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)
```

```
## Warning: package 'statnet' was built under R version 3.2.5
```

```
## Warning: package 'tergm' was built under R version 3.2.5
```

```
## Warning: package 'statnet.common' was built under R version 3.2.5
```

```
## Warning: package 'ergm' was built under R version 3.2.5
```

```
## Warning: package 'network' was built under R version 3.2.5
```

```
## Warning: package 'networkDynamic' was built under R version 3.2.5
```

```
## Warning: package 'ergm.count' was built under R version 3.2.5
```

```
## Warning: package 'sna' was built under R version 3.2.5
```

```
load("problemset4_data.Rdata")
load("block.fit.Rdata")
```

---

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

**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 fraterity (`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 interaction networks.
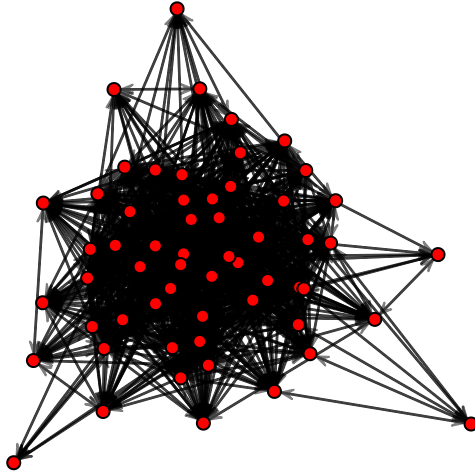
**(a) Network Visualization**

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.

```
gplot(bkham, edge.col = rgb(0,0,0,0.5))
```
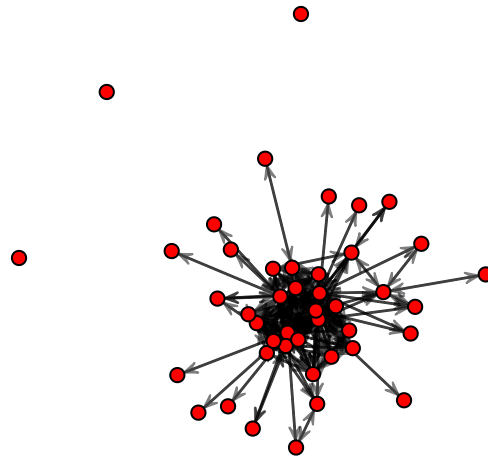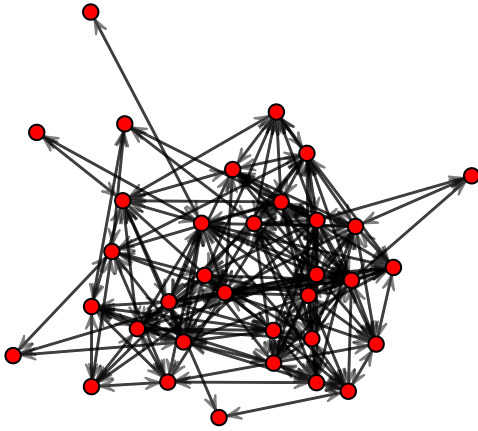


```
gplot(bkfrat, edge.col = rgb(0,0,0,0.5))
```
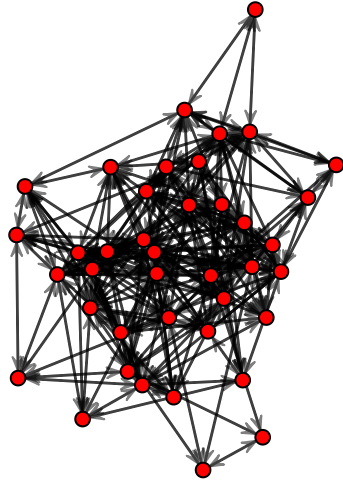
---

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

```
gplot(bktec, edge.col = rgb(0,0,0,0.5))
```

```
gplot(bkoff, edge.col = rgb(0,0,0,0.5))
```

Looking at the visualizations, there appears to be an undirected two-class block structure. This looks like 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.

```
#All Netoworks Core w/in, out ties
#BKHAM Network
bkh1<-block.fit(bkham,c(1,1,1,0))    # Core w/in,out ties
```

```
## Entering annealing loop...
##   Iteration 100, current GOF is 0.054472.   (Best GOF=0.1359903)
##   Iteration 200, current GOF is -0.1894515.   (Best GOF=0.1359903)
##   Iteration 300, current GOF is -0.000786267.   (Best GOF=0.1359903)
##   Iteration 400, current GOF is 0.04279181.   (Best GOF=0.1359903)
##   Iteration 500, current GOF is -0.01876235.   (Best GOF=0.1359903)
##   Iteration 600, current GOF is 0.00472014.   (Best GOF=0.1359903)
##   Iteration 700, current GOF is 0.0828362.   (Best GOF=0.1359903)
##   Iteration 800, current GOF is 0.01051794.   (Best GOF=0.1359903)
##   Iteration 900, current GOF is 0.06490255.   (Best GOF=0.1359903)
##   Iteration 1000, current GOF is -0.02851073.   (Best GOF=0.1359903)
##   Iteration 1100, current GOF is 0.1224578.   (Best GOF=0.1568894)
##   Iteration 1200, current GOF is 0.1597877.   (Best GOF=0.1597877)
```

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```
##   Iteration 1300, current GOF is 0.07831474.  (Best GOF=0.2039533)
##   Iteration 1400, current GOF is 0.1830759.  (Best GOF=0.2039533)
##   Iteration 1500, current GOF is 0.2660657.  (Best GOF=0.2660657)
##   Iteration 1600, current GOF is 0.2880959.  (Best GOF=0.2880959)
##   Iteration 1700, current GOF is 0.3563676.  (Best GOF=0.3625934)
##   Iteration 1800, current GOF is 0.3563676.  (Best GOF=0.3625934)
##   Iteration 1900, current GOF is 0.3625934.  (Best GOF=0.3625934)
##   Iteration 2000, current GOF is 0.3625934.  (Best GOF=0.3625934)
##   Iteration 2100, current GOF is 0.3625934.  (Best GOF=0.3625934)
##   Iteration 2200, current GOF is 0.3625934.  (Best GOF=0.3625934)
##   Iteration 2300, current GOF is 0.3625934.  (Best GOF=0.3625934)
##   Iteration 2400, current GOF is 0.3625934.  (Best GOF=0.3625934)
##   Iteration 2500, current GOF is 0.3625934.  (Best GOF=0.3625934)
##   Iteration 2600, current GOF is 0.3625934.  (Best GOF=0.3625934)
##   Iteration 2700, current GOF is 0.3625934.  (Best GOF=0.3625934)
##   Iteration 2800, current GOF is 0.3625934.  (Best GOF=0.3625934)
##   Iteration 2900, current GOF is 0.3625934.  (Best GOF=0.3625934)
##   Iteration 3000, current GOF is 0.3625934.  (Best GOF=0.3625934)
## Annealing completed.
## Refining solution via hill-climbing procedure...
##   Refining; current GOF is  0.3625934
## Preparing and returning output.
```
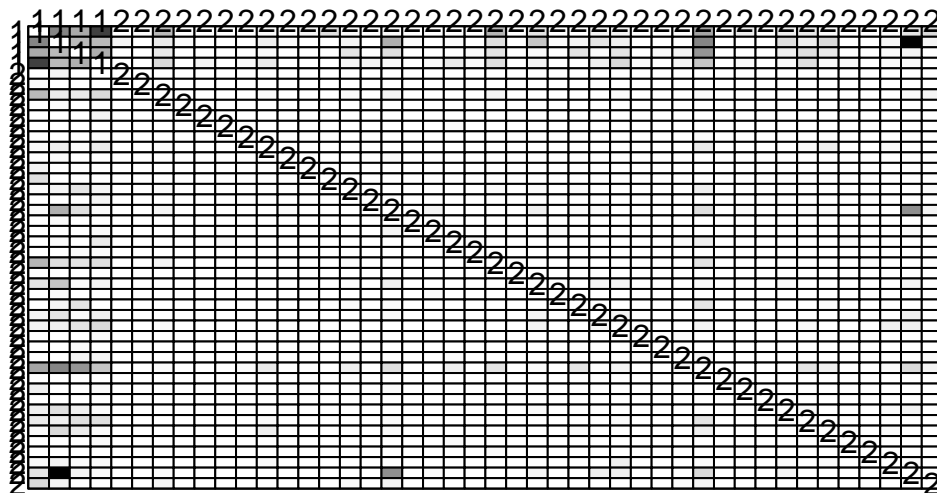
```r
lab<-bkh1$block.membership[bkh1$order.vector]
plot.sociomatrix(bkh1$blocked.data,labels=list(lab,lab))
title(main="communication among radio operators")
```

communication among radio operators

```
summary(bkh1$blocked.data)
```

```
##       V1              V2              V3              V4
##  Min.   : 0.000   Min.   : 0.00   Min.   : 0.000   Min.   : 0.000
##  1st Qu.: 0.000   1st Qu.: 0.00   1st Qu.: 0.000   1st Qu.: 0.000
##  Median : 0.500   Median : 1.00   Median : 0.000   Median : 1.000
##  Mean   : 3.727   Mean   : 4.50   Mean   : 2.659   Mean   : 3.023
##  3rd Qu.: 3.250   3rd Qu.: 4.25   3rd Qu.: 4.000   3rd Qu.: 2.250
##  Max.   :36.000   Max.   :48.00   Max.   :20.000   Max.   :36.000
##       V5              V6              V7              V8
##  Min.   :0.00000  Min.   :0.00000  Min.   : 0.0000  Min.   :0.00000
##  1st Qu.:0.00000  1st Qu.:0.00000  1st Qu.: 0.0000  1st Qu.:0.00000
##  Median :0.00000  Median :0.00000  Median : 0.0000  Median :0.00000
##  Mean   :0.04545  Mean   :0.02273  Mean   : 0.8864  Mean   :0.02273
##  3rd Qu.:0.00000  3rd Qu.:0.00000  3rd Qu.: 1.0000  3rd Qu.:0.00000
##  Max.   :2.00000  Max.   :1.00000  Max.   :13.0000  Max.   :1.00000
##       V9              V10             V11             V12
##  Min.   :0.00000  Min.   :0.00000  Min.   :0.00000  Min.   :0.0000
##  1st Qu.:0.00000  1st Qu.:0.00000  1st Qu.:0.00000  1st Qu.:0.0000
##  Median :0.00000  Median :0.00000  Median :0.00000  Median :0.0000
##  Mean   :0.04545  Mean   :0.02273  Mean   :0.04545  Mean   :0.4318
##  3rd Qu.:0.00000  3rd Qu.:0.00000  3rd Qu.:0.00000  3rd Qu.:0.0000
##  Max.   :2.00000  Max.   :1.00000  Max.   :1.00000  Max.   :4.0000
##       V13             V14             V15             V16
##  Min.   :0.00000  Min.   :0.00000  Min.   :0.0000   Min.   :0.0000
##  1st Qu.:0.00000  1st Qu.:0.00000  1st Qu.:0.0000   1st Qu.:0.0000
##  Median :0.00000  Median :0.00000  Median :0.0000   Median :0.0000
##  Mean   :0.04545  Mean   :0.04545  Mean   :0.1364   Mean   :0.4091
##  3rd Qu.:0.00000  3rd Qu.:0.00000  3rd Qu.:0.0000   3rd Qu.:0.0000
##  Max.   :1.00000  Max.   :2.00000  Max.   :6.0000   Max.   :5.0000
##       V17             V18             V19             V20
##  Min.   :0.00000  Min.   : 0.000   Min.   :0.00000  Min.   :0.0000
##  1st Qu.:0.00000  1st Qu.: 0.000   1st Qu.:0.00000  1st Qu.:0.0000
##  Median :0.00000  Median : 0.000   Median :0.00000  Median :0.0000
##  Mean   :0.04545  Mean   : 1.477   Mean   :0.02273  Mean   :0.1136
##  3rd Qu.:0.00000  3rd Qu.: 1.000   3rd Qu.:0.00000  3rd Qu.:0.0000
##  Max.   :2.00000  Max.   :21.000   Max.   :1.00000  Max.   :2.0000
##       V21             V22             V23             V24
##  Min.   :0.0000   Min.   :0.00000  Min.   : 0.0000  Min.   :0
##  1st Qu.:0.0000   1st Qu.:0.00000  1st Qu.: 0.0000  1st Qu.:0
##  Median :0.0000   Median :0.00000  Median : 0.0000  Median :0
##  Mean   :0.2727   Mean   :0.06818  Mean   : 0.9091  Mean   :0
##  3rd Qu.:0.0000   3rd Qu.:0.00000  3rd Qu.: 0.0000  3rd Qu.:0
##  Max.   :4.0000   Max.   :1.00000  Max.   :14.0000  Max.   :0
##       V25             V26             V27             V28
##  Min.   : 0.0000  Min.   :0.00000  Min.   :0.0000   Min.   :0.0000
##  1st Qu.: 0.0000  1st Qu.:0.00000  1st Qu.:0.0000   1st Qu.:0.0000
##  Median : 0.0000  Median :0.00000  Median :0.0000   Median :0.0000
##  Mean   : 0.7045  Mean   :0.04545  Mean   :0.3409   Mean   :0.4318
##  3rd Qu.: 0.2500  3rd Qu.:0.00000  3rd Qu.:0.0000   3rd Qu.:0.0000
##  Max.   :11.0000  Max.   :1.00000  Max.   :5.0000   Max.   :5.0000
##       V29             V30             V31             V32
##  Min.   :0.0000   Min.   :0.00000  Min.   :0.00000  Min.   :0.0000
##  1st Qu.:0.0000   1st Qu.:0.00000  1st Qu.:0.00000  1st Qu.:0.0000
```

```
##   Median :0.0000     Median :0.00000     Median :0.00000     Median :0.0000
##   Mean   :0.7045     Mean   :0.04545     Mean   :0.02273     Mean   :0.2045
##   3rd Qu.:0.2500     3rd Qu.:0.00000     3rd Qu.:0.00000     3rd Qu.:0.0000
##   Max.   :7.0000     Max.   :1.00000     Max.   :1.00000     Max.   :2.0000
##        V33                V34             V35                V36
##   Min.   : 0.000     Min.   :0     Min.   :0.0000     Min.   :0
##   1st Qu.: 0.000     1st Qu.:0     1st Qu.:0.0000     1st Qu.:0
##   Median : 0.000     Median :0     Median :0.0000     Median :0
##   Mean   : 2.773     Mean   :0     Mean   :0.1136     Mean   :0
##   3rd Qu.: 3.000     3rd Qu.:0     3rd Qu.:0.0000     3rd Qu.:0
##   Max.   :23.000     Max.   :0     Max.   :3.0000     Max.   :0
##        V37                V38             V39                V40
##   Min.   :0.0000     Min.   :0.0000     Min.   :0.0     Min.   :0.00000
##   1st Qu.:0.0000     1st Qu.:0.0000     1st Qu.:0.0     1st Qu.:0.00000
##   Median :0.0000     Median :0.0000     Median :0.0     Median :0.00000
##   Mean   :0.4091     Mean   :0.6364     Mean   :0.5     Mean   :0.04545
##   3rd Qu.:0.0000     3rd Qu.:0.0000     3rd Qu.:0.0     3rd Qu.:0.00000
##   Max.   :6.0000     Max.   :6.0000     Max.   :7.0     Max.   :1.00000
##        V41                V42             V43                V44
##   Min.   :0.00000     Min.   :0.0000     Min.   : 0.000     Min.   :0.0000
##   1st Qu.:0.00000     1st Qu.:0.0000     1st Qu.: 0.000     1st Qu.:0.0000
##   Median :0.00000     Median :0.0000     Median : 0.000     Median :0.0000
##   Mean   :0.02273     Mean   :0.2955     Mean   : 2.205     Mean   :0.3864
##   3rd Qu.:0.00000     3rd Qu.:0.0000     3rd Qu.: 1.000     3rd Qu.:0.0000
##   Max.   :1.00000     Max.   :3.0000     Max.   :48.000     Max.   :7.0000
```

```r
#BKTEC Network
bkt1 <- block.fit(bktec,c(1,1,1,0))    # Core w/in,out ties
```

```
## Entering annealing loop...
##   Iteration 100, current GOF is -0.02719068.  (Best GOF=0.06103012)
##   Iteration 200, current GOF is -0.01786253.  (Best GOF=0.06103012)
##   Iteration 300, current GOF is -0.05864872.  (Best GOF=0.09817744)
##   Iteration 400, current GOF is -0.03225387.  (Best GOF=0.1096068)
##   Iteration 500, current GOF is -0.03667902.  (Best GOF=0.1096068)
##   Iteration 600, current GOF is -0.02070961.  (Best GOF=0.1157367)
##   Iteration 700, current GOF is 0.03796807.  (Best GOF=0.1157367)
##   Iteration 800, current GOF is 0.1189173.  (Best GOF=0.1250139)
##   Iteration 900, current GOF is 0.05682338.  (Best GOF=0.1250139)
##   Iteration 1000, current GOF is 0.1126831.  (Best GOF=0.1303097)
##   Iteration 1100, current GOF is 0.05686083.  (Best GOF=0.138506)
##   Iteration 1200, current GOF is 0.06930324.  (Best GOF=0.138506)
##   Iteration 1300, current GOF is 0.1006384.  (Best GOF=0.1652824)
##   Iteration 1400, current GOF is 0.1735154.  (Best GOF=0.1748487)
##   Iteration 1500, current GOF is 0.1606975.  (Best GOF=0.1811624)
##   Iteration 1600, current GOF is 0.1916112.  (Best GOF=0.1978197)
##   Iteration 1700, current GOF is 0.2003534.  (Best GOF=0.2016146)
##   Iteration 1800, current GOF is 0.2196866.  (Best GOF=0.2196866)
##   Iteration 1900, current GOF is 0.2366215.  (Best GOF=0.2366215)
##   Iteration 2000, current GOF is 0.2394306.  (Best GOF=0.2394306)
##   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
  lab<-bkt1$block.membership[bkt1$order.vector]
  plot.sociomatrix(bkt1$blocked.data,labels=list(lab,lab))
  title(main="face-to-face interactions among members of a fraterity")
```


face–to–face interactions among members of a fraterity
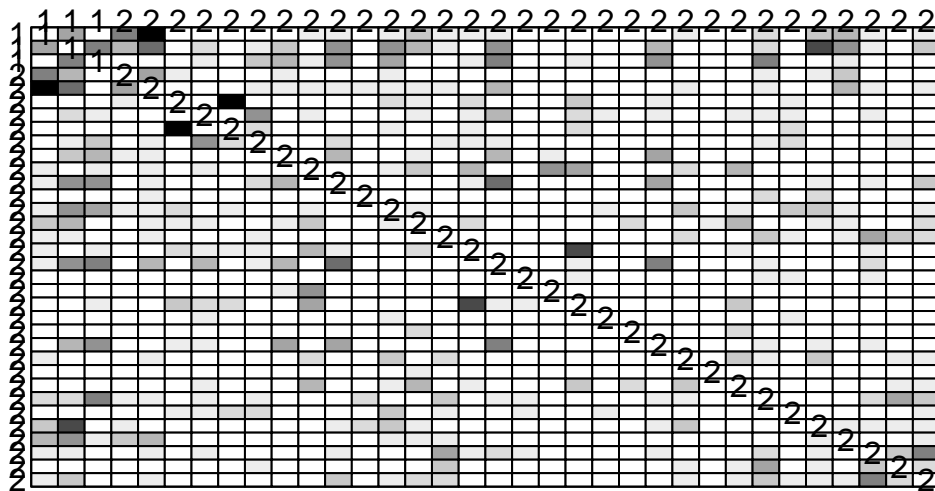
```r
#BKFRAT Network
bkf1<-block.fit(bkfrat,c(1,1,1,0))    # Core w/in,out ties
```

```
## Entering annealing loop...
##  Iteration 100, current GOF is 0.01691689.   (Best GOF=0.07356366)
##  Iteration 200, current GOF is 0.05156705.   (Best GOF=0.07356366)
##  Iteration 300, current GOF is -0.06355821.  (Best GOF=0.1244486)
##  Iteration 400, current GOF is -0.08784389.  (Best GOF=0.1244486)
##  Iteration 500, current GOF is -0.006050607.  (Best GOF=0.1244486)
##  Iteration 600, current GOF is 0.003512252.  (Best GOF=0.1244486)
##  Iteration 700, current GOF is 0.1136005.  (Best GOF=0.1458396)
##  Iteration 800, current GOF is 0.05243702.  (Best GOF=0.1541747)
##  Iteration 900, current GOF is 0.1493069.  (Best GOF=0.1568026)
```

```
##   Iteration 1000, current GOF is 0.1095903.   (Best GOF=0.1631922)
##   Iteration 1100, current GOF is 0.1084064.   (Best GOF=0.1631922)
##   Iteration 1200, current GOF is 0.06928086.   (Best GOF=0.1631922)
##   Iteration 1300, current GOF is 0.1482586.   (Best GOF=0.1631922)
##   Iteration 1400, current GOF is 0.2067123.   (Best GOF=0.2091852)
##   Iteration 1500, current GOF is 0.2834963.   (Best GOF=0.2834963)
##   Iteration 1600, current GOF is 0.280913.   (Best GOF=0.2834963)
##   Iteration 1700, current GOF is 0.3505872.   (Best GOF=0.3505872)
##   Iteration 1800, current GOF is 0.4009407.   (Best GOF=0.4009407)
##   Iteration 1900, current GOF is 0.4009407.   (Best GOF=0.4009407)
##   Iteration 2000, current GOF is 0.4009407.   (Best GOF=0.4009407)
##   Iteration 2100, current GOF is 0.4207104.   (Best GOF=0.4207104)
##   Iteration 2200, current GOF is 0.4207104.   (Best GOF=0.4207104)
##   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.
```

```r
lab<-bkf1$block.membership[bkf1$order.vector]
plot.sociomatrix(bkf1$blocked.data,labels=list(lab,lab))
title(main="face-to-face interactions in a university research group")
```

face–to–face interactions in a university research group
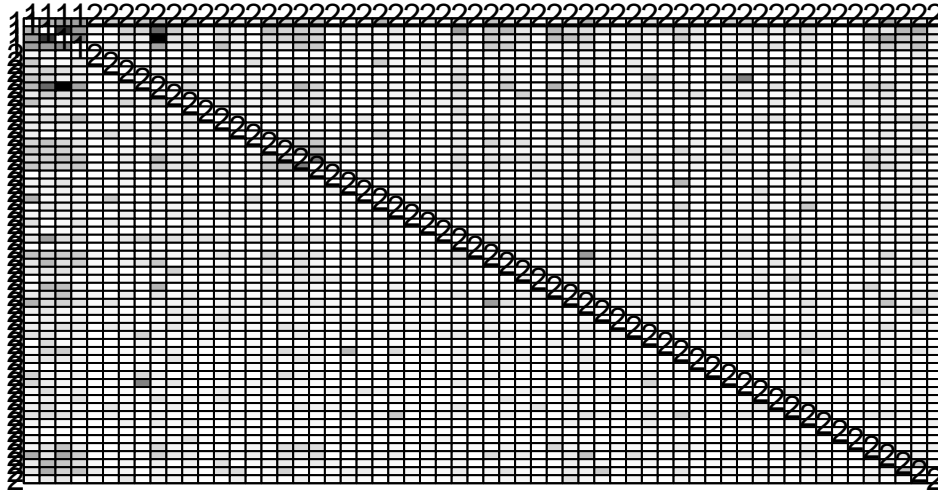

```
#BKOFF Network
bko1 <- block.fit(bkoff,c(1,1,1,0))    # Core w/in,out ties

## Entering annealing loop...
##   Iteration 100, current GOF is 0.01196262.  (Best GOF=0.07460163)
##   Iteration 200, current GOF is 0.01284817.  (Best GOF=0.07903551)
##   Iteration 300, current GOF is -0.06638983.  (Best GOF=0.09580374)
##   Iteration 400, current GOF is 0.02453501.  (Best GOF=0.09580374)
##   Iteration 500, current GOF is -0.01061371.  (Best GOF=0.09580374)
##   Iteration 600, current GOF is 0.02212994.  (Best GOF=0.09580374)
##   Iteration 700, current GOF is -0.05656396.  (Best GOF=0.09580374)
##   Iteration 800, current GOF is -0.007245322.  (Best GOF=0.09580374)
##   Iteration 900, current GOF is 0.05514033.  (Best GOF=0.104982)
##   Iteration 1000, current GOF is -0.04703146.  (Best GOF=0.104982)
##   Iteration 1100, current GOF is 0.02515284.  (Best GOF=0.104982)
##   Iteration 1200, current GOF is 0.07376947.  (Best GOF=0.104982)
##   Iteration 1300, current GOF is 0.1088738.  (Best GOF=0.1169726)
##   Iteration 1400, current GOF is 0.1759557.  (Best GOF=0.1759557)
##   Iteration 1500, current GOF is 0.1552953.  (Best GOF=0.1759557)
##   Iteration 1600, current GOF is 0.1618751.  (Best GOF=0.1759557)
##   Iteration 1700, current GOF is 0.1967947.  (Best GOF=0.1967947)
##   Iteration 1800, current GOF is 0.1953488.  (Best GOF=0.1967947)
##   Iteration 1900, current GOF is 0.2059834.  (Best GOF=0.2059834)
##   Iteration 2000, current GOF is 0.2118476.  (Best GOF=0.2118476)
##   Iteration 2100, current GOF is 0.2107397.  (Best GOF=0.2118476)
##   Iteration 2200, current GOF is 0.2118476.  (Best GOF=0.2118476)
```

```
##  Iteration 2300, current GOF is 0.2118476.   (Best GOF=0.2118476)
##  Iteration 2400, current GOF is 0.2118476.   (Best GOF=0.2118476)
##  Iteration 2500, current GOF is 0.2118476.   (Best GOF=0.2118476)
##  Iteration 2600, current GOF is 0.2118476.   (Best GOF=0.2118476)
##  Iteration 2700, current GOF is 0.2118476.   (Best GOF=0.2118476)
##  Iteration 2800, current GOF is 0.2118476.   (Best GOF=0.2118476)
##  Iteration 2900, current GOF is 0.2118476.   (Best GOF=0.2118476)
##  Iteration 3000, current GOF is 0.2118476.   (Best GOF=0.2118476)
## Annealing completed.
## Refining solution via hill-climbing procedure...
##  Refining; current GOF is  0.2118476
## Preparing and returning output.
```

```r
lab<-bko1$block.membership[bko1$order.vector]
plot.sociomatrix(bko1$blocked.data,labels=list(lab,lab))
title(main="face-to-face interactions in a small business")
```


face–to–face interactions in a small business
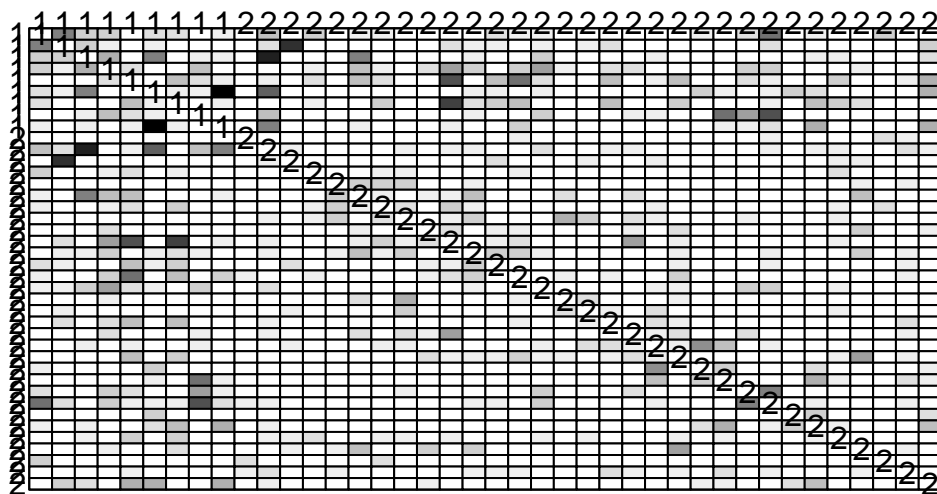
In the first network,communication among radio operators (bkham), the core periphery structure is strong. Within periphery interaction is lesser as compared to the other networks. This means that the interactions among radio operators are divided into a core and a periphery.

Later, the BKTEC and BKFRAT have a less stronger separation between core and periphery.

The last network, face-to-face interactions in a small business(bkoff), the core periphery structure seems to be weak. This means that there is an even interaction pattern across the small businesses.

#All Networks – Core to/from periphery ties

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```
#BKHAM
bkh2<-block.fit(bkham,c(0,1,1,0))
```

```
## Entering annealing loop...
##  Iteration 100, current GOF is -0.01521843.  (Best GOF=0.04289822)
##  Iteration 200, current GOF is -0.05180726.  (Best GOF=0.04289822)
##  Iteration 300, current GOF is 0.02066049.  (Best GOF=0.05006754)
##  Iteration 400, current GOF is -0.1014574.  (Best GOF=0.05006754)
##  Iteration 500, current GOF is 0.0414584.  (Best GOF=0.05867984)
##  Iteration 600, current GOF is -0.01090275.  (Best GOF=0.05943343)
##  Iteration 700, current GOF is -0.02740172.  (Best GOF=0.05943343)
##  Iteration 800, current GOF is 0.03572476.  (Best GOF=0.05943343)
##  Iteration 900, current GOF is 0.02375967.  (Best GOF=0.05943343)
##  Iteration 1000, current GOF is 0.03094786.  (Best GOF=0.05943343)
##  Iteration 1100, current GOF is 0.04888762.  (Best GOF=0.05943343)
##  Iteration 1200, current GOF is 0.04074618.  (Best GOF=0.05943343)
##  Iteration 1300, current GOF is 0.05274732.  (Best GOF=0.05943343)
##  Iteration 1400, current GOF is 0.05541405.  (Best GOF=0.06562627)
##  Iteration 1500, current GOF is 0.04576297.  (Best GOF=0.09173541)
##  Iteration 1600, current GOF is 0.04795651.  (Best GOF=0.09173541)
##  Iteration 1700, current GOF is 0.09146507.  (Best GOF=0.09246066)
##  Iteration 1800, current GOF is 0.1752132.  (Best GOF=0.1752132)
##  Iteration 1900, current GOF is 0.2004559.  (Best GOF=0.2004559)
##  Iteration 2000, current GOF is 0.2467868.  (Best GOF=0.2467868)
##  Iteration 2100, current GOF is 0.2585164.  (Best GOF=0.2585164)
##  Iteration 2200, current GOF is 0.2585164.  (Best GOF=0.2585164)
##  Iteration 2300, current GOF is 0.2585164.  (Best GOF=0.2585164)
##  Iteration 2400, current GOF is 0.2585164.  (Best GOF=0.2585164)
##  Iteration 2500, current GOF is 0.2585164.  (Best GOF=0.2585164)
##  Iteration 2600, current GOF is 0.2585164.  (Best GOF=0.2585164)
##  Iteration 2700, current GOF is 0.2585164.  (Best GOF=0.2585164)
##  Iteration 2800, current GOF is 0.2585164.  (Best GOF=0.2585164)
##  Iteration 2900, current GOF is 0.2585164.  (Best GOF=0.2585164)
##  Iteration 3000, current GOF is 0.2585164.  (Best GOF=0.2585164)
## Annealing completed.
## Refining solution via hill-climbing procedure...
##  Refining; current GOF is  0.2585164
## Preparing and returning output.
```
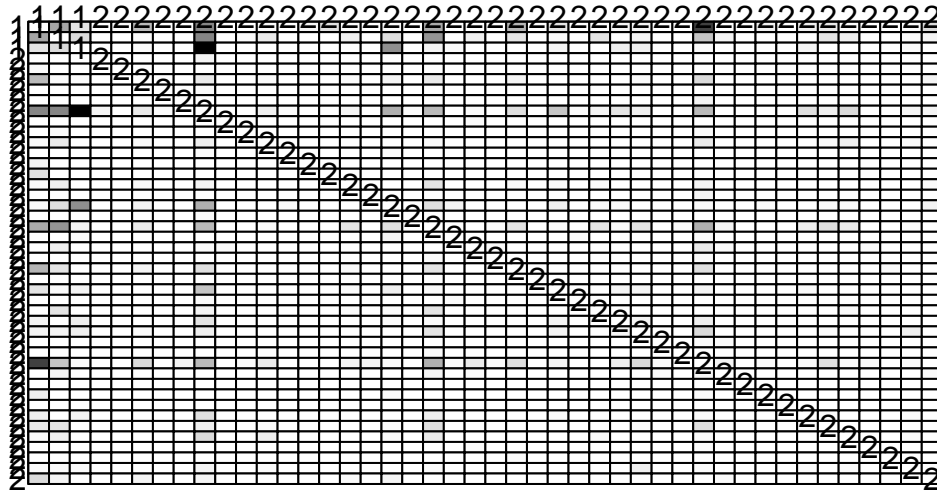
```
  lab<-bkh2$block.membership[bkh2$order.vector]
  plot.sociomatrix(bkh2$blocked.data,labels=list(lab,lab))
```

```
#BKFRAT
bkf2<-block.fit(bkfrat,c(0,1,1,0))
```

```
## Entering annealing loop...
##   Iteration 100, current GOF is -0.03553038.  (Best GOF=0.01171231)
##   Iteration 200, current GOF is 0.03421622.  (Best GOF=0.04002823)
##   Iteration 300, current GOF is -0.01163311.  (Best GOF=0.04002823)
##   Iteration 400, current GOF is 0.0177466.  (Best GOF=0.04002823)
##   Iteration 500, current GOF is 0.007097865.  (Best GOF=0.04002823)
##   Iteration 600, current GOF is -0.02058883.  (Best GOF=0.04002823)
##   Iteration 700, current GOF is 0.008162738.  (Best GOF=0.04486376)
##   Iteration 800, current GOF is 0.009227611.  (Best GOF=0.04486376)
##   Iteration 900, current GOF is -0.00388682.  (Best GOF=0.04486376)
##   Iteration 1000, current GOF is 0.01163311.  (Best GOF=0.04486376)
##   Iteration 1100, current GOF is 0.02350585.  (Best GOF=0.05588648)
##   Iteration 1200, current GOF is 0.01096295.  (Best GOF=0.05588648)
##   Iteration 1300, current GOF is 0.02236105.  (Best GOF=0.05588648)
##   Iteration 1400, current GOF is 0.03541402.  (Best GOF=0.05588648)
##   Iteration 1500, current GOF is 0.07482246.  (Best GOF=0.08302943)
##   Iteration 1600, current GOF is 0.1692233.  (Best GOF=0.1692233)
##   Iteration 1700, current GOF is 0.2511353.  (Best GOF=0.2511353)
##   Iteration 1800, current GOF is 0.3460899.  (Best GOF=0.3460899)
##   Iteration 1900, current GOF is 0.3460899.  (Best GOF=0.3460899)
##   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.
```

```
  lab<-bkf2$block.membership[bkf2$order.vector]
  plot.sociomatrix(bkf2$blocked.data,labels=list(lab,lab))
```
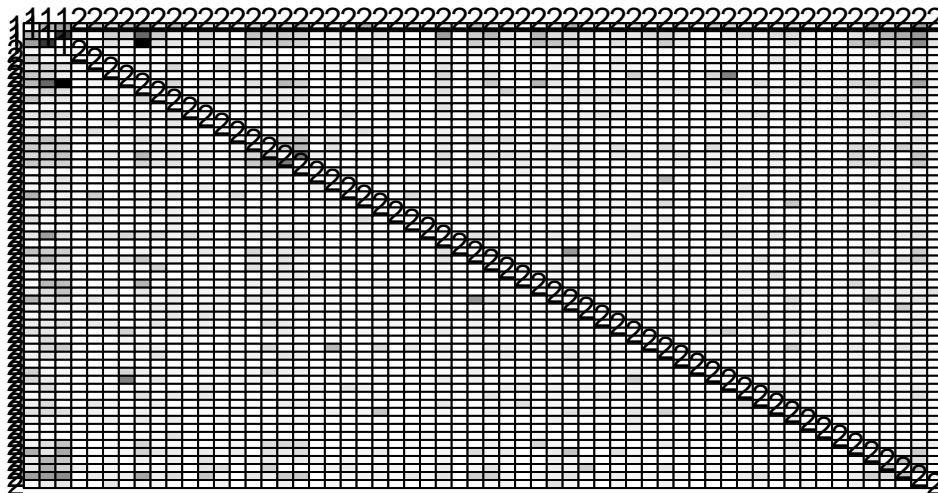


```
#BKTEC
  bkt2<-block.fit(bktec,c(0,1,1,0))
```

```
## Entering annealing loop...
##   Iteration 100, current GOF is -0.01244.   (Best GOF=0.09074457)
##   Iteration 200, current GOF is -0.0700898.   (Best GOF=0.09074457)
##   Iteration 300, current GOF is -0.08392669.   (Best GOF=0.09074457)
##   Iteration 400, current GOF is -0.04112964.   (Best GOF=0.09074457)
##   Iteration 500, current GOF is 0.02520394.   (Best GOF=0.09074457)
##   Iteration 600, current GOF is 0.08318561.   (Best GOF=0.09074457)
##   Iteration 700, current GOF is -0.04971232.   (Best GOF=0.09074457)
```
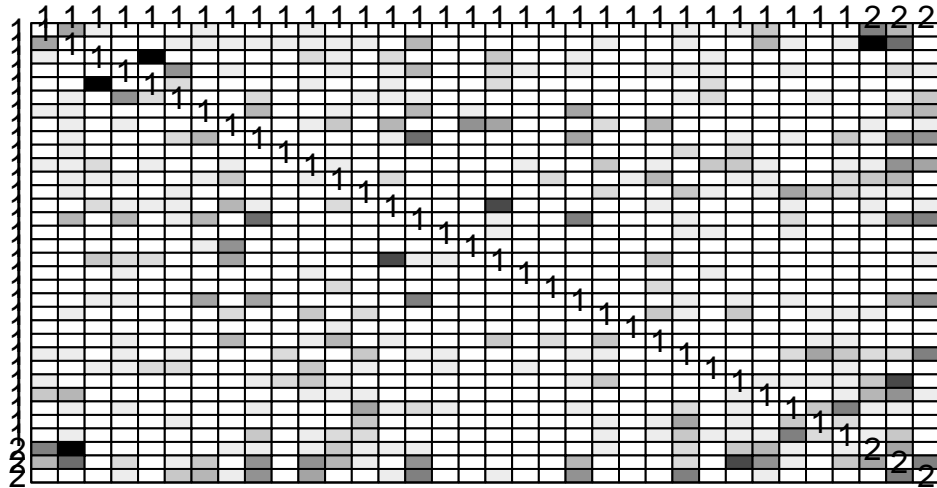
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```
##   Iteration 800, current GOF is -0.01463622.  (Best GOF=0.09074457)
##   Iteration 900, current GOF is 0.003269114.  (Best GOF=0.09074457)
##   Iteration 1000, current GOF is 0.04474392.  (Best GOF=0.09074457)
##   Iteration 1100, current GOF is 0.003856181.  (Best GOF=0.1274745)
##   Iteration 1200, current GOF is 0.02951379.  (Best GOF=0.1274745)
##   Iteration 1300, current GOF is 0.0566922.  (Best GOF=0.1274745)
##   Iteration 1400, current GOF is 0.09541334.  (Best GOF=0.1274745)
##   Iteration 1500, current GOF is 0.08681676.  (Best GOF=0.1274745)
##   Iteration 1600, current GOF is 0.1274745.  (Best GOF=0.1274745)
##   Iteration 1700, current GOF is 0.1271467.  (Best GOF=0.1274745)
##   Iteration 1800, current GOF is 0.1315556.  (Best GOF=0.1315556)
##   Iteration 1900, current GOF is 0.1619443.  (Best GOF=0.1619443)
##   Iteration 2000, current GOF is 0.1674393.  (Best GOF=0.1674393)
##   Iteration 2100, current GOF is 0.1789836.  (Best GOF=0.1789836)
##   Iteration 2200, current GOF is 0.2104544.  (Best GOF=0.2104544)
##   Iteration 2300, current GOF is 0.2160739.  (Best GOF=0.2160739)
##   Iteration 2400, current GOF is 0.2160739.  (Best GOF=0.2160739)
##   Iteration 2500, current GOF is 0.2160739.  (Best GOF=0.2160739)
##   Iteration 2600, current GOF is 0.2160739.  (Best GOF=0.2160739)
##   Iteration 2700, current GOF is 0.2160739.  (Best GOF=0.2160739)
##   Iteration 2800, current GOF is 0.2160739.  (Best GOF=0.2160739)
##   Iteration 2900, current GOF is 0.2160739.  (Best GOF=0.2160739)
##   Iteration 3000, current GOF is 0.2160739.  (Best GOF=0.2160739)
## Annealing completed.
## Refining solution via hill-climbing procedure...
##   Refining; current GOF is  0.2160739
## Preparing and returning output.
```

```r
  lab<-bkt2$block.membership[bkt2$order.vector]
  plot.sociomatrix(bkt2$blocked.data,labels=list(lab,lab))
```
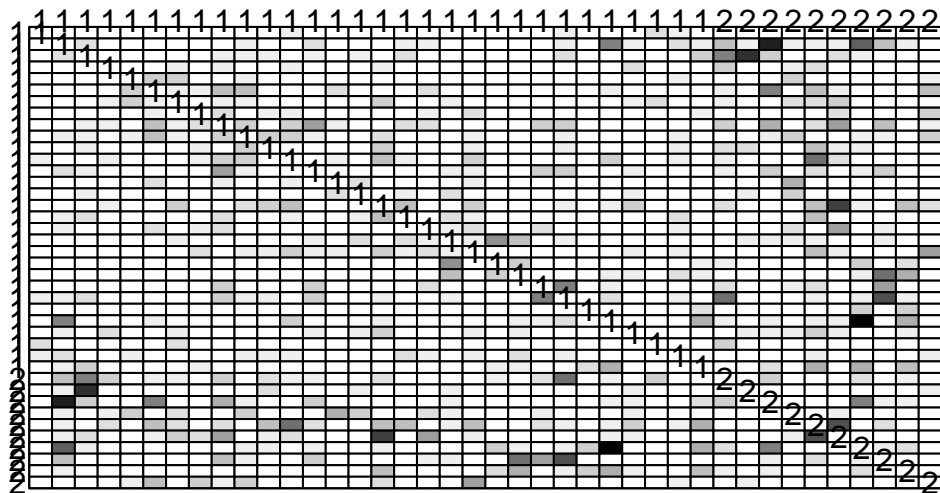
```
#BKOFF
  bko2<-block.fit(bkoff,c(0,1,1,0))
```

```
## Entering annealing loop...
##   Iteration 100, current GOF is 0.03399322.  (Best GOF=0.07683615)
##   Iteration 200, current GOF is 0.01453483.  (Best GOF=0.07683615)
##   Iteration 300, current GOF is 0.01021755.  (Best GOF=0.07683615)
##   Iteration 400, current GOF is 0.02585837.  (Best GOF=0.07683615)
##   Iteration 500, current GOF is 0.01511763.  (Best GOF=0.07683615)
##   Iteration 600, current GOF is 0.03107979.  (Best GOF=0.07683615)
##   Iteration 700, current GOF is -0.009735296.  (Best GOF=0.07683615)
##   Iteration 800, current GOF is 0.02892575.  (Best GOF=0.07683615)
##   Iteration 900, current GOF is 0.003741086.  (Best GOF=0.07683615)
##   Iteration 1000, current GOF is 0.05948619.  (Best GOF=0.07683615)
##   Iteration 1100, current GOF is 0.0001439092.  (Best GOF=0.07683615)
##   Iteration 1200, current GOF is 0.07344163.  (Best GOF=0.07683615)
##   Iteration 1300, current GOF is 0.08521981.  (Best GOF=0.0941027)
##   Iteration 1400, current GOF is 0.08361126.  (Best GOF=0.0941027)
##   Iteration 1500, current GOF is 0.1068005.  (Best GOF=0.1187814)
##   Iteration 1600, current GOF is 0.1166991.  (Best GOF=0.1401132)
##   Iteration 1700, current GOF is 0.1397698.  (Best GOF=0.1484213)
##   Iteration 1800, current GOF is 0.1430051.  (Best GOF=0.1484213)
##   Iteration 1900, current GOF is 0.1645079.  (Best GOF=0.1645079)
##   Iteration 2000, current GOF is 0.1700412.  (Best GOF=0.1700412)
##   Iteration 2100, current GOF is 0.1700412.  (Best GOF=0.1700412)
##   Iteration 2200, current GOF is 0.1700412.  (Best GOF=0.1700412)
```

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```
##  Iteration 2300, current GOF is 0.1700412.  (Best GOF=0.1700412)
##  Iteration 2400, current GOF is 0.1700412.  (Best GOF=0.1700412)
##  Iteration 2500, current GOF is 0.1700412.  (Best GOF=0.1700412)
##  Iteration 2600, current GOF is 0.1700412.  (Best GOF=0.1700412)
##  Iteration 2700, current GOF is 0.1700412.  (Best GOF=0.1700412)
##  Iteration 2800, current GOF is 0.1700412.  (Best GOF=0.1700412)
##  Iteration 2900, current GOF is 0.1700412.  (Best GOF=0.1700412)
##  Iteration 3000, current GOF is 0.1700412.  (Best GOF=0.1700412)
## Annealing completed.
## Refining solution via hill-climbing procedure...
##  Refining; current GOF is  0.1700412
## Preparing and returning output.
```

```
  lab<-bko2$block.membership[bko2$order.vector]
  plot.sociomatrix(bko2$blocked.data,labels=list(lab,lab))
```


The core-periphery ties vary widely in the 4 BKS networks. The interactions are lesser in the BKHAM network, and go on increasing in BKFRAT, BKTEC and BKOFF networks.

```
#All netrworks - Isolated Core

#BKHAM Network
bkh4<-block.fit(bkham,c(1,0,0,0))   # Isolated core
```
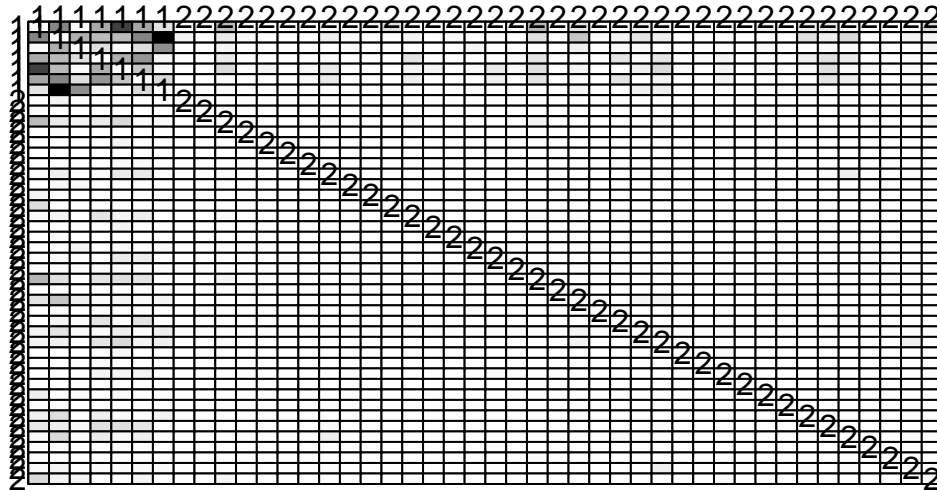
```
## Entering annealing loop...
##  Iteration 100, current GOF is -0.02278419.  (Best GOF=0.09885611)
##  Iteration 200, current GOF is 0.09296207.  (Best GOF=0.139202)
##  Iteration 300, current GOF is 0.005210639.  (Best GOF=0.2537313)
```

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```
##   Iteration 400, current GOF is -0.008424416.   (Best GOF=0.2537313)
##   Iteration 500, current GOF is -0.05780199.   (Best GOF=0.2537313)
##   Iteration 600, current GOF is 0.04961415.   (Best GOF=0.2537313)
##   Iteration 700, current GOF is -0.001059053.   (Best GOF=0.2537313)
##   Iteration 800, current GOF is -0.01173576.   (Best GOF=0.2537313)
##   Iteration 900, current GOF is -0.003099653.   (Best GOF=0.2537313)
##   Iteration 1000, current GOF is 0.06916641.   (Best GOF=0.2537313)
##   Iteration 1100, current GOF is 0.1651255.   (Best GOF=0.2537313)
##   Iteration 1200, current GOF is 0.2059432.   (Best GOF=0.2537313)
##   Iteration 1300, current GOF is 0.2470528.   (Best GOF=0.3030864)
##   Iteration 1400, current GOF is 0.3905803.   (Best GOF=0.4150276)
##   Iteration 1500, current GOF is 0.48666.   (Best GOF=0.48666)
##   Iteration 1600, current GOF is 0.6482456.   (Best GOF=0.6482456)
##   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.
```

```
lab<-bkh4$block.membership[bkh4$order.vector]
plot.sociomatrix(bkh4$blocked.data,labels=list(lab,lab))
```

```
#BKFRAT Network
bkf4<-block.fit(bkfrat,c(1,0,0,0))    # Isolated core

## Entering annealing loop...
##  Iteration 100, current GOF is -0.03483289.  (Best GOF=0.1133555)
##  Iteration 200, current GOF is 0.08657629.  (Best GOF=0.1227564)
##  Iteration 300, current GOF is -0.05237077.  (Best GOF=0.1227564)
##  Iteration 400, current GOF is -0.03124161.  (Best GOF=0.1227564)
##  Iteration 500, current GOF is -0.004470935.  (Best GOF=0.1227564)
##  Iteration 600, current GOF is 0.1196062.  (Best GOF=0.1227564)
##  Iteration 700, current GOF is 0.0248865.  (Best GOF=0.1437583)
##  Iteration 800, current GOF is -0.05773007.  (Best GOF=0.1437583)
##  Iteration 900, current GOF is -0.008017361.  (Best GOF=0.1437583)
##  Iteration 1000, current GOF is 0.03770946.  (Best GOF=0.1437583)
##  Iteration 1100, current GOF is 0.2224469.  (Best GOF=0.2224469)
##  Iteration 1200, current GOF is 0.2553917.  (Best GOF=0.2912429)
##  Iteration 1300, current GOF is 0.1776672.  (Best GOF=0.2912429)
##  Iteration 1400, current GOF is 0.3089649.  (Best GOF=0.3182459)
##  Iteration 1500, current GOF is 0.4296261.  (Best GOF=0.4296261)
##  Iteration 1600, current GOF is 0.499229.  (Best GOF=0.5119656)
##  Iteration 1700, current GOF is 0.5142176.  (Best GOF=0.5142176)
##  Iteration 1800, current GOF is 0.5229485.  (Best GOF=0.5229485)
##  Iteration 1900, current GOF is 0.5437819.  (Best GOF=0.5444052)
##  Iteration 2000, current GOF is 0.5437819.  (Best GOF=0.5444052)
##  Iteration 2100, current GOF is 0.5437819.  (Best GOF=0.5444052)
##  Iteration 2200, current GOF is 0.5455123.  (Best GOF=0.5455123)
```

```
##   Iteration 2300, current GOF is 0.5462324.   (Best GOF=0.5462324)
##   Iteration 2400, current GOF is 0.5462324.   (Best GOF=0.5462324)
##   Iteration 2500, current GOF is 0.5462324.   (Best GOF=0.5462324)
##   Iteration 2600, current GOF is 0.5462324.   (Best GOF=0.5462324)
##   Iteration 2700, current GOF is 0.5462324.   (Best GOF=0.5462324)
##   Iteration 2800, current GOF is 0.5462324.   (Best GOF=0.5462324)
##   Iteration 2900, current GOF is 0.5462324.   (Best GOF=0.5462324)
##   Iteration 3000, current GOF is 0.5462324.   (Best GOF=0.5462324)
## Annealing completed.
## Refining solution via hill-climbing procedure...
##   Refining; current GOF is  0.5462324
## Preparing and returning output.
```

```
  lab<-bkf4$block.membership[bkf4$order.vector]
  plot.sociomatrix(bkf4$blocked.data,labels=list(lab,lab))
```



```
#BKTEC network
bkt4<-block.fit(bktec,c(1,0,0,0))   # Isolated core
```

```
## Entering annealing loop...
##   Iteration 100, current GOF is 0.07650533.   (Best GOF=0.1155829)
##   Iteration 200, current GOF is -0.01490085.  (Best GOF=0.1155829)
##   Iteration 300, current GOF is 0.01407934.   (Best GOF=0.1155829)
##   Iteration 400, current GOF is 0.01456322.   (Best GOF=0.1155829)
##   Iteration 500, current GOF is -0.1184782.   (Best GOF=0.1155829)
##   Iteration 600, current GOF is -0.05120888.  (Best GOF=0.1155829)
##   Iteration 700, current GOF is -0.03796807.  (Best GOF=0.173711)
```

```
##  Iteration 800, current GOF is -0.03068031.  (Best GOF=0.173711)
##  Iteration 900, current GOF is -0.009766033.  (Best GOF=0.173711)
##  Iteration 1000, current GOF is 0.2158974.  (Best GOF=0.2208961)
##  Iteration 1100, current GOF is -0.006913872.  (Best GOF=0.2208961)
##  Iteration 1200, current GOF is -0.0009347233.  (Best GOF=0.2208961)
##  Iteration 1300, current GOF is 0.227979.  (Best GOF=0.227979)
##  Iteration 1400, current GOF is 0.2943898.  (Best GOF=0.3353228)
##  Iteration 1500, current GOF is 0.3876517.  (Best GOF=0.3876517)
##  Iteration 1600, current GOF is 0.3977511.  (Best GOF=0.4019073)
##  Iteration 1700, current GOF is 0.4310008.  (Best GOF=0.4310008)
##  Iteration 1800, current GOF is 0.4432779.  (Best GOF=0.4442833)
##  Iteration 1900, current GOF is 0.4432779.  (Best GOF=0.4442833)
##  Iteration 2000, current GOF is 0.4432779.  (Best GOF=0.4442833)
##  Iteration 2100, current GOF is 0.4432779.  (Best GOF=0.4442833)
##  Iteration 2200, current GOF is 0.4432779.  (Best GOF=0.4442833)
##  Iteration 2300, current GOF is 0.4432779.  (Best GOF=0.4442833)
##  Iteration 2400, current GOF is 0.4432779.  (Best GOF=0.4442833)
##  Iteration 2500, current GOF is 0.4432779.  (Best GOF=0.4442833)
##  Iteration 2600, current GOF is 0.4432779.  (Best GOF=0.4442833)
##  Iteration 2700, current GOF is 0.4432779.  (Best GOF=0.4442833)
##  Iteration 2800, current GOF is 0.4432779.  (Best GOF=0.4442833)
##  Iteration 2900, current GOF is 0.4432779.  (Best GOF=0.4442833)
##  Iteration 3000, current GOF is 0.4432779.  (Best GOF=0.4442833)
## Annealing completed.
## Refining solution via hill-climbing procedure...
##  Refining; current GOF is  0.4442833
## Preparing and returning output.
```

```r
lab<-bkt4$block.membership[bkt4$order.vector]
plot.sociomatrix(bkt4$blocked.data,labels=list(lab,lab))
```
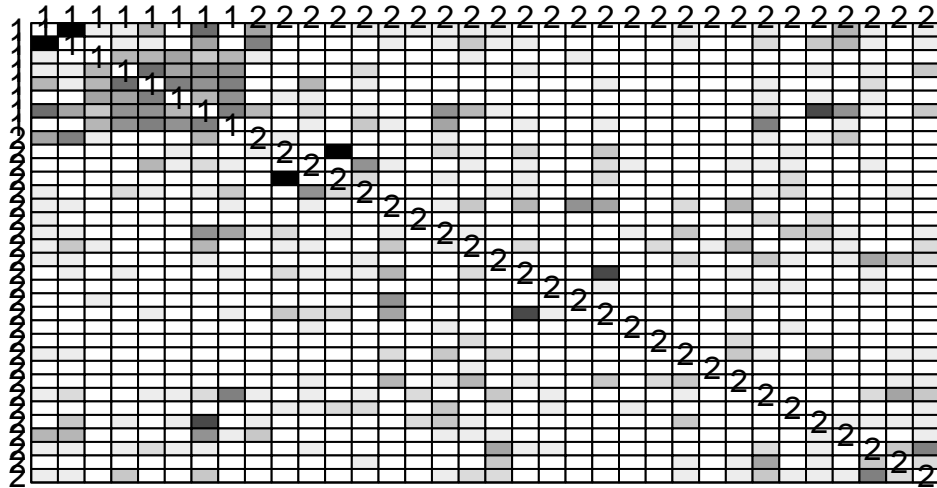
```
#BKOFF network
bko4<-block.fit(bkoff,c(1,0,0,0))   # Isolated core
```

```
## Entering annealing loop...
##  Iteration 100, current GOF is 0.07764764.  (Best GOF=0.1250143)
##  Iteration 200, current GOF is -0.05054835.  (Best GOF=0.1250143)
##  Iteration 300, current GOF is 0.0328619.  (Best GOF=0.1589778)
##  Iteration 400, current GOF is -0.02594839.  (Best GOF=0.1589778)
##  Iteration 500, current GOF is -0.1336364.  (Best GOF=0.1589778)
##  Iteration 600, current GOF is 0.0328619.  (Best GOF=0.1589778)
##  Iteration 700, current GOF is -0.05306853.  (Best GOF=0.1589778)
##  Iteration 800, current GOF is 0.0305604.  (Best GOF=0.1589778)
##  Iteration 900, current GOF is -0.0494562.  (Best GOF=0.1589778)
##  Iteration 1000, current GOF is 0.03568817.  (Best GOF=0.1589778)
##  Iteration 1100, current GOF is 0.04865324.  (Best GOF=0.1714952)
##  Iteration 1200, current GOF is 0.06601755.  (Best GOF=0.1714952)
##  Iteration 1300, current GOF is 0.1914842.  (Best GOF=0.2023537)
##  Iteration 1400, current GOF is 0.2162859.  (Best GOF=0.2672619)
##  Iteration 1500, current GOF is 0.2933655.  (Best GOF=0.3201066)
##  Iteration 1600, current GOF is 0.3319492.  (Best GOF=0.3319492)
##  Iteration 1700, current GOF is 0.3523318.  (Best GOF=0.3523318)
##  Iteration 1800, current GOF is 0.3478502.  (Best GOF=0.3523318)
##  Iteration 1900, current GOF is 0.3523318.  (Best GOF=0.3523318)
##  Iteration 2000, current GOF is 0.3523318.  (Best GOF=0.3523318)
##  Iteration 2100, current GOF is 0.3523318.  (Best GOF=0.3523318)
##  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.
```

```
  lab<-bko4$block.membership[bko4$order.vector]
  plot.sociomatrix(bko4$blocked.data,labels=list(lab,lab))
```
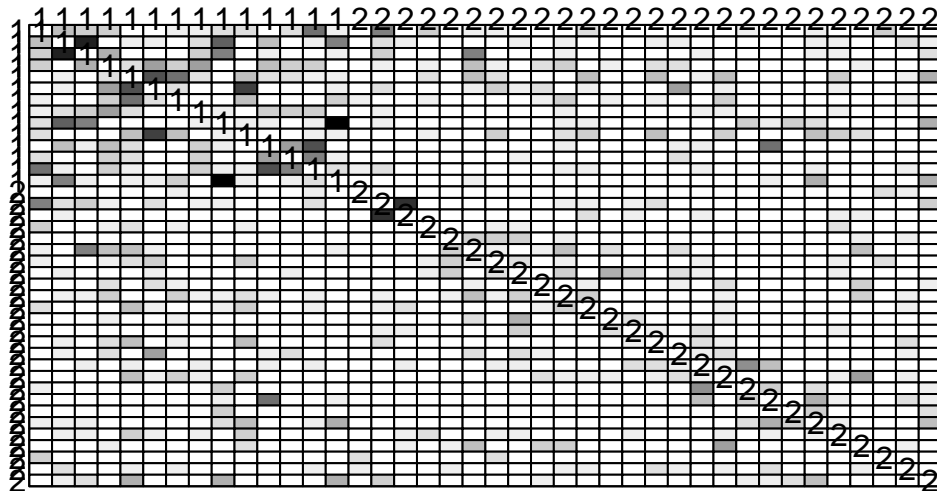

Within core interactions are the most clearly identifiable in the BKHAM network, mainly because it has a strong core-periphery seperation. For the rest of the networks, it is less clear.

```
#All networks - Borgatti - Everett Variant

#BKHAM Network
bkh5 <- block.fit(bkham,c(1,0,0,1))    # Borgatti - Everett Variant
```

```
## Entering annealing loop...
##  Iteration 100, current GOF is 0.007326716.  (Best GOF=0.1364142)
##  Iteration 200, current GOF is -0.03867586.  (Best GOF=0.1364142)
##  Iteration 300, current GOF is 0.03646801.  (Best GOF=0.1364142)
```
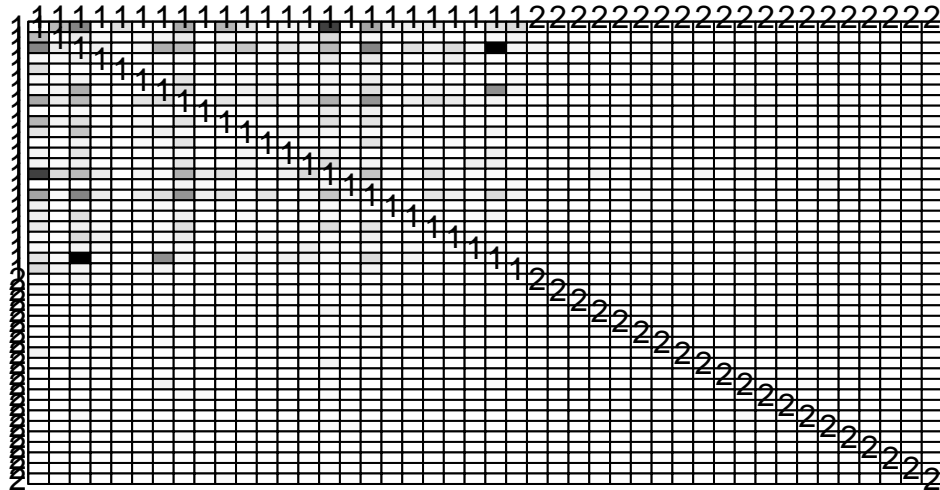
24

```
##   Iteration 400, current GOF is 0.04032841.   (Best GOF=0.1364142)
##   Iteration 500, current GOF is 0.01521843.   (Best GOF=0.1364142)
##   Iteration 600, current GOF is -0.03454214.   (Best GOF=0.1364142)
##   Iteration 700, current GOF is 0.04606784.   (Best GOF=0.1364142)
##   Iteration 800, current GOF is 0.02309764.   (Best GOF=0.1364142)
##   Iteration 900, current GOF is 0.01857058.   (Best GOF=0.1364142)
##   Iteration 1000, current GOF is 0.0558786.   (Best GOF=0.1364142)
##   Iteration 1100, current GOF is -0.04078343.   (Best GOF=0.1364142)
##   Iteration 1200, current GOF is 0.061117.   (Best GOF=0.1364142)
##   Iteration 1300, current GOF is 0.02740172.   (Best GOF=0.1364142)
##   Iteration 1400, current GOF is 0.134979.   (Best GOF=0.1385435)
##   Iteration 1500, current GOF is 0.1478685.   (Best GOF=0.1651175)
##   Iteration 1600, current GOF is 0.1532681.   (Best GOF=0.1651175)
##   Iteration 1700, current GOF is 0.1642111.   (Best GOF=0.1829573)
##   Iteration 1800, current GOF is 0.1844922.   (Best GOF=0.1844922)
##   Iteration 1900, current GOF is 0.1923416.   (Best GOF=0.1923416)
##   Iteration 2000, current GOF is 0.2014411.   (Best GOF=0.2017142)
##   Iteration 2100, current GOF is 0.2045863.   (Best GOF=0.2045863)
##   Iteration 2200, current GOF is 0.2093311.   (Best GOF=0.2093311)
##   Iteration 2300, current GOF is 0.2093311.   (Best GOF=0.2093311)
##   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.
```

```
  lab<-bkh5$block.membership[bkh5$order.vector]
  plot.sociomatrix(bkh5$blocked.data,labels=list(lab,lab))
```
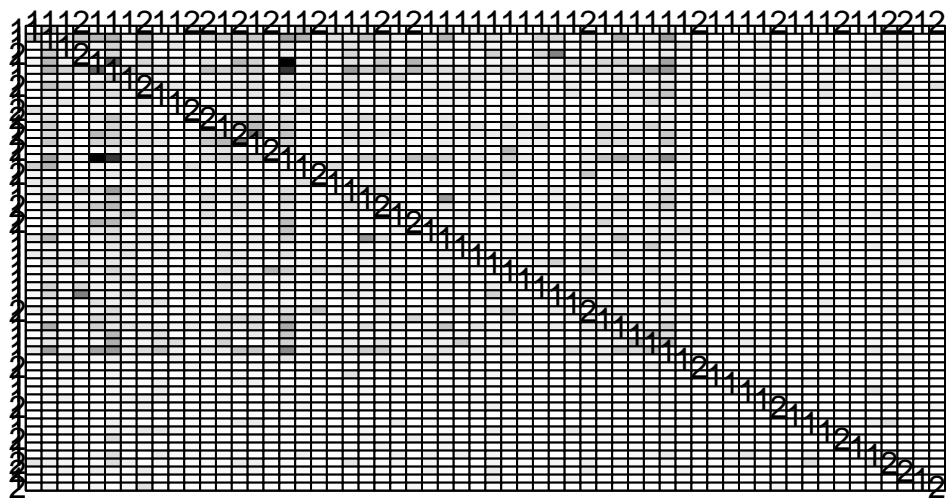
```
bkh5$block.gof
```

```
## [1] 0.2096077
#BKFRAT Network
bkf5 <- block.fit(bkfrat,c(1,0,0,1))    # Borgatti - Everett Variant
```

```
## Entering annealing loop...
##  Iteration 100, current GOF is -0.01766707.  (Best GOF=0.03876822)
##  Iteration 200, current GOF is 0.01476249.  (Best GOF=0.03876822)
##  Iteration 300, current GOF is 0.01198805.  (Best GOF=0.03876822)
##  Iteration 400, current GOF is -0.02325047.  (Best GOF=0.03876822)
##  Iteration 500, current GOF is 0.008728883.  (Best GOF=0.0403339)
##  Iteration 600, current GOF is 0.01459064.  (Best GOF=0.05682504)
##  Iteration 700, current GOF is 0.01033171.  (Best GOF=0.0580783)
##  Iteration 800, current GOF is 0.01943192.  (Best GOF=0.0580783)
##  Iteration 900, current GOF is 0.01736837.  (Best GOF=0.0744097)
##  Iteration 1000, current GOF is 0.01459064.  (Best GOF=0.09571153)
##  Iteration 1100, current GOF is -0.01029248.  (Best GOF=0.09571153)
##  Iteration 1200, current GOF is 0.01085839.  (Best GOF=0.09571153)
##  Iteration 1300, current GOF is 0.06480596.  (Best GOF=0.09571153)
##  Iteration 1400, current GOF is 0.1092027.  (Best GOF=0.1437029)
##  Iteration 1500, current GOF is 0.1946443.  (Best GOF=0.1946443)
##  Iteration 1600, current GOF is 0.2121392.  (Best GOF=0.2121392)
##  Iteration 1700, current GOF is 0.2689933.  (Best GOF=0.2693527)
##  Iteration 1800, current GOF is 0.2948664.  (Best GOF=0.2948664)
##  Iteration 1900, current GOF is 0.2952258.  (Best GOF=0.2952258)
```

```
##  Iteration 2000, current GOF is 0.2982005.  (Best GOF=0.2982005)
##  Iteration 2100, current GOF is 0.2982005.  (Best GOF=0.2982005)
##  Iteration 2200, current GOF is 0.2980884.  (Best GOF=0.2982005)
##  Iteration 2300, current GOF is 0.2980884.  (Best GOF=0.2982005)
##  Iteration 2400, current GOF is 0.2980884.  (Best GOF=0.2982005)
##  Iteration 2500, current GOF is 0.2982005.  (Best GOF=0.2982005)
##  Iteration 2600, current GOF is 0.2982005.  (Best GOF=0.2982005)
##  Iteration 2700, current GOF is 0.2982005.  (Best GOF=0.2982005)
##  Iteration 2800, current GOF is 0.2982005.  (Best GOF=0.2982005)
##  Iteration 2900, current GOF is 0.2982005.  (Best GOF=0.2982005)
##  Iteration 3000, current GOF is 0.2982005.  (Best GOF=0.2982005)
## Annealing completed.
## Refining solution via hill-climbing procedure...
##  Refining; current GOF is  0.2982005
## Preparing and returning output.
```

```
lab<-bkf5$block.membership[bkh5$order.vector]
plot.sociomatrix(bkf5$blocked.data,labels=list(lab,lab))
```



```
bkf5$block.gof
```

```
## [1] 0.2982005
```

```
#BKTEC Network
bkt5 <- block.fit(bktec,c(1,0,0,1))    # Borgatti - Everett Variant
```

```
## Entering annealing loop...
##  Iteration 100, current GOF is 0.03994857.  (Best GOF=0.102069)
```
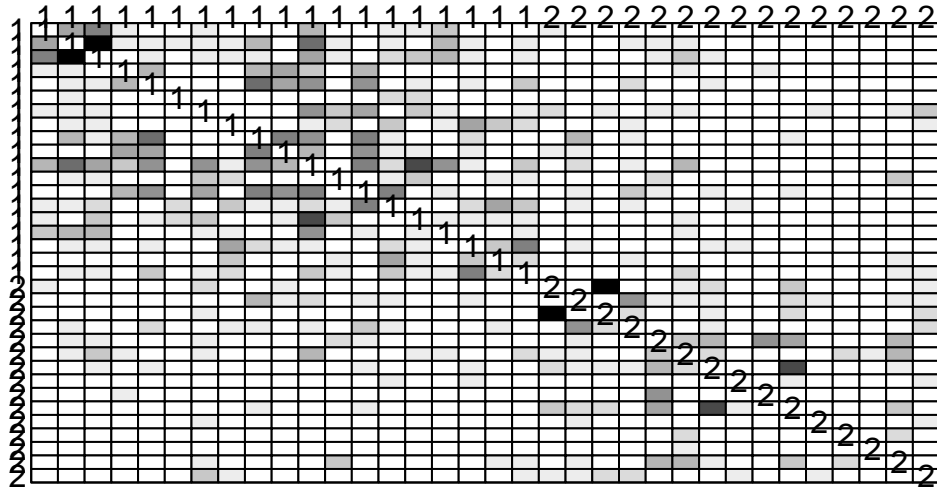
```
##   Iteration 200, current GOF is -0.02204697.  (Best GOF=0.102069)
##   Iteration 300, current GOF is -0.05478174.  (Best GOF=0.1047315)
##   Iteration 400, current GOF is 0.0611947.  (Best GOF=0.1047315)
##   Iteration 500, current GOF is 0.069661.  (Best GOF=0.1183652)
##   Iteration 600, current GOF is 0.01229995.  (Best GOF=0.1183652)
##   Iteration 700, current GOF is 0.02525935.  (Best GOF=0.1183652)
##   Iteration 800, current GOF is -0.005743328.  (Best GOF=0.1183652)
##   Iteration 900, current GOF is 0.00720195.  (Best GOF=0.1183652)
##   Iteration 1000, current GOF is 0.03705373.  (Best GOF=0.1845795)
##   Iteration 1100, current GOF is 0.07545567.  (Best GOF=0.1845795)
##   Iteration 1200, current GOF is 0.06643929.  (Best GOF=0.1845795)
##   Iteration 1300, current GOF is 0.1214585.  (Best GOF=0.1845795)
##   Iteration 1400, current GOF is 0.2384382.  (Best GOF=0.2412606)
##   Iteration 1500, current GOF is 0.2520682.  (Best GOF=0.2759023)
##   Iteration 1600, current GOF is 0.258811.  (Best GOF=0.2759023)
##   Iteration 1700, current GOF is 0.2636758.  (Best GOF=0.2759023)
##   Iteration 1800, current GOF is 0.3199294.  (Best GOF=0.3199294)
##   Iteration 1900, current GOF is 0.3199294.  (Best GOF=0.3199294)
##   Iteration 2000, current GOF is 0.3199294.  (Best GOF=0.3199294)
##   Iteration 2100, current GOF is 0.3199294.  (Best GOF=0.3199294)
##   Iteration 2200, current GOF is 0.3199294.  (Best GOF=0.3199294)
##   Iteration 2300, current GOF is 0.3199294.  (Best GOF=0.3199294)
##   Iteration 2400, current GOF is 0.3199294.  (Best GOF=0.3199294)
##   Iteration 2500, current GOF is 0.3199294.  (Best GOF=0.3199294)
##   Iteration 2600, current GOF is 0.3199294.  (Best GOF=0.3199294)
##   Iteration 2700, current GOF is 0.3199294.  (Best GOF=0.3199294)
##   Iteration 2800, current GOF is 0.3199294.  (Best GOF=0.3199294)
##   Iteration 2900, current GOF is 0.3199294.  (Best GOF=0.3199294)
##   Iteration 3000, current GOF is 0.3199294.  (Best GOF=0.3199294)
## Annealing completed.
## Refining solution via hill-climbing procedure...
##   Refining; current GOF is  0.3199294
## Preparing and returning output.
```

```r
lab<-bkt5$block.membership[bkt5$order.vector]
plot.sociomatrix(bkt5$blocked.data,labels=list(lab,lab))
```

```
bkt5$block.gof
```

```
## [1] 0.3199294
```

```
#BKOFF Network
bko5 <- block.fit(bkoff,c(1,0,0,1))    # Borgatti - Everett Variant
```

```
## Entering annealing loop...
##   Iteration 100, current GOF is 0.01692886.  (Best GOF=0.06244736)
##   Iteration 200, current GOF is -0.0389994.  (Best GOF=0.08907981)
##   Iteration 300, current GOF is 0.03871158.  (Best GOF=0.08907981)
##   Iteration 400, current GOF is 0.01280792.  (Best GOF=0.08907981)
##   Iteration 500, current GOF is 0.016691.  (Best GOF=0.08907981)
##   Iteration 600, current GOF is -0.06507781.  (Best GOF=0.08907981)
##   Iteration 700, current GOF is -0.01093548.  (Best GOF=0.09306711)
##   Iteration 800, current GOF is 0.02000338.  (Best GOF=0.1260458)
##   Iteration 900, current GOF is 0.04259083.  (Best GOF=0.1260458)
##   Iteration 1000, current GOF is 0.01208659.  (Best GOF=0.1260458)
##   Iteration 1100, current GOF is 0.04690746.  (Best GOF=0.1260458)
##   Iteration 1200, current GOF is 0.05093632.  (Best GOF=0.1260458)
##   Iteration 1300, current GOF is 0.1941335.  (Best GOF=0.1941335)
##   Iteration 1400, current GOF is 0.1851748.  (Best GOF=0.2037453)
##   Iteration 1500, current GOF is 0.1912554.  (Best GOF=0.2037453)
##   Iteration 1600, current GOF is 0.2416236.  (Best GOF=0.2416236)
##   Iteration 1700, current GOF is 0.2469117.  (Best GOF=0.2469117)
##   Iteration 1800, current GOF is 0.2469117.  (Best GOF=0.2469117)
##   Iteration 1900, current GOF is 0.2469117.  (Best GOF=0.2469117)
```

```
##  Iteration 2000, current GOF is 0.2646491.   (Best GOF=0.2646491)
##  Iteration 2100, current GOF is 0.2646491.   (Best GOF=0.2646491)
##  Iteration 2200, current GOF is 0.2646491.   (Best GOF=0.2646491)
##  Iteration 2300, current GOF is 0.2646491.   (Best GOF=0.2646491)
##  Iteration 2400, current GOF is 0.2646491.   (Best GOF=0.2646491)
##  Iteration 2500, current GOF is 0.2646491.   (Best GOF=0.2646491)
##  Iteration 2600, current GOF is 0.2646491.   (Best GOF=0.2646491)
##  Iteration 2700, current GOF is 0.2646491.   (Best GOF=0.2646491)
##  Iteration 2800, current GOF is 0.2646491.   (Best GOF=0.2646491)
##  Iteration 2900, current GOF is 0.2646491.   (Best GOF=0.2646491)
##  Iteration 3000, current GOF is 0.2646491.   (Best GOF=0.2646491)
## Annealing completed.
## Refining solution via hill-climbing procedure...
##  Refining; current GOF is  0.2646491
## Preparing and returning output.
```

```r
lab<-bko5$block.membership[bko5$order.vector]
plot.sociomatrix(bko5$blocked.data,labels=list(lab,lab))
```
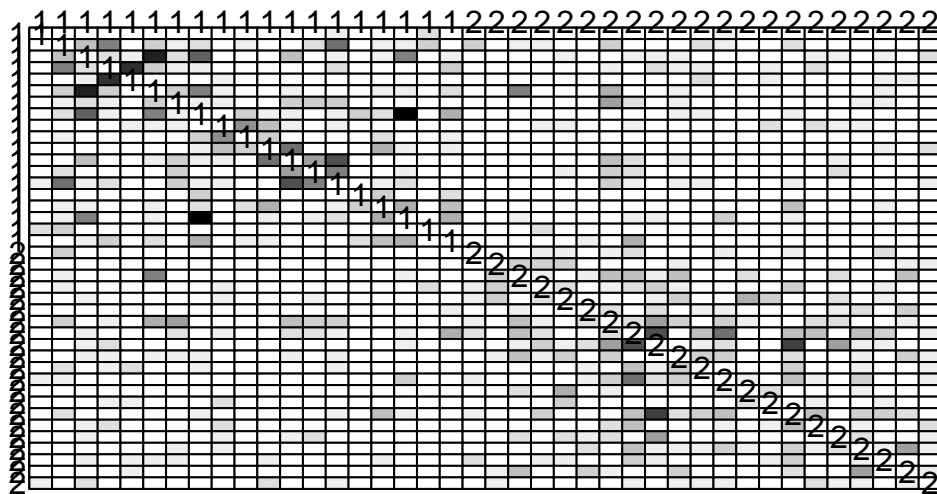


```r
bko5$block.gof
```

```
## [1] 0.2646491
```

The within core interactions in the BKHAM and not many interactions within peripheral class. The BKOFF network on the other hand, shows a good interaction within the periphery.

(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?

```
#With in/out ties
bkh1$block.gof
```

```
## [1] 0.3625934
```

```
bkf1$block.gof
```

```
## [1] 0.4207104
```

```
bkt1$block.gof
```

```
## [1] 0.2394306
```

```
bko1$block.gof
```

```
## [1] 0.2118476
```

```
#With core-periphery ties
bkh2$block.gof
```

```
## [1] 0.2585164
```

```
bkf2$block.gof
```

```
## [1] 0.3730622
```

```
bkt2$block.gof
```

```
## [1] 0.2160739
```

```
bko2$block.gof
```

```
## [1] 0.1700412
```

```
#Isolated core
bkh4$block.gof
```

```
## [1] 0.6959562
```

```
bkf4$block.gof
```

```
## [1] 0.5462324
```

```
bkt4$block.gof
```

```
## [1] 0.4442833
```

```
bko4$block.gof
```

```
## [1] 0.3523318
```

```
#Borgatti - Everett
bkh5$block.gof
```

```
## [1] 0.2096077
```

```
bkf5$block.gof
```

```
## [1] 0.2982005
```

```
bkt5$block.gof
```

[1] 0.3199294

```
bko5$block.gof
```

[1] 0.2646491

The model variant that seeks to explain all the edges is the core with in/out ties(1,1,1,0). The goodness of fit is the best for the BKFRAT network. 42% of the variability in this network is explained by the model. Therefore, the core in/out model fits best.For other networks it is in between 21% to 36%.

The model variant with core-periphery ties explains between 16% to 37% of the variance in all the networks.

The model variant with Isolated core, (1,0,0,0), explains 33% to 69% of the variance in all the networks.

The model variant with Borgatti-Everett (1,0,0,1), explains 19% to 31% of the variance in all the networks.

(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?

The BKHAM network shows a clear separation between the core and periphery. This network is a clear seperation from BKFRAT, BKTEC networks, where there is much more interaction beween core and periphery. BKOFF network doesnt seem to have a clear separation between the core and periphery. This means that the BFOFF network is homogenously connected, and the face-to-face interactions in a small business is homogenous. Thus, the overall structure is a 2 block structure, with a range of interactions within core, within periphery and between core and periphery.