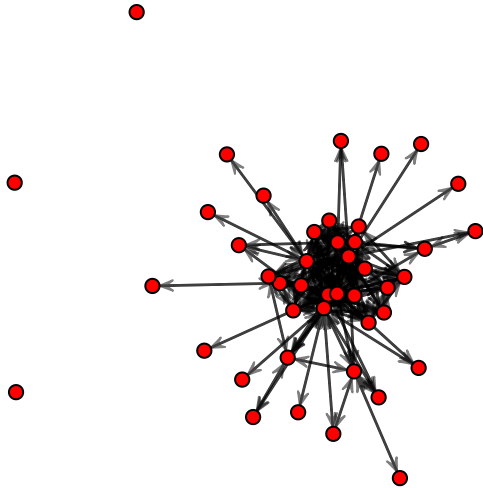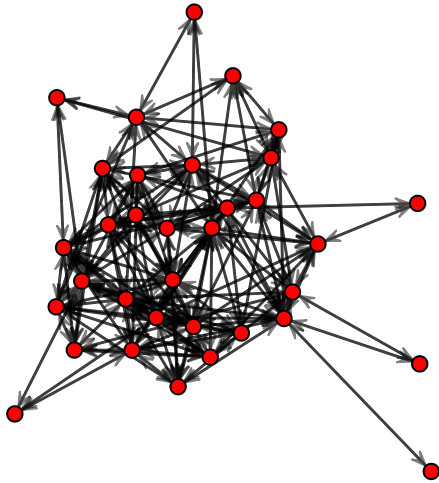


```
#plot the networks BKFRAT
gplot(bkfrat,edge.col=rgb(0,0,0,0.5), main="BKFRAT")
```
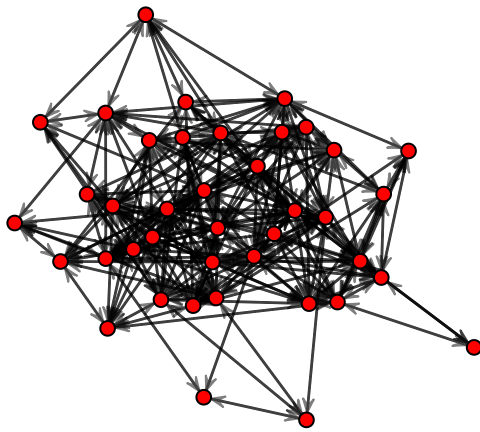


```
#plot the networks BKTEC
gplot(bktec,edge.col=rgb(0,0,0,0.5), main="BKTEC")
```

BKTEC


```
#plot the networks BKOFF
gplot(bkoff,edge.col=rgb(0,0,0,0.5), main="BKOFF")
```

BKOFF

- Looking at the networks, the network appears to be a two class block structure, specifically, a core-periphery structure.

(b) Blockmodels

For each of the BKS networks, fit each of the four non-degrenerate undirected two-class blockmodels. (You may omit the null graph and complete graph blockmodels.) In addition, fit the Borgatti and Everett variant in which only within-class edges are considered. Plot each blocked data matrix with the `plot.sociomatrix` function. Comment on your results.

```
#calculate core w/in,out ties in BKHAM
bkham_kb1<-block.fit(bkham,c(1,1,1,0))
```

```
## Entering annealing loop...
##  Iteration 100, current GOF is 0.04344562.  (Best GOF=0.1067028)
##  Iteration 200, current GOF is -0.03362087.  (Best GOF=0.1067028)
```

```
##   Iteration 300, current GOF is -0.07475812.  (Best GOF=0.1067028)
##   Iteration 400, current GOF is 0.107738.  (Best GOF=0.1319635)
##   Iteration 500, current GOF is 0.1052491.  (Best GOF=0.1345587)
##   Iteration 600, current GOF is -0.02283156.  (Best GOF=0.1345587)
##   Iteration 700, current GOF is 0.03185071.  (Best GOF=0.1345587)
##   Iteration 800, current GOF is 0.05819622.  (Best GOF=0.1345587)
##   Iteration 900, current GOF is -0.0217831.  (Best GOF=0.1345587)
##   Iteration 1000, current GOF is 0.08453787.  (Best GOF=0.1345587)
##   Iteration 1100, current GOF is 0.006870892.  (Best GOF=0.1345587)
##   Iteration 1200, current GOF is 0.05731759.  (Best GOF=0.2011696)
##   Iteration 1300, current GOF is 0.1027722.  (Best GOF=0.2011696)
##   Iteration 1400, current GOF is 0.1535628.  (Best GOF=0.2011696)
##   Iteration 1500, current GOF is 0.1313014.  (Best GOF=0.2011696)
##   Iteration 1600, current GOF is 0.2464304.  (Best GOF=0.2486204)
##   Iteration 1700, current GOF is 0.283099.  (Best GOF=0.2915142)
##   Iteration 1800, current GOF is 0.3103696.  (Best GOF=0.3103696)
##   Iteration 1900, current GOF is 0.3446625.  (Best GOF=0.3446625)
##   Iteration 2000, current GOF is 0.3607077.  (Best GOF=0.3607077)
##   Iteration 2100, current GOF is 0.3607077.  (Best GOF=0.3607077)
##   Iteration 2200, current GOF is 0.3607077.  (Best GOF=0.3607077)
##   Iteration 2300, current GOF is 0.3607077.  (Best GOF=0.3607077)
##   Iteration 2400, current GOF is 0.3607077.  (Best GOF=0.3607077)
##   Iteration 2500, current GOF is 0.3607077.  (Best GOF=0.3607077)
##   Iteration 2600, current GOF is 0.3607077.  (Best GOF=0.3607077)
##   Iteration 2700, current GOF is 0.3607077.  (Best GOF=0.3607077)
##   Iteration 2800, current GOF is 0.3607077.  (Best GOF=0.3607077)
##   Iteration 2900, current GOF is 0.3607077.  (Best GOF=0.3607077)
##   Iteration 3000, current GOF is 0.3607077.  (Best GOF=0.3607077)
## Annealing completed.
## Refining solution via hill-climbing procedure...
##   Refining; current GOF is  0.3607077
## Preparing and returning output.
```

```
bkham_kb1lab<-bkham_kb1$block.membership[bkham_kb1$order.vector]

#calculate ties between core and periphery in BKHAM
bkham_kb2<-block.fit(bkham,c(0,1,1,0))
```

```
## Entering annealing loop...
##   Iteration 100, current GOF is -0.05824761.  (Best GOF=0.05297766)
##   Iteration 200, current GOF is -0.03140199.  (Best GOF=0.05297766)
##   Iteration 300, current GOF is 0.03142068.  (Best GOF=0.05297766)
##   Iteration 400, current GOF is 0.01563906.  (Best GOF=0.07556267)
##   Iteration 500, current GOF is -0.02167528.  (Best GOF=0.07556267)
##   Iteration 600, current GOF is 0.0655647.  (Best GOF=0.07556267)
##   Iteration 700, current GOF is -0.03076743.  (Best GOF=0.07556267)
##   Iteration 800, current GOF is 0.01084535.  (Best GOF=0.07556267)
##   Iteration 900, current GOF is 0.01025777.  (Best GOF=0.07556267)
##   Iteration 1000, current GOF is -0.03650713.  (Best GOF=0.07556267)
##   Iteration 1100, current GOF is 0.0293065.  (Best GOF=0.07556267)
##   Iteration 1200, current GOF is 0.02783395.  (Best GOF=0.07556267)
##   Iteration 1300, current GOF is 0.02791213.  (Best GOF=0.07556267)
##   Iteration 1400, current GOF is 0.04817035.  (Best GOF=0.07556267)
##   Iteration 1500, current GOF is 0.09511663.  (Best GOF=0.09511663)
##   Iteration 1600, current GOF is 0.1166539.  (Best GOF=0.1246522)
```

```
##  Iteration 1700, current GOF is 0.1800651.   (Best GOF=0.1800651)
##  Iteration 1800, current GOF is 0.2521185.   (Best GOF=0.2521185)
##  Iteration 1900, current GOF is 0.2569673.   (Best GOF=0.2569673)
##  Iteration 2000, current GOF is 0.2607941.   (Best GOF=0.2607941)
##  Iteration 2100, current GOF is 0.2659807.   (Best GOF=0.2659807)
##  Iteration 2200, current GOF is 0.2659807.   (Best GOF=0.2659807)
##  Iteration 2300, current GOF is 0.2659807.   (Best GOF=0.2659807)
##  Iteration 2400, current GOF is 0.2659807.   (Best GOF=0.2659807)
##  Iteration 2500, current GOF is 0.3273251.   (Best GOF=0.3273251)
##  Iteration 2600, current GOF is 0.3273251.   (Best GOF=0.3273251)
##  Iteration 2700, current GOF is 0.3273251.   (Best GOF=0.3273251)
##  Iteration 2800, current GOF is 0.3273251.   (Best GOF=0.3273251)
##  Iteration 2900, current GOF is 0.3273251.   (Best GOF=0.3273251)

## Warning in cor(as.vector(d[g1[i], , ]), as.vector(d[g2[j], , ]), use =
## "complete.obs"): the standard deviation is zero

##  Iteration 3000, current GOF is 0.3273251.   (Best GOF=0.3273251)
## Annealing completed.
## Refining solution via hill-climbing procedure...
##  Refining; current GOF is  0.3273251
## Preparing and returning output.
```

```
bkham_kb2lab<-bkham_kb1$block.membership[bkham_kb2$order.vector]

#calculate isolated core ties in BKHAM
bkham_kb3<-block.fit(bkham,c(1,0,0,0))
```

```
## Entering annealing loop...
##  Iteration 100, current GOF is -0.03987198.   (Best GOF=0.09980128)
##  Iteration 200, current GOF is -0.02554542.   (Best GOF=0.1570927)
##  Iteration 300, current GOF is 0.1509877.   (Best GOF=0.1570927)
##  Iteration 400, current GOF is 0.07468373.   (Best GOF=0.1661382)
##  Iteration 500, current GOF is 0.0558832.   (Best GOF=0.3168419)
##  Iteration 600, current GOF is 0.04503077.   (Best GOF=0.3168419)
##  Iteration 700, current GOF is 0.05143907.   (Best GOF=0.3168419)
##  Iteration 800, current GOF is 0.1569273.   (Best GOF=0.3168419)
##  Iteration 900, current GOF is -0.005453451.   (Best GOF=0.3168419)
##  Iteration 1000, current GOF is 0.09331933.   (Best GOF=0.3168419)
##  Iteration 1100, current GOF is -0.0002883884.   (Best GOF=0.3168419)
##  Iteration 1200, current GOF is 0.1840666.   (Best GOF=0.3168419)
##  Iteration 1300, current GOF is 0.2456906.   (Best GOF=0.3168419)
##  Iteration 1400, current GOF is 0.305489.   (Best GOF=0.3168419)
##  Iteration 1500, current GOF is 0.3758689.   (Best GOF=0.4013564)
##  Iteration 1600, current GOF is 0.6088825.   (Best GOF=0.6088825)
##  Iteration 1700, current GOF is 0.6959562.   (Best GOF=0.6959562)
##  Iteration 1800, current GOF is 0.6959562.   (Best GOF=0.6959562)
##  Iteration 1900, current GOF is 0.6959562.   (Best GOF=0.6959562)
##  Iteration 2000, current GOF is 0.6959562.   (Best GOF=0.6959562)
##  Iteration 2100, current GOF is 0.6959562.   (Best GOF=0.6959562)
##  Iteration 2200, current GOF is 0.6959562.   (Best GOF=0.6959562)
##  Iteration 2300, current GOF is 0.6959562.   (Best GOF=0.6959562)
##  Iteration 2400, current GOF is 0.6959562.   (Best GOF=0.6959562)
##  Iteration 2500, current GOF is 0.6959562.   (Best GOF=0.6959562)
##  Iteration 2600, current GOF is 0.6959562.   (Best GOF=0.6959562)
##  Iteration 2700, current GOF is 0.6959562.   (Best GOF=0.6959562)
```

```
##  Iteration 2800, current GOF is 0.6959562.   (Best GOF=0.6959562)
##  Iteration 2900, current GOF is 0.6959562.   (Best GOF=0.6959562)
##  Iteration 3000, current GOF is 0.6959562.   (Best GOF=0.6959562)
## Annealing completed.
## Refining solution via hill-climbing procedure...
##  Refining; current GOF is  0.6959562
## Preparing and returning output.
```
```
bkham_kb3lab<-bkham_kb1$block.membership[bkham_kb3$order.vector]

#calculate core and periphery within ties in BKHAM
bkham_kb4<-block.fit(bkham,c(1,0,0,1))
```
```
## Entering annealing loop...
##  Iteration 100, current GOF is 0.09389163.   (Best GOF=0.09389163)
##  Iteration 200, current GOF is -0.03213183.   (Best GOF=0.1439721)
##  Iteration 300, current GOF is 0.003011945.   (Best GOF=0.1439721)
##  Iteration 400, current GOF is -0.02065298.   (Best GOF=0.1439721)
##  Iteration 500, current GOF is 0.06515898.   (Best GOF=0.1439721)
##  Iteration 600, current GOF is 0.00921159.   (Best GOF=0.1439721)
##  Iteration 700, current GOF is -0.01563906.   (Best GOF=0.1439721)
##  Iteration 800, current GOF is -0.0216312.   (Best GOF=0.1439721)
##  Iteration 900, current GOF is -0.004152134.   (Best GOF=0.1439721)
##  Iteration 1000, current GOF is 0.02714345.   (Best GOF=0.1439721)
##  Iteration 1100, current GOF is 0.03315413.   (Best GOF=0.1439721)
##  Iteration 1200, current GOF is 0.1177416.   (Best GOF=0.1439721)
##  Iteration 1300, current GOF is 0.1471512.   (Best GOF=0.1564762)
##  Iteration 1400, current GOF is 0.1384245.   (Best GOF=0.1729743)
##  Iteration 1500, current GOF is 0.1721833.   (Best GOF=0.1773164)
##  Iteration 1600, current GOF is 0.1698188.   (Best GOF=0.179366)
##  Iteration 1700, current GOF is 0.1922949.   (Best GOF=0.1952109)
##  Iteration 1800, current GOF is 0.2021584.   (Best GOF=0.2028756)
##  Iteration 1900, current GOF is 0.203902.   (Best GOF=0.2045863)
##  Iteration 2000, current GOF is 0.2074051.   (Best GOF=0.2074051)
##  Iteration 2100, current GOF is 0.2086138.   (Best GOF=0.2086138)
##  Iteration 2200, current GOF is 0.2086138.   (Best GOF=0.2086138)
##  Iteration 2300, current GOF is 0.2086138.   (Best GOF=0.2086138)
##  Iteration 2400, current GOF is 0.2096077.   (Best GOF=0.2096077)
##  Iteration 2500, current GOF is 0.2096077.   (Best GOF=0.2096077)
##  Iteration 2600, current GOF is 0.2096077.   (Best GOF=0.2096077)
##  Iteration 2700, current GOF is 0.2096077.   (Best GOF=0.2096077)
##  Iteration 2800, current GOF is 0.2096077.   (Best GOF=0.2096077)
##  Iteration 2900, current GOF is 0.2096077.   (Best GOF=0.2096077)
##  Iteration 3000, current GOF is 0.2096077.   (Best GOF=0.2096077)
## Annealing completed.
## Refining solution via hill-climbing procedure...
##  Refining; current GOF is  0.2096077
## Preparing and returning output.
```
```
bkham_kb4lab<-bkham_kb1$block.membership[bkham_kb4$order.vector]


#calculate core w/in,out ties in BKFRAT
bkfrat_kb1<-block.fit(bkfrat,c(1,1,1,0))
```

```
## Entering annealing loop...
##   Iteration 100, current GOF is 0.03170534.   (Best GOF=0.06849327)
##   Iteration 200, current GOF is -0.01294254.   (Best GOF=0.06849327)
##   Iteration 300, current GOF is -0.09541986.   (Best GOF=0.07557126)
##   Iteration 400, current GOF is 0.05979135.   (Best GOF=0.08050791)
##   Iteration 500, current GOF is 0.1024864.   (Best GOF=0.1024864)
##   Iteration 600, current GOF is 0.06061585.   (Best GOF=0.1024864)
##   Iteration 700, current GOF is -0.05687664.   (Best GOF=0.1024864)
##   Iteration 800, current GOF is -0.03469747.   (Best GOF=0.119156)
##   Iteration 900, current GOF is 0.0357883.   (Best GOF=0.119156)
##   Iteration 1000, current GOF is 0.1020105.   (Best GOF=0.1314507)
##   Iteration 1100, current GOF is 0.03032239.   (Best GOF=0.1314507)
##   Iteration 1200, current GOF is 0.0560157.   (Best GOF=0.1314507)
##   Iteration 1300, current GOF is 0.0933322.   (Best GOF=0.1314507)
##   Iteration 1400, current GOF is 0.1723162.   (Best GOF=0.1723162)
##   Iteration 1500, current GOF is 0.2342321.   (Best GOF=0.2342321)
##   Iteration 1600, current GOF is 0.3013552.   (Best GOF=0.311352)
##   Iteration 1700, current GOF is 0.355211.   (Best GOF=0.355211)
##   Iteration 1800, current GOF is 0.3933352.   (Best GOF=0.3933352)
##   Iteration 1900, current GOF is 0.4085089.   (Best GOF=0.4085089)
##   Iteration 2000, current GOF is 0.4085089.   (Best GOF=0.4085089)
##   Iteration 2100, current GOF is 0.4085089.   (Best GOF=0.4085089)
##   Iteration 2200, current GOF is 0.4085089.   (Best GOF=0.4085089)
##   Iteration 2300, current GOF is 0.4207104.   (Best GOF=0.4207104)
##   Iteration 2400, current GOF is 0.4207104.   (Best GOF=0.4207104)
##   Iteration 2500, current GOF is 0.4207104.   (Best GOF=0.4207104)
##   Iteration 2600, current GOF is 0.4207104.   (Best GOF=0.4207104)
##   Iteration 2700, current GOF is 0.4207104.   (Best GOF=0.4207104)
##   Iteration 2800, current GOF is 0.4207104.   (Best GOF=0.4207104)
##   Iteration 2900, current GOF is 0.4207104.   (Best GOF=0.4207104)
##   Iteration 3000, current GOF is 0.4207104.   (Best GOF=0.4207104)
## Annealing completed.
## Refining solution via hill-climbing procedure...
##   Refining; current GOF is  0.4207104
## Preparing and returning output.

bkfrat_kb1lab<-bkfrat_kb1$block.membership[bkfrat_kb1$order.vector]

#calculate ties between core and periphery in BKFRAT
bkfrat_kb2<-block.fit(bkfrat,c(0,1,1,0))

## Entering annealing loop...
##   Iteration 100, current GOF is 0.01498731.   (Best GOF=0.02405597)
##   Iteration 200, current GOF is -0.006035569.   (Best GOF=0.02964442)
##   Iteration 300, current GOF is 0.02449079.   (Best GOF=0.03687144)
##   Iteration 400, current GOF is 0.02960228.   (Best GOF=0.04231761)
##   Iteration 500, current GOF is 0.007452823.   (Best GOF=0.04231761)
##   Iteration 600, current GOF is -0.03836967.   (Best GOF=0.04231761)
##   Iteration 700, current GOF is 0.02555566.   (Best GOF=0.04409231)
##   Iteration 800, current GOF is -0.01597438.   (Best GOF=0.05083615)
##   Iteration 900, current GOF is -0.008520273.   (Best GOF=0.05083615)
##   Iteration 1000, current GOF is -0.006663963.   (Best GOF=0.05083615)
##   Iteration 1100, current GOF is 0.02025791.   (Best GOF=0.05083615)
##   Iteration 1200, current GOF is 0.01706323.   (Best GOF=0.1018546)
##   Iteration 1300, current GOF is 0.02108424.   (Best GOF=0.1018546)
```

```
## Iteration 1400, current GOF is 0.04609913.  (Best GOF=0.1018546)
## Iteration 1500, current GOF is 0.04592852.  (Best GOF=0.1018546)
## Iteration 1600, current GOF is 0.07194406.  (Best GOF=0.1018546)
## Iteration 1700, current GOF is 0.2120681.  (Best GOF=0.2120681)
## Iteration 1800, current GOF is 0.2666602.  (Best GOF=0.2666602)
## Iteration 1900, current GOF is 0.3238413.  (Best GOF=0.3238413)
## Iteration 2000, current GOF is 0.3730622.  (Best GOF=0.3730622)
## Iteration 2100, current GOF is 0.3730622.  (Best GOF=0.3730622)
## Iteration 2200, current GOF is 0.3730622.  (Best GOF=0.3730622)
## Iteration 2300, current GOF is 0.3730622.  (Best GOF=0.3730622)
## Iteration 2400, current GOF is 0.3730622.  (Best GOF=0.3730622)
## Iteration 2500, current GOF is 0.3730622.  (Best GOF=0.3730622)
## Iteration 2600, current GOF is 0.3730622.  (Best GOF=0.3730622)
## Iteration 2700, current GOF is 0.3730622.  (Best GOF=0.3730622)
## Iteration 2800, current GOF is 0.3730622.  (Best GOF=0.3730622)
## Iteration 2900, current GOF is 0.3730622.  (Best GOF=0.3730622)
## Iteration 3000, current GOF is 0.3730622.  (Best GOF=0.3730622)
## Annealing completed.
## Refining solution via hill-climbing procedure...
##  Refining; current GOF is  0.3730622
## Preparing and returning output.
```

```r
bkfrat_kb2lab<-bkfrat_kb1$block.membership[bkfrat_kb2$order.vector]

#calculate isolated core ties in BKFRAT
bkfrat_kb3<-block.fit(bkfrat,c(1,0,0,0))
```

```
## Entering annealing loop...
## Iteration 100, current GOF is -0.003031244.  (Best GOF=0.02008653)
## Iteration 200, current GOF is -0.05962008.  (Best GOF=0.02365852)
## Iteration 300, current GOF is -0.03864453.  (Best GOF=0.02365852)
## Iteration 400, current GOF is -0.07102847.  (Best GOF=0.02365852)
## Iteration 500, current GOF is -0.0003923422.  (Best GOF=0.05973982)
## Iteration 600, current GOF is -0.05918522.  (Best GOF=0.1145781)
## Iteration 700, current GOF is 0.242844.  (Best GOF=0.2785311)
## Iteration 800, current GOF is -0.06990091.  (Best GOF=0.2785311)
## Iteration 900, current GOF is 0.1548659.  (Best GOF=0.2785311)
## Iteration 1000, current GOF is 0.07024457.  (Best GOF=0.2785311)
## Iteration 1100, current GOF is -0.01440906.  (Best GOF=0.2785311)
## Iteration 1200, current GOF is 0.2112682.  (Best GOF=0.2785311)
## Iteration 1300, current GOF is 0.2187787.  (Best GOF=0.2785311)
## Iteration 1400, current GOF is 0.332467.  (Best GOF=0.3779749)
## Iteration 1500, current GOF is 0.4237219.  (Best GOF=0.4237219)
## Iteration 1600, current GOF is 0.5163548.  (Best GOF=0.5163548)
## Iteration 1700, current GOF is 0.5083969.  (Best GOF=0.5166657)
## Iteration 1800, current GOF is 0.5181917.  (Best GOF=0.5181917)
## Iteration 1900, current GOF is 0.5201233.  (Best GOF=0.5201233)
## Iteration 2000, current GOF is 0.5390102.  (Best GOF=0.5390102)
## Iteration 2100, current GOF is 0.5390102.  (Best GOF=0.5390102)
## Iteration 2200, current GOF is 0.5390102.  (Best GOF=0.5390102)
## Iteration 2300, current GOF is 0.5390102.  (Best GOF=0.5390102)
## Iteration 2400, current GOF is 0.5390102.  (Best GOF=0.5390102)
## Iteration 2500, current GOF is 0.5390102.  (Best GOF=0.5390102)
## Iteration 2600, current GOF is 0.5390102.  (Best GOF=0.5390102)
## Iteration 2700, current GOF is 0.5390102.  (Best GOF=0.5390102)
```

```
##  Iteration 2800, current GOF is 0.5390102.   (Best GOF=0.5390102)
##  Iteration 2900, current GOF is 0.5390102.   (Best GOF=0.5390102)
##  Iteration 3000, current GOF is 0.5390102.   (Best GOF=0.5390102)
## Annealing completed.
## Refining solution via hill-climbing procedure...
##  Refining; current GOF is  0.5390102
## Preparing and returning output.
```

```
bkfrat_kb3lab<-bkfrat_kb1$block.membership[bkfrat_kb3$order.vector]

#calculate core and periphery within ties in BKFRAT
bkfrat_kb4<-block.fit(bkfrat,c(1,0,0,1))
```

```
## Entering annealing loop...
##  Iteration 100, current GOF is -0.006663963.   (Best GOF=0.03896341)
##  Iteration 200, current GOF is 0.002919389.   (Best GOF=0.03896341)
##  Iteration 300, current GOF is 0.001104024.   (Best GOF=0.0832617)
##  Iteration 400, current GOF is 0.009581006.   (Best GOF=0.0832617)
##  Iteration 500, current GOF is 0.03592871.   (Best GOF=0.0832617)
##  Iteration 600, current GOF is -0.008162738.   (Best GOF=0.1212737)
##  Iteration 700, current GOF is -0.01242223.   (Best GOF=0.1212737)
##  Iteration 800, current GOF is 0.02832064.   (Best GOF=0.1212737)
##  Iteration 900, current GOF is 0.02227631.   (Best GOF=0.1212737)
##  Iteration 1000, current GOF is 0.007178657.   (Best GOF=0.1212737)
##  Iteration 1100, current GOF is 0.009559144.   (Best GOF=0.1212737)
##  Iteration 1200, current GOF is -0.01766707.   (Best GOF=0.1212737)
##  Iteration 1300, current GOF is 0.05296578.   (Best GOF=0.1212737)
##  Iteration 1400, current GOF is 0.09855178.   (Best GOF=0.1212737)
##  Iteration 1500, current GOF is 0.1474794.   (Best GOF=0.1535454)
##  Iteration 1600, current GOF is 0.167657.   (Best GOF=0.167657)
##  Iteration 1700, current GOF is 0.2213421.   (Best GOF=0.2213421)
##  Iteration 1800, current GOF is 0.2458232.   (Best GOF=0.2458232)
##  Iteration 1900, current GOF is 0.2955704.   (Best GOF=0.2955704)
##  Iteration 2000, current GOF is 0.2959445.   (Best GOF=0.2959445)
##  Iteration 2100, current GOF is 0.2987915.   (Best GOF=0.2987915)
##  Iteration 2200, current GOF is 0.2987915.   (Best GOF=0.2987915)
##  Iteration 2300, current GOF is 0.2987915.   (Best GOF=0.2987915)
##  Iteration 2400, current GOF is 0.2987915.   (Best GOF=0.2987915)
##  Iteration 2500, current GOF is 0.2987915.   (Best GOF=0.2987915)
##  Iteration 2600, current GOF is 0.2987915.   (Best GOF=0.2987915)
##  Iteration 2700, current GOF is 0.2987915.   (Best GOF=0.2987915)
##  Iteration 2800, current GOF is 0.2987915.   (Best GOF=0.2987915)
##  Iteration 2900, current GOF is 0.2987915.   (Best GOF=0.2987915)
##  Iteration 3000, current GOF is 0.2987915.   (Best GOF=0.2987915)
## Annealing completed.
## Refining solution via hill-climbing procedure...
##  Refining; current GOF is  0.2987915
## Preparing and returning output.
```

```
bkfrat_kb4lab<-bkfrat_kb1$block.membership[bkfrat_kb4$order.vector]

#calculate core w/in,out ties in BKTEC
bktec_kb1<-block.fit(bktec,c(1,1,1,0))
```

```
## Entering annealing loop...
```

```
##   Iteration 100, current GOF is -0.02873578.  (Best GOF=0.07157979)
##   Iteration 200, current GOF is -0.1010126.  (Best GOF=0.07157979)
##   Iteration 300, current GOF is -0.05603746.  (Best GOF=0.07157979)
##   Iteration 400, current GOF is 0.0007710764.  (Best GOF=0.07452577)
##   Iteration 500, current GOF is 0.05242168.  (Best GOF=0.0803991)
##   Iteration 600, current GOF is 0.009290515.  (Best GOF=0.08436316)
##   Iteration 700, current GOF is 0.1083765.  (Best GOF=0.1381142)
##   Iteration 800, current GOF is -0.01084638.  (Best GOF=0.1460822)
##   Iteration 900, current GOF is 0.02910603.  (Best GOF=0.1460822)
##   Iteration 1000, current GOF is -0.04774893.  (Best GOF=0.1460822)
##   Iteration 1100, current GOF is 0.1058325.  (Best GOF=0.1584992)
##   Iteration 1200, current GOF is 0.1159205.  (Best GOF=0.1834269)
##   Iteration 1300, current GOF is 0.1081092.  (Best GOF=0.1834269)
##   Iteration 1400, current GOF is 0.1675693.  (Best GOF=0.1834269)
##   Iteration 1500, current GOF is 0.1390709.  (Best GOF=0.1834269)
##   Iteration 1600, current GOF is 0.1801531.  (Best GOF=0.1890034)
##   Iteration 1700, current GOF is 0.2036519.  (Best GOF=0.2036519)
##   Iteration 1800, current GOF is 0.2024003.  (Best GOF=0.2036519)
##   Iteration 1900, current GOF is 0.2217497.  (Best GOF=0.2217497)
##   Iteration 2000, current GOF is 0.2304023.  (Best GOF=0.2304023)
##   Iteration 2100, current GOF is 0.2394306.  (Best GOF=0.2394306)
##   Iteration 2200, current GOF is 0.2394306.  (Best GOF=0.2394306)
##   Iteration 2300, current GOF is 0.2394306.  (Best GOF=0.2394306)
##   Iteration 2400, current GOF is 0.2394306.  (Best GOF=0.2394306)
##   Iteration 2500, current GOF is 0.2394306.  (Best GOF=0.2394306)
##   Iteration 2600, current GOF is 0.2394306.  (Best GOF=0.2394306)
##   Iteration 2700, current GOF is 0.2394306.  (Best GOF=0.2394306)
##   Iteration 2800, current GOF is 0.2394306.  (Best GOF=0.2394306)
##   Iteration 2900, current GOF is 0.2394306.  (Best GOF=0.2394306)
##   Iteration 3000, current GOF is 0.2394306.  (Best GOF=0.2394306)
## Annealing completed.
## Refining solution via hill-climbing procedure...
##   Refining; current GOF is  0.2394306
## Preparing and returning output.
```

```r
bktec_kb1lab<-bktec_kb1$block.membership[bktec_kb1$order.vector]

#calculate ties between core and periphery in BKTEC
bktec_kb2<-block.fit(bktec,c(0,1,1,0))
```

```
## Entering annealing loop...
##   Iteration 100, current GOF is 0.04052258.  (Best GOF=0.08885451)
##   Iteration 200, current GOF is -0.09392089.  (Best GOF=0.08885451)
##   Iteration 300, current GOF is -0.03892129.  (Best GOF=0.08885451)
##   Iteration 400, current GOF is 0.02626343.  (Best GOF=0.08885451)
##   Iteration 500, current GOF is -0.002408492.  (Best GOF=0.08885451)
##   Iteration 600, current GOF is 0.02437111.  (Best GOF=0.08885451)
##   Iteration 700, current GOF is -0.01447702.  (Best GOF=0.09658052)
##   Iteration 800, current GOF is -0.06132853.  (Best GOF=0.09658052)
##   Iteration 900, current GOF is 0.001231366.  (Best GOF=0.09658052)
##   Iteration 1000, current GOF is 0.1213529.  (Best GOF=0.1213529)
##   Iteration 1100, current GOF is -0.01710836.  (Best GOF=0.1213529)
##   Iteration 1200, current GOF is 0.04881849.  (Best GOF=0.1213529)
##   Iteration 1300, current GOF is 0.07311494.  (Best GOF=0.1251005)
##   Iteration 1400, current GOF is 0.0691913.  (Best GOF=0.1251005)
```

```
## Iteration 1500, current GOF is 0.118086.   (Best GOF=0.1251005)
## Iteration 1600, current GOF is 0.14788.   (Best GOF=0.14788)
## Iteration 1700, current GOF is 0.1777323.   (Best GOF=0.1777323)
## Iteration 1800, current GOF is 0.1905524.   (Best GOF=0.1905524)
## Iteration 1900, current GOF is 0.1933196.   (Best GOF=0.1933196)
## Iteration 2000, current GOF is 0.1933196.   (Best GOF=0.1933196)
## Iteration 2100, current GOF is 0.1933196.   (Best GOF=0.1933196)
## Iteration 2200, current GOF is 0.1933196.   (Best GOF=0.1933196)
## Iteration 2300, current GOF is 0.1933196.   (Best GOF=0.1933196)
## Iteration 2400, current GOF is 0.1933196.   (Best GOF=0.1933196)
## Iteration 2500, current GOF is 0.1933196.   (Best GOF=0.1933196)
## Iteration 2600, current GOF is 0.1933196.   (Best GOF=0.1933196)
## Iteration 2700, current GOF is 0.1933196.   (Best GOF=0.1933196)
## Iteration 2800, current GOF is 0.1933196.   (Best GOF=0.1933196)
## Iteration 2900, current GOF is 0.1933196.   (Best GOF=0.1933196)
## Iteration 3000, current GOF is 0.1933196.   (Best GOF=0.1933196)
## Annealing completed.
## Refining solution via hill-climbing procedure...
## Refining; current GOF is  0.1933196
## Preparing and returning output.
```

```r
bktec_kb2lab<-bktec_kb1$block.membership[bktec_kb2$order.vector]

#calculate isolated core ties in BKTEC
bktec_kb3<-block.fit(bktec,c(1,0,0,0))
```

```
## Entering annealing loop...
## Iteration 100, current GOF is -0.06237071.   (Best GOF=0.1274442)
## Iteration 200, current GOF is -0.0140438.   (Best GOF=0.1274442)
## Iteration 300, current GOF is -0.06923149.   (Best GOF=0.1274442)
## Iteration 400, current GOF is 0.01447592.   (Best GOF=0.1274442)
## Iteration 500, current GOF is 0.0176717.   (Best GOF=0.1274442)
## Iteration 600, current GOF is 0.04657531.   (Best GOF=0.1274442)
## Iteration 700, current GOF is -0.0007710764.   (Best GOF=0.1532425)
## Iteration 800, current GOF is 0.01904696.   (Best GOF=0.1532425)
## Iteration 900, current GOF is -0.01368373.   (Best GOF=0.1804963)
## Iteration 1000, current GOF is -0.0309006.   (Best GOF=0.1804963)
## Iteration 1100, current GOF is 0.1639235.   (Best GOF=0.1805609)
## Iteration 1200, current GOF is 0.2208961.   (Best GOF=0.2943645)
## Iteration 1300, current GOF is 0.1903475.   (Best GOF=0.3093301)
## Iteration 1400, current GOF is 0.2525249.   (Best GOF=0.3093301)
## Iteration 1500, current GOF is 0.3323199.   (Best GOF=0.3323199)
## Iteration 1600, current GOF is 0.4373116.   (Best GOF=0.4373116)
## Iteration 1700, current GOF is 0.4393132.   (Best GOF=0.4393132)
## Iteration 1800, current GOF is 0.4442833.   (Best GOF=0.4442833)
## Iteration 1900, current GOF is 0.4442833.   (Best GOF=0.4442833)
## Iteration 2000, current GOF is 0.4442833.   (Best GOF=0.4442833)
## Iteration 2100, current GOF is 0.4442833.   (Best GOF=0.4442833)
## Iteration 2200, current GOF is 0.4442833.   (Best GOF=0.4442833)
## Iteration 2300, current GOF is 0.4442833.   (Best GOF=0.4442833)
## Iteration 2400, current GOF is 0.4442833.   (Best GOF=0.4442833)
## Iteration 2500, current GOF is 0.4442833.   (Best GOF=0.4442833)
## Iteration 2600, current GOF is 0.4442833.   (Best GOF=0.4442833)
## Iteration 2700, current GOF is 0.4442833.   (Best GOF=0.4442833)
## Iteration 2800, current GOF is 0.4442833.   (Best GOF=0.4442833)
```

```
##   Iteration 2900, current GOF is 0.4442833.   (Best GOF=0.4442833)
##   Iteration 3000, current GOF is 0.4442833.   (Best GOF=0.4442833)
## Annealing completed.
## Refining solution via hill-climbing procedure...
##   Refining; current GOF is  0.4442833
## Preparing and returning output.
```

```
bktec_kb3lab<-bktec_kb1$block.membership[bktec_kb3$order.vector]

#calculate core and periphery within ties in BKTEC
bktec_kb4<-block.fit(bktec,c(1,0,0,1))
```

```
## Entering annealing loop...
##   Iteration 100, current GOF is 0.006919624.   (Best GOF=0.05378782)
##   Iteration 200, current GOF is 0.08842953.   (Best GOF=0.09188386)
##   Iteration 300, current GOF is 0.04285917.   (Best GOF=0.09188386)
##   Iteration 400, current GOF is 0.04082189.   (Best GOF=0.10818)
##   Iteration 500, current GOF is 0.02525935.   (Best GOF=0.10818)
##   Iteration 600, current GOF is 0.0387846.   (Best GOF=0.10818)
##   Iteration 700, current GOF is -0.01404129.   (Best GOF=0.1194207)
##   Iteration 800, current GOF is -0.04402406.   (Best GOF=0.1194207)
##   Iteration 900, current GOF is 0.01128305.   (Best GOF=0.1194207)
##   Iteration 1000, current GOF is -0.01456897.   (Best GOF=0.1194207)
##   Iteration 1100, current GOF is 0.1602434.   (Best GOF=0.1602434)
##   Iteration 1200, current GOF is 0.06947662.   (Best GOF=0.1990139)
##   Iteration 1300, current GOF is 0.2163938.   (Best GOF=0.2371851)
##   Iteration 1400, current GOF is 0.2404754.   (Best GOF=0.2596003)
##   Iteration 1500, current GOF is 0.2551149.   (Best GOF=0.2657136)
##   Iteration 1600, current GOF is 0.258811.   (Best GOF=0.2657136)
##   Iteration 1700, current GOF is 0.2799778.   (Best GOF=0.2799778)
##   Iteration 1800, current GOF is 0.3179933.   (Best GOF=0.3179933)
##   Iteration 1900, current GOF is 0.3170822.   (Best GOF=0.3179933)
##   Iteration 2000, current GOF is 0.3179933.   (Best GOF=0.3179933)
##   Iteration 2100, current GOF is 0.3179933.   (Best GOF=0.3179933)
##   Iteration 2200, current GOF is 0.3179933.   (Best GOF=0.3179933)
##   Iteration 2300, current GOF is 0.3179933.   (Best GOF=0.3179933)
##   Iteration 2400, current GOF is 0.3179933.   (Best GOF=0.3179933)
##   Iteration 2500, current GOF is 0.3179933.   (Best GOF=0.3179933)
##   Iteration 2600, current GOF is 0.3179933.   (Best GOF=0.3179933)
##   Iteration 2700, current GOF is 0.3179933.   (Best GOF=0.3179933)
##   Iteration 2800, current GOF is 0.3179933.   (Best GOF=0.3179933)
##   Iteration 2900, current GOF is 0.3179933.   (Best GOF=0.3179933)
##   Iteration 3000, current GOF is 0.3179933.   (Best GOF=0.3179933)
## Annealing completed.
## Refining solution via hill-climbing procedure...
##   Refining; current GOF is  0.3179933
## Preparing and returning output.
```

```
bktec_kb4lab<-bktec_kb1$block.membership[bktec_kb4$order.vector]


#calculate core w/in,out ties in BKOFF
bkoff_kb1<-block.fit(bkoff,c(1,1,1,0))
```

```
## Entering annealing loop...
```

```
##   Iteration 100, current GOF is -0.009296027.   (Best GOF=0.09311783)
##   Iteration 200, current GOF is -0.05626513.   (Best GOF=0.09311783)
##   Iteration 300, current GOF is 0.04984424.   (Best GOF=0.09311783)
##   Iteration 400, current GOF is -0.02347641.   (Best GOF=0.09311783)
##   Iteration 500, current GOF is -0.01966236.   (Best GOF=0.09311783)
##   Iteration 600, current GOF is 0.01591354.   (Best GOF=0.09311783)
##   Iteration 700, current GOF is -0.07735456.   (Best GOF=0.09311783)
##   Iteration 800, current GOF is -0.03741327.   (Best GOF=0.09311783)
##   Iteration 900, current GOF is 0.07060506.   (Best GOF=0.11105)
##   Iteration 1000, current GOF is 0.08189394.   (Best GOF=0.113191)
##   Iteration 1100, current GOF is 0.04364199.   (Best GOF=0.113191)
##   Iteration 1200, current GOF is 0.1244969.   (Best GOF=0.1244969)
##   Iteration 1300, current GOF is 0.1021718.   (Best GOF=0.1537269)
##   Iteration 1400, current GOF is 0.1025714.   (Best GOF=0.1678756)
##   Iteration 1500, current GOF is 0.1092384.   (Best GOF=0.1729984)
##   Iteration 1600, current GOF is 0.1826328.   (Best GOF=0.1826328)
##   Iteration 1700, current GOF is 0.1913226.   (Best GOF=0.196242)
##   Iteration 1800, current GOF is 0.2156769.   (Best GOF=0.2156769)
##   Iteration 1900, current GOF is 0.2156769.   (Best GOF=0.2156769)
##   Iteration 2000, current GOF is 0.2258117.   (Best GOF=0.2258117)
##   Iteration 2100, current GOF is 0.2258117.   (Best GOF=0.2258117)
##   Iteration 2200, current GOF is 0.2258117.   (Best GOF=0.2258117)
##   Iteration 2300, current GOF is 0.2258117.   (Best GOF=0.2258117)
##   Iteration 2400, current GOF is 0.2258117.   (Best GOF=0.2258117)
##   Iteration 2500, current GOF is 0.2258117.   (Best GOF=0.2258117)
##   Iteration 2600, current GOF is 0.2258117.   (Best GOF=0.2258117)
##   Iteration 2700, current GOF is 0.2258117.   (Best GOF=0.2258117)
##   Iteration 2800, current GOF is 0.2258117.   (Best GOF=0.2258117)
##   Iteration 2900, current GOF is 0.2258117.   (Best GOF=0.2258117)
##   Iteration 3000, current GOF is 0.2258117.   (Best GOF=0.2258117)
## Annealing completed.
## Refining solution via hill-climbing procedure...
##   Refining; current GOF is  0.2258117
## Preparing and returning output.
```

```
bkoff_kb1lab<-bkoff_kb1$block.membership[bkoff_kb1$order.vector]


#calculate ties between core and periphery in BKOFF
bkoff_kb2<-block.fit(bkoff,c(0,1,1,0))
```

```
## Entering annealing loop...
##   Iteration 100, current GOF is -0.02830391.   (Best GOF=0.08234238)
##   Iteration 200, current GOF is 0.04230305.   (Best GOF=0.08234238)
##   Iteration 300, current GOF is -0.02244652.   (Best GOF=0.08234238)
##   Iteration 400, current GOF is -0.03827419.   (Best GOF=0.08234238)
##   Iteration 500, current GOF is 0.06778124.   (Best GOF=0.08234238)
##   Iteration 600, current GOF is -0.05577413.   (Best GOF=0.08998589)
##   Iteration 700, current GOF is 0.01453483.   (Best GOF=0.08998589)
##   Iteration 800, current GOF is 0.01760026.   (Best GOF=0.08998589)
##   Iteration 900, current GOF is 0.04365519.   (Best GOF=0.08998589)
##   Iteration 1000, current GOF is 0.01309574.   (Best GOF=0.08998589)
##   Iteration 1100, current GOF is 0.02892575.   (Best GOF=0.08998589)
##   Iteration 1200, current GOF is -0.021108.   (Best GOF=0.09672952)
##   Iteration 1300, current GOF is 0.04907304.   (Best GOF=0.09672952)
##   Iteration 1400, current GOF is 0.1152572.   (Best GOF=0.1153445)
```

```
##  Iteration 1500, current GOF is 0.1102181.   (Best GOF=0.1574729)
##  Iteration 1600, current GOF is 0.1530967.   (Best GOF=0.1574729)
##  Iteration 1700, current GOF is 0.1571555.   (Best GOF=0.1574729)
##  Iteration 1800, current GOF is 0.1937904.   (Best GOF=0.1937904)
##  Iteration 1900, current GOF is 0.1981606.   (Best GOF=0.1981606)
##  Iteration 2000, current GOF is 0.198135.   (Best GOF=0.1981606)
##  Iteration 2100, current GOF is 0.2057567.   (Best GOF=0.2057567)
##  Iteration 2200, current GOF is 0.2057567.   (Best GOF=0.2057567)
##  Iteration 2300, current GOF is 0.2057567.   (Best GOF=0.2057567)
##  Iteration 2400, current GOF is 0.2057567.   (Best GOF=0.2057567)
##  Iteration 2500, current GOF is 0.2057567.   (Best GOF=0.2057567)
##  Iteration 2600, current GOF is 0.2057567.   (Best GOF=0.2057567)
##  Iteration 2700, current GOF is 0.2057567.   (Best GOF=0.2057567)
##  Iteration 2800, current GOF is 0.2057567.   (Best GOF=0.2057567)
##  Iteration 2900, current GOF is 0.2057567.   (Best GOF=0.2057567)
##  Iteration 3000, current GOF is 0.2057567.   (Best GOF=0.2057567)
## Annealing completed.
## Refining solution via hill-climbing procedure...
##  Refining; current GOF is  0.2057567
## Preparing and returning output.
```

```r
bkoff_kb2lab<-bkoff_kb1$block.membership[bkoff_kb2$order.vector]

#calculate isolated core ties in BKOFF
bkoff_kb3<-block.fit(bkoff,c(1,0,0,0))
```

```
## Entering annealing loop...
##  Iteration 100, current GOF is -0.009968848.   (Best GOF=0.03910313)
##  Iteration 200, current GOF is -0.01452402.   (Best GOF=0.1491052)
##  Iteration 300, current GOF is -0.03713627.   (Best GOF=0.1491052)
##  Iteration 400, current GOF is -0.02047088.   (Best GOF=0.1491052)
##  Iteration 500, current GOF is 0.08114313.   (Best GOF=0.1491052)
##  Iteration 600, current GOF is 0.04768704.   (Best GOF=0.1491052)
##  Iteration 700, current GOF is 0.006144832.   (Best GOF=0.1491052)
##  Iteration 800, current GOF is 0.1229824.   (Best GOF=0.1491052)
##  Iteration 900, current GOF is -0.007128772.   (Best GOF=0.1491052)
##  Iteration 1000, current GOF is -0.01955157.   (Best GOF=0.1491052)
##  Iteration 1100, current GOF is 0.008123843.   (Best GOF=0.1491052)
##  Iteration 1200, current GOF is 0.1798744.   (Best GOF=0.1798744)
##  Iteration 1300, current GOF is 0.1966724.   (Best GOF=0.2050121)
##  Iteration 1400, current GOF is 0.1767734.   (Best GOF=0.2096001)
##  Iteration 1500, current GOF is 0.2904804.   (Best GOF=0.2904804)
##  Iteration 1600, current GOF is 0.3142209.   (Best GOF=0.3199087)
##  Iteration 1700, current GOF is 0.3449221.   (Best GOF=0.3509034)
##  Iteration 1800, current GOF is 0.3509034.   (Best GOF=0.3509034)
##  Iteration 1900, current GOF is 0.3509034.   (Best GOF=0.3509034)
##  Iteration 2000, current GOF is 0.3509034.   (Best GOF=0.3509034)
##  Iteration 2100, current GOF is 0.3509177.   (Best GOF=0.3509177)
##  Iteration 2200, current GOF is 0.3523318.   (Best GOF=0.3523318)
##  Iteration 2300, current GOF is 0.3523318.   (Best GOF=0.3523318)
##  Iteration 2400, current GOF is 0.3523318.   (Best GOF=0.3523318)
##  Iteration 2500, current GOF is 0.3523318.   (Best GOF=0.3523318)
##  Iteration 2600, current GOF is 0.3523318.   (Best GOF=0.3523318)
##  Iteration 2700, current GOF is 0.3523318.   (Best GOF=0.3523318)
##  Iteration 2800, current GOF is 0.3523318.   (Best GOF=0.3523318)
```

```
##  Iteration 2900, current GOF is 0.3523318.  (Best GOF=0.3523318)
##  Iteration 3000, current GOF is 0.3523318.  (Best GOF=0.3523318)
## Annealing completed.
## Refining solution via hill-climbing procedure...
##  Refining; current GOF is  0.3523318
## Preparing and returning output.
```

```
bkoff_kb3lab<-bkoff_kb1$block.membership[bkoff_kb3$order.vector]
```

```
#calculate core and periphery within ties in BKOFF
bkoff_kb4<-block.fit(bkoff,c(1,0,0,1))
```

```
## Entering annealing loop...
##  Iteration 100, current GOF is -0.01741302.  (Best GOF=0.0629677)
##  Iteration 200, current GOF is -0.005900278.  (Best GOF=0.0629677)
##  Iteration 300, current GOF is 0.06749342.  (Best GOF=0.09985822)
##  Iteration 400, current GOF is 0.02556115.  (Best GOF=0.09985822)
##  Iteration 500, current GOF is 0.004892189.  (Best GOF=0.09985822)
##  Iteration 600, current GOF is 0.04679266.  (Best GOF=0.09985822)
##  Iteration 700, current GOF is 0.02987729.  (Best GOF=0.1739862)
##  Iteration 800, current GOF is -0.01165665.  (Best GOF=0.1739862)
##  Iteration 900, current GOF is -0.003022094.  (Best GOF=0.1739862)
##  Iteration 1000, current GOF is -0.01812988.  (Best GOF=0.1739862)
##  Iteration 1100, current GOF is 0.0941027.  (Best GOF=0.1739862)
##  Iteration 1200, current GOF is 0.139448.  (Best GOF=0.1739862)
##  Iteration 1300, current GOF is 0.08167098.  (Best GOF=0.1739862)
##  Iteration 1400, current GOF is 0.1200025.  (Best GOF=0.1739862)
##  Iteration 1500, current GOF is 0.1490679.  (Best GOF=0.1739862)
##  Iteration 1600, current GOF is 0.1535128.  (Best GOF=0.1739862)
##  Iteration 1700, current GOF is 0.1706511.  (Best GOF=0.1739862)
##  Iteration 1800, current GOF is 0.1936731.  (Best GOF=0.1941335)
##  Iteration 1900, current GOF is 0.2111552.  (Best GOF=0.2111552)
##  Iteration 2000, current GOF is 0.2111552.  (Best GOF=0.2111552)
##  Iteration 2100, current GOF is 0.2111552.  (Best GOF=0.2111552)
##  Iteration 2200, current GOF is 0.2111552.  (Best GOF=0.2111552)
##  Iteration 2300, current GOF is 0.2111552.  (Best GOF=0.2111552)
##  Iteration 2400, current GOF is 0.2111552.  (Best GOF=0.2111552)
##  Iteration 2500, current GOF is 0.2111552.  (Best GOF=0.2111552)
##  Iteration 2600, current GOF is 0.2111552.  (Best GOF=0.2111552)
##  Iteration 2700, current GOF is 0.2111552.  (Best GOF=0.2111552)
##  Iteration 2800, current GOF is 0.2111552.  (Best GOF=0.2111552)
##  Iteration 2900, current GOF is 0.2111552.  (Best GOF=0.2111552)
##  Iteration 3000, current GOF is 0.2111552.  (Best GOF=0.2111552)
## Annealing completed.
## Refining solution via hill-climbing procedure...
##  Refining; current GOF is  0.2111552
## Preparing and returning output.
```
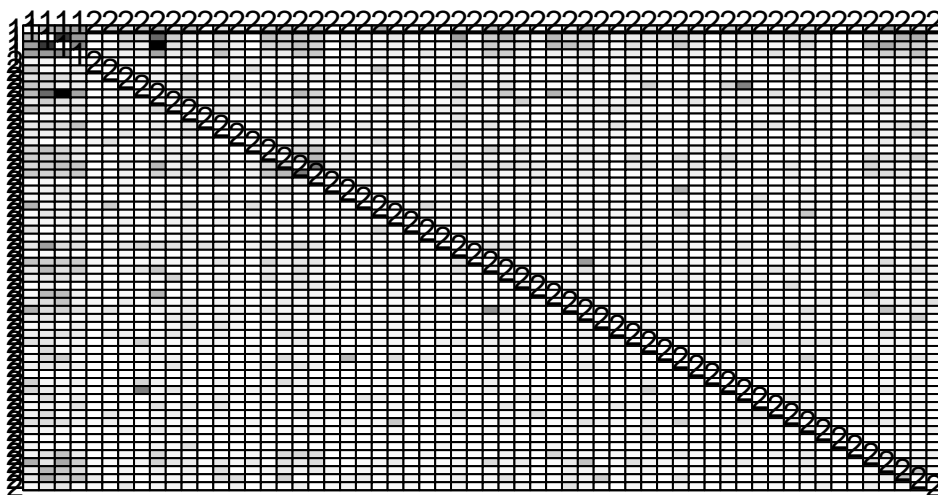
```
bkoff_kb4lab<-bkoff_kb1$block.membership[bkoff_kb4$order.vector]
```

```
#plot soiomatrix of all the networks with model having configuration(1,1,1,0)
plot.sociomatrix(bkham_kb1$blocked.data,labels = list(bkham_kb1lab,bkham_kb1lab))
```
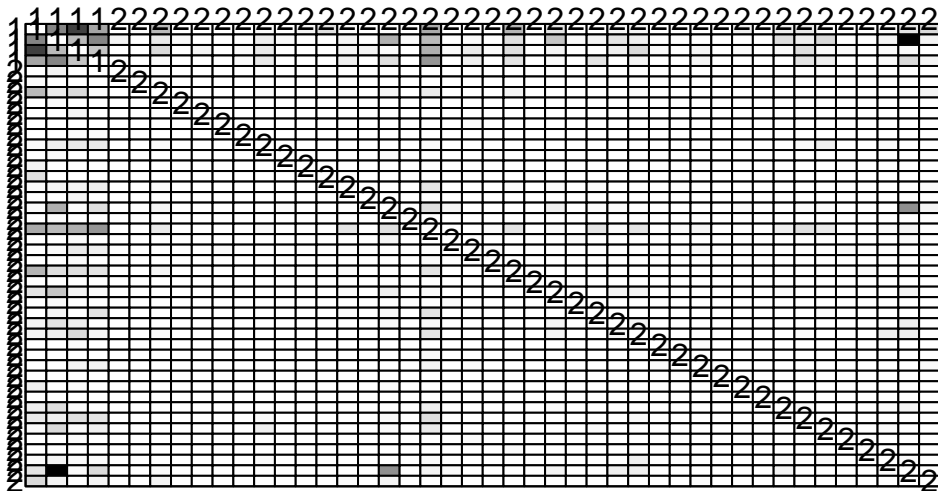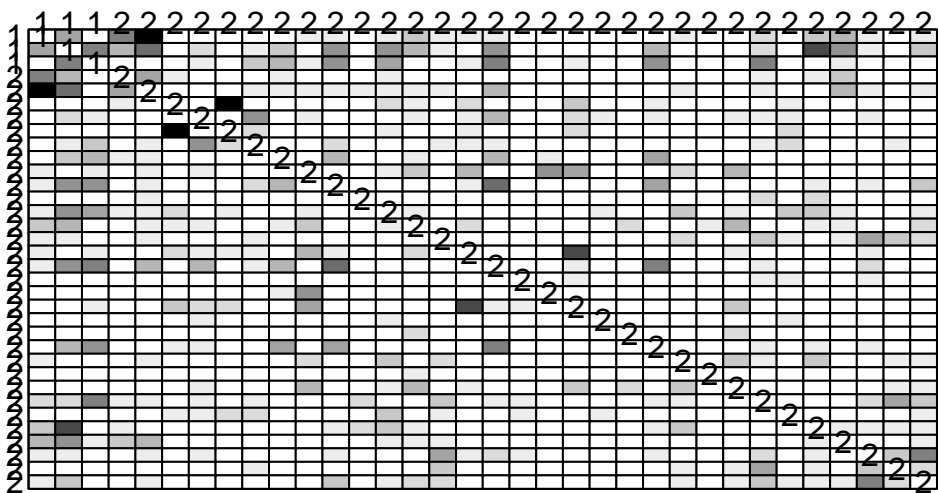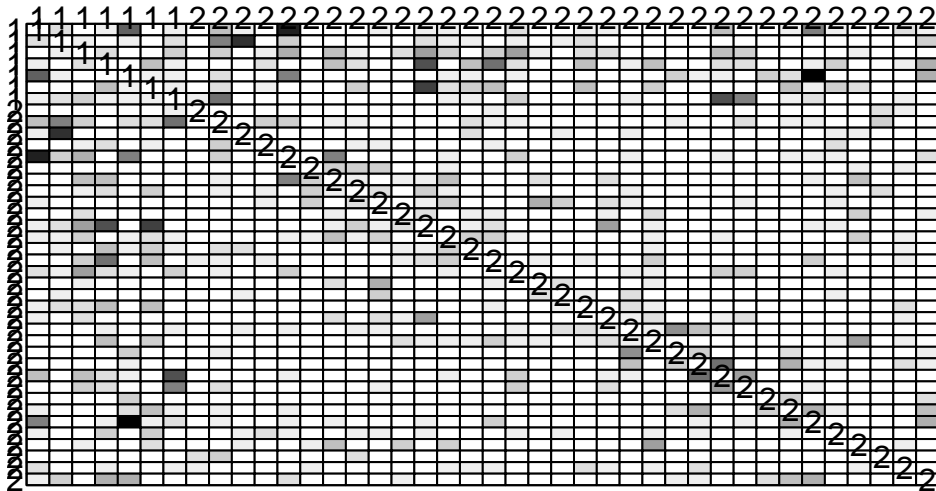
```
plot.sociomatrix(bkfrat_kb1$blocked.data, labels = list(bkfrat_kb1lab,bkfrat_kb1lab))
```
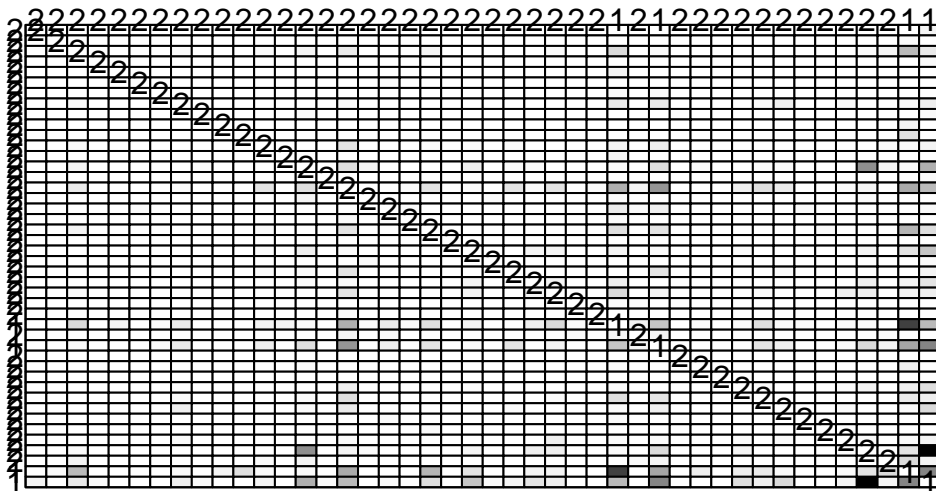


```
plot.sociomatrix(bktec_kb1$blocked.data, labels = list(bktec_kb1lab,bktec_kb1lab))
```
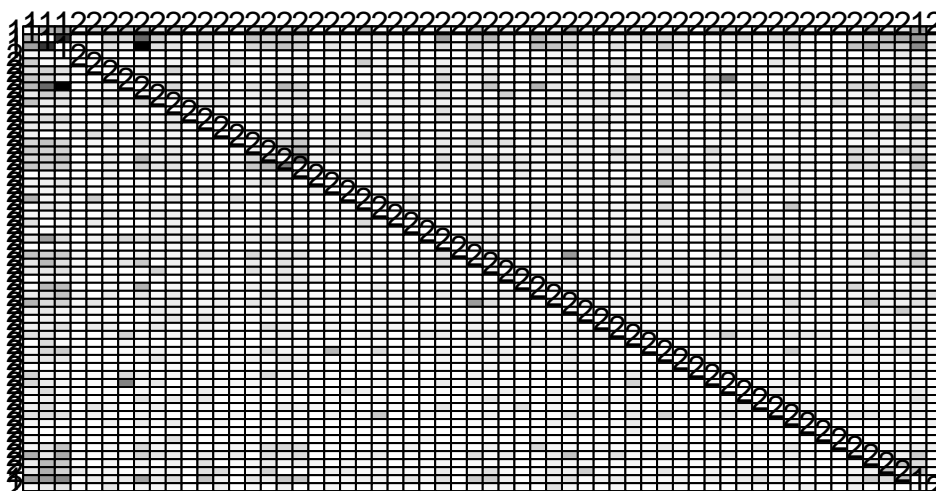

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```
plot.sociomatrix(bkoff_kb1$blocked.data, labels = list(bkoff_kb1lab,bkoff_kb1lab))
```
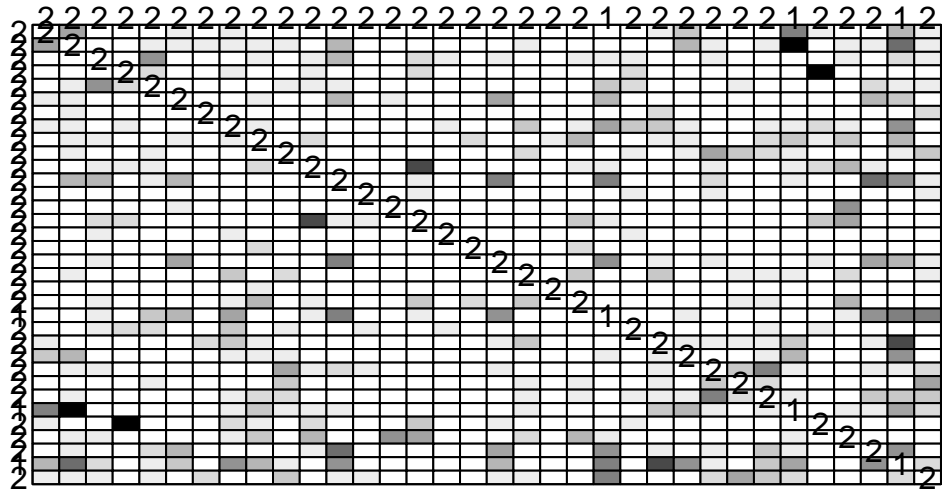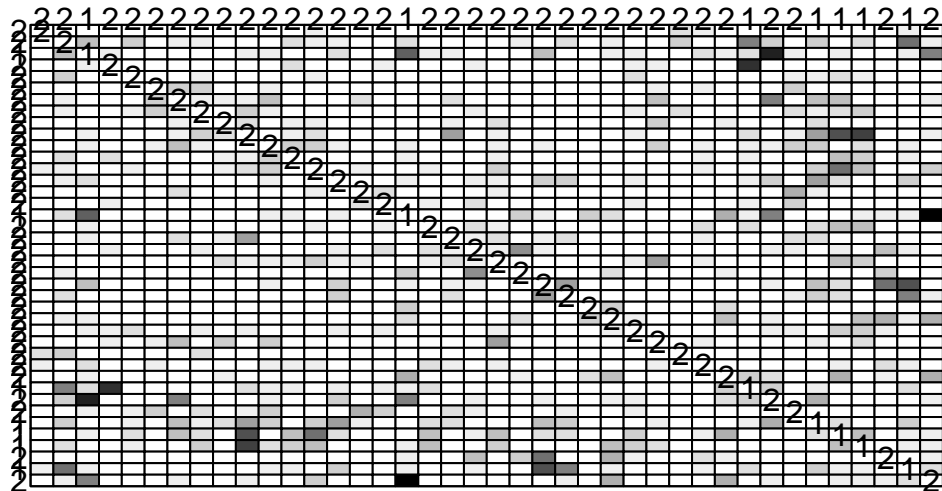


```
#plot soiomatrix of all the networks with model having configuration(0,1,1,0)
plot.sociomatrix(bkham_kb2$blocked.data,labels = list(bkham_kb2lab,bkham_kb2lab))
```



```
plot.sociomatrix(bkfrat_kb2$blocked.data, labels = list(bkfrat_kb2lab,bkfrat_kb2lab))
```

```
plot.sociomatrix(bktec_kb2$blocked.data, labels = list(bktec_kb2lab,bktec_kb2lab))
```
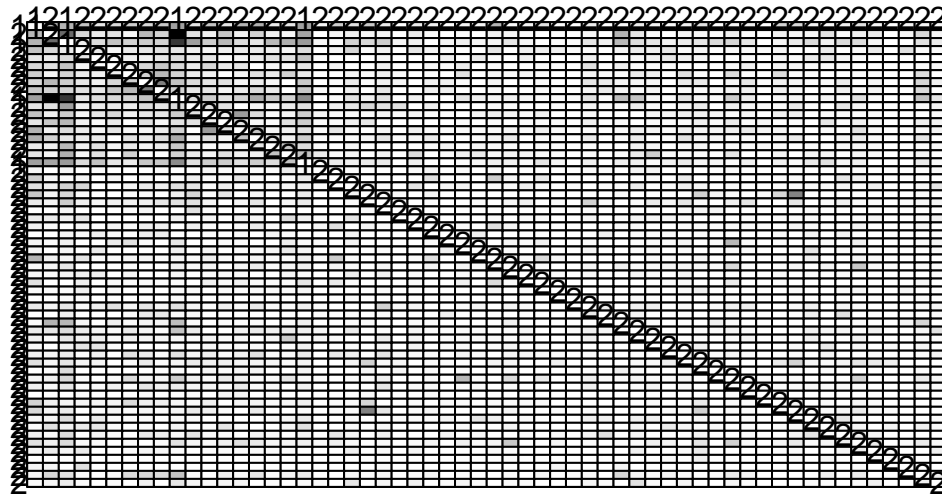


```
plot.sociomatrix(bkoff_kb2$blocked.data, labels = list(bkoff_kb2lab,bkoff_kb2lab))
```
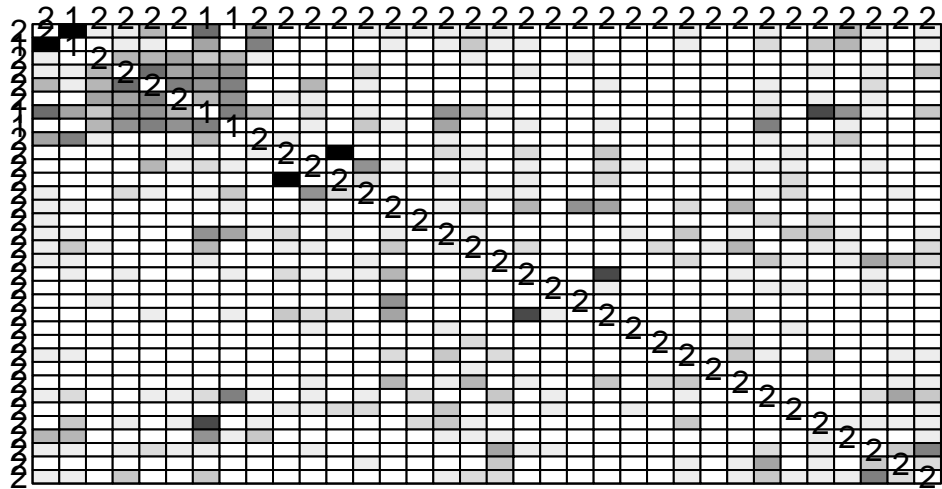


```
#plot soiomatrix of all the networks with model having configuration(1,0,0,0)
plot.sociomatrix(bkham_kb3$blocked.data,labels = list(bkham_kb3lab,bkham_kb3lab))
```
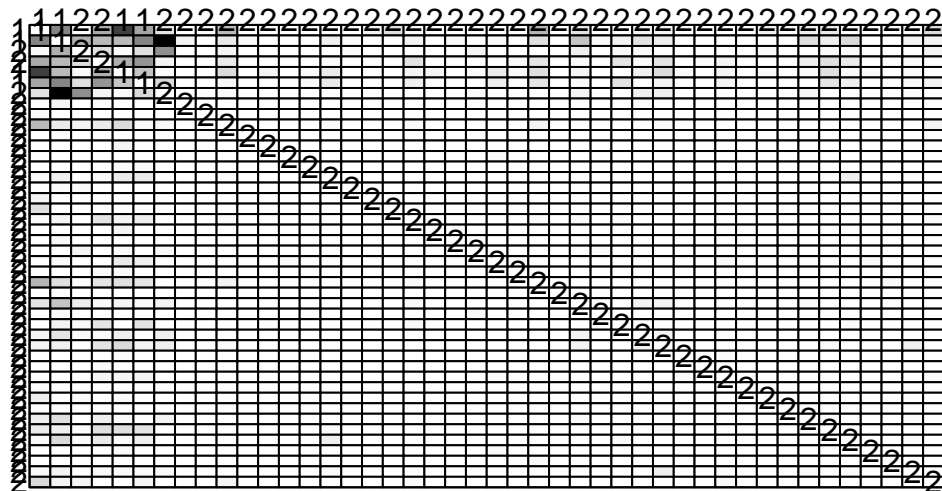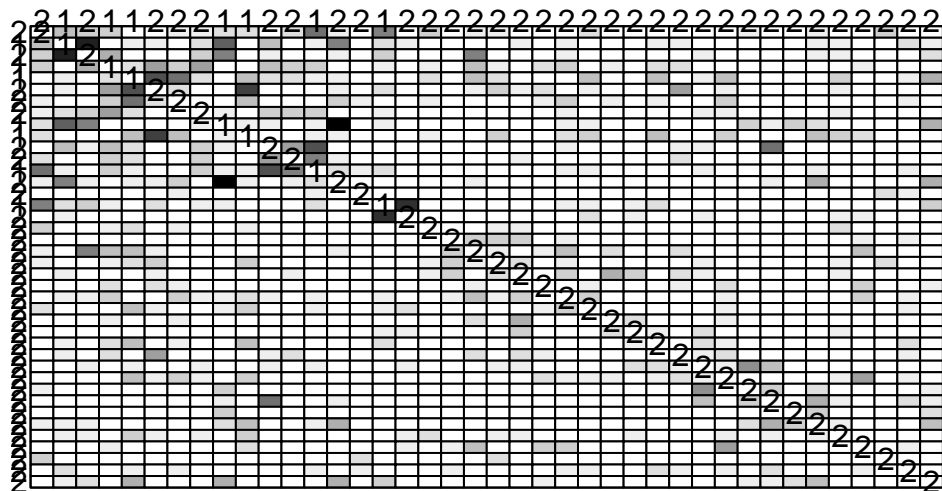

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```

```
plot.sociomatrix(bkfrat_kb3$blocked.data, labels = list(bkfrat_kb3lab,bkfrat_kb3lab))
```



```
plot.sociomatrix(bktec_kb3$blocked.data, labels = list(bktec_kb3lab,bktec_kb3lab))
```



```
plot.sociomatrix(bkoff_kb3$blocked.data, labels = list(bkoff_kb3lab,bkoff_kb3lab))
```

```
#plot soiomatrix of all the networks with model having configuration(1,0,0,1)
plot.sociomatrix(bkham_kb4$blocked.data,labels = list(bkham_kb4lab,bkham_kb4lab))
```



```
plot.sociomatrix(bkfrat_kb4$blocked.data, labels = list(bkfrat_kb4lab,bkfrat_kb4lab))
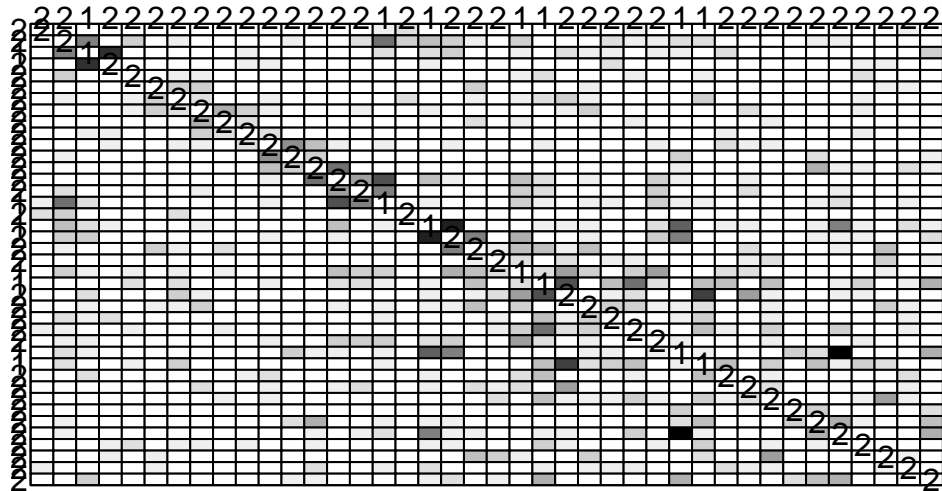```



```
plot.sociomatrix(bktec_kb4$blocked.data, labels = list(bktec_kb4lab,bktec_kb4lab))
```

```r
plot.sociomatrix(bkoff_kb4$blocked.data, labels = list(bkoff_kb4lab,bkoff_kb4lab))
```


• The first network, which depicts the communication between the radio operators, the core-periphery structure is pretty prominent. There is a clear distinction between the core and the periphery, with a densely connected connected core and the periphery connecte with the core, and less withng periphery connections.

The network for interactions among members of a fraterity and interactions in a university research group also has a core-periphery structure, with a densely connected core, but having a greater connection between the periphery nodes.

In the network of interaction between small businesses, the core-periphery structure is less prominent, based on the observations from it's sociomatrix

• Here we observe that the core-periphery interations varies widely in each of the four network. The core-periphery interaction is the least in BKHAM network, and the interaction keeps on increasing in the networks BHFRAT,BKTEC and BKOFF in that order

• The within core interactions are very prominent in the the BKHAM network, and the BKTEC network, whereas in other networks, there are core interactions, but not very prominent.

• The network BKHAM exhibits mainly witing core interaction, where as the networks BKFRAT and BKTEC exhibits within core as well as within periphery interactions. The network BKTEC has a within periphery interactions which are more prominent that within core interactions

(c) Goodness-of-Fit

Examine the goodness-of-fit scores (in this case, maximized correlations) for each model on each network. Which model fits best (among those which seek to explain all edges)? How much variance is accounted for by each model?

• Analyzing the goodness-of-fit scores among the models which explain all the ties, we get the model 'core with in and out ties' which is fits best in the BKFRAT network. • The variance accounted for by the model with configuration (1,1,1,0): 21% to 42% • The variance accounted for by the model with configuration (0,1,1,0):16% to 37% • The variance accounted for by the model with configuration (1,0,0,0):36% to 69% • The variance accounted for by the model with configuration (1,0,0,1):19% to 31%

```r
#print goodness of fit of for all configurations of BKHAM network
bkham_kb1$block.gof
```

```
## [1] 0.3607077
```

```
bkham_kb2$block.gof
```

[1] 0.3273251
```
bkham_kb3$block.gof
```

[1] 0.6959562
```
bkham_kb4$block.gof
```

[1] 0.2096077
```
#print goodness of fit of for all configurations of BKFRAT network
bkfrat_kb1$block.gof
```

[1] 0.4207104
```
bkfrat_kb2$block.gof
```

[1] 0.3730622
```
bkfrat_kb3$block.gof
```

[1] 0.5390102
```
bkfrat_kb4$block.gof
```

[1] 0.2987915
```
#print goodness of fit of for all configurations of BKTEC network
bktec_kb1$block.gof
```

[1] 0.2394306
```
bktec_kb2$block.gof
```

[1] 0.1933196
```
bktec_kb3$block.gof
```

[1] 0.4442833
```
bktec_kb4$block.gof
```

[1] 0.3179933
```
#print goodness of fit of for all configurations of BKOFFF network
bkoff_kb1$block.gof
```

[1] 0.2258117
```
bkoff_kb2$block.gof
```

[1] 0.2057567
```
bkoff_kb3$block.gof
```

[1] 0.3523318
```
bkoff_kb4$block.gof
```

[1] 0.2111552

(c) Discussion

Based on the above results, how would you describe the overall structure of these data sets? Are they ultimately similar in form or are there notable differences?

- As per the above results, we can see that the overall structure of the BKOFF dataset is less tending towards a core-periphery structure, whereas the other 3 networks which are the BKHAM, BKFRAT and BKTEC are showing similar structure in all the models.