Network Summary

Для получения графа друзей я использую такие пакеты как: igraph, rmarkdown, dplyr, vkR. Мы используем пакет vkR для запроса и авторизации. С помощью OAuth мы получаем access_token. Теперь можно отправлять запросы используя access_token и получать информацию из приложения vk. Далее используем запрос getFriends(), чтобы получить граф друзей. Также удалим вершины, степень которых равна 0.

```
library(igraph)
library(rmarkdown)
library(dplyr)
library("vkR", lib.loc = "~/R/win-library/3.5" )
library(data.table)
#vkOAuth(6481300, 'friends')
```

```
setAccessToken(access_token = '458952d13d34de0037b043e41d2edf9cd98d45aeaf3802
111d86798b20a5208a050b642270da9183c1546')
my_friends <- getFriends(user_id = 182468682, fields = 'sex')
my_friends <- subset(my_friends$items, is.na(my_friends$items$deactivated))
n <- nrow(my_friends)
adjacency <- matrix(nrow = n, ncol = n)
dt <- data.table(my_friends$id)
l <- length(my_friends$id)
for (i in 1:l) {
  dt$num[i] <- i
}
for (i in 1:n) {
  user <- getFriends(user = my_friends$id[i])$items
  u <- length(user)
  for (j in 1:u) {
    if(is.na(match(user[j], dt$V1)) == F) {
      x <- match(user[j], dt$V1)
      adjacency[i,x] <- 1
      adjacency[x,i] <- 1
    }
  }
}
g <- graph_from_adjacency_matrix(adjacency, mode = "undirected")
V(g)
```

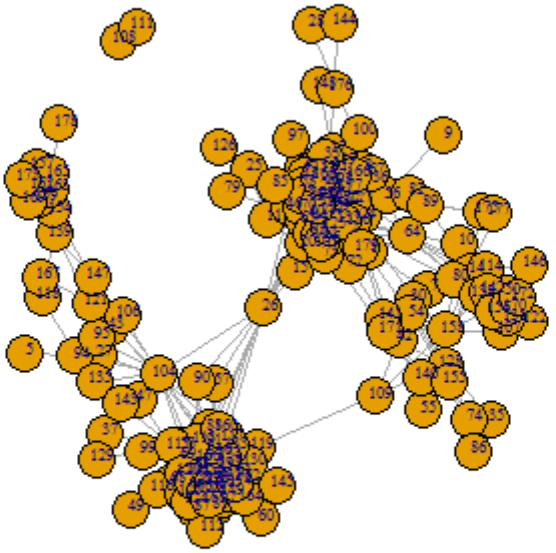
```
+ 190/190 vertices, from d857795:
```

```
  [1]   1   2   3   4   5   6   7   8   9  10  11  12  13  14  15  16  17  18
19  20  21  22  23  24  25  26

 [27]  27  28  29  30  31  32  33  34  35  36  37  38  39  40  41  42  43  44
45  46  47  48  49  50  51  52

 [53]  53  54  55  56  57  58  59  60  61  62  63  64  65  66  67  68  69  70
71  72  73  74  75  76  77  78

 [79]  79  80  81  82  83  84  85  86  87  88  89  90  91  92  93  94  95  96
97  98  99 100 101 102 103 104

[105] 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121 122
123 124 125 126 127 128 129 130

[131] 131 132 133 134 135 136 137 138 139 140 141 142 143 144 145 146 147 148
149 150 151 152 153 154 155 156

[157] 157 158 159 160 161 162 163 164 165 166 167 168 169 170 171 172 173 174
175 176 177 178 179 180 181 182

[183] 183 184 185 186 187 188 189 190
```

```
g <- delete.vertices(simplify(g), degree(g) == 0)

simplify(g)
```

```
IGRAPH 13ea479 U--- 179 1294 --

+ edges from 13ea479:

  [1] 1--  2 1--  7 1-- 21 1-- 38 1-- 64 1-- 72 1-- 83 1-- 96 1--125 2--  3 2
-- 20 2-- 21 2-- 22 2-- 32 2-- 44

 [16] 2-- 45 2-- 51 2-- 59 2-- 71 2-- 72 2-- 73 2-- 77 2-- 96 2--125 2--127 2
--166 3--  4 3-- 12 3-- 18 3-- 21

 [31] 3-- 22 3-- 23 3-- 31 3-- 32 3-- 34 3-- 39 3-- 40 3-- 44 3-- 45 3-- 48 3
-- 51 3-- 56 3-- 59 3-- 70 3-- 71

 [46] 3-- 72 3-- 75 3-- 77 3-- 83 3-- 96 3-- 98 3--100 3--102 3--103 3--125 3
--127 3--136 3--137 3--151 3--166

 [61] 3--168 3--179 4-- 12 4-- 22 4-- 23 4-- 39 4-- 45 4-- 46 4-- 51 4-- 59 4
-- 63 4-- 67 4-- 70 4-- 75 4-- 97

 [76] 4--168 5-- 94 6-- 16 6-- 41 6-- 52 6-- 53 6-- 57 6-- 61 6-- 62 6-- 65 6
-- 66 6-- 69 6-- 78 6-- 81 6-- 84

 [91] 6-- 87 6-- 92 6-- 93 6--101 6--105 6--110 6--113 6--117 6--123 6--132 6
--134 6--149 6--150 6--152 6--153

[106] 6--160 6--161 6--164 6--174 7-- 10 7-- 42 8-- 18 8-- 19 8-- 31 8-- 32 8
-- 33 8-- 34 8-- 51 8-- 59 8-- 64

[121] 8-- 67 8-- 77 8-- 98 8--151 9-- 56

+ ... omitted several edges
```

```
plot(g, vertex.label.font = 5, vertex.label.cex = 0.5, vertex.label.dist = 0.
5)
```



```
ecount(g)
```

```
[1] 1294
```

```
vcount(g)
```

```
[1] 179
```

```
# the length of the "longest shortest path"
```

```
diameter(g)
```

```
[1] 10
```

```
get_diameter(g)
```

```
+ 11/179 vertices, from a062e4e:
 [1]  86 155  30  32  34  26 104 121 139 165 178
```

```
graph.density(g)
```

```
[1] 0.08122528
```

Мы выяснили, что граф g имеет 179 вершин и 1294 ребер. Диаметр графа равен 10.В графе g диаметр может быть построен следующим образом: 86 155 30 32 34 26 104 121 139 165 178. Что касается плотности графа, то она равна ~0.08.

Degree distribution

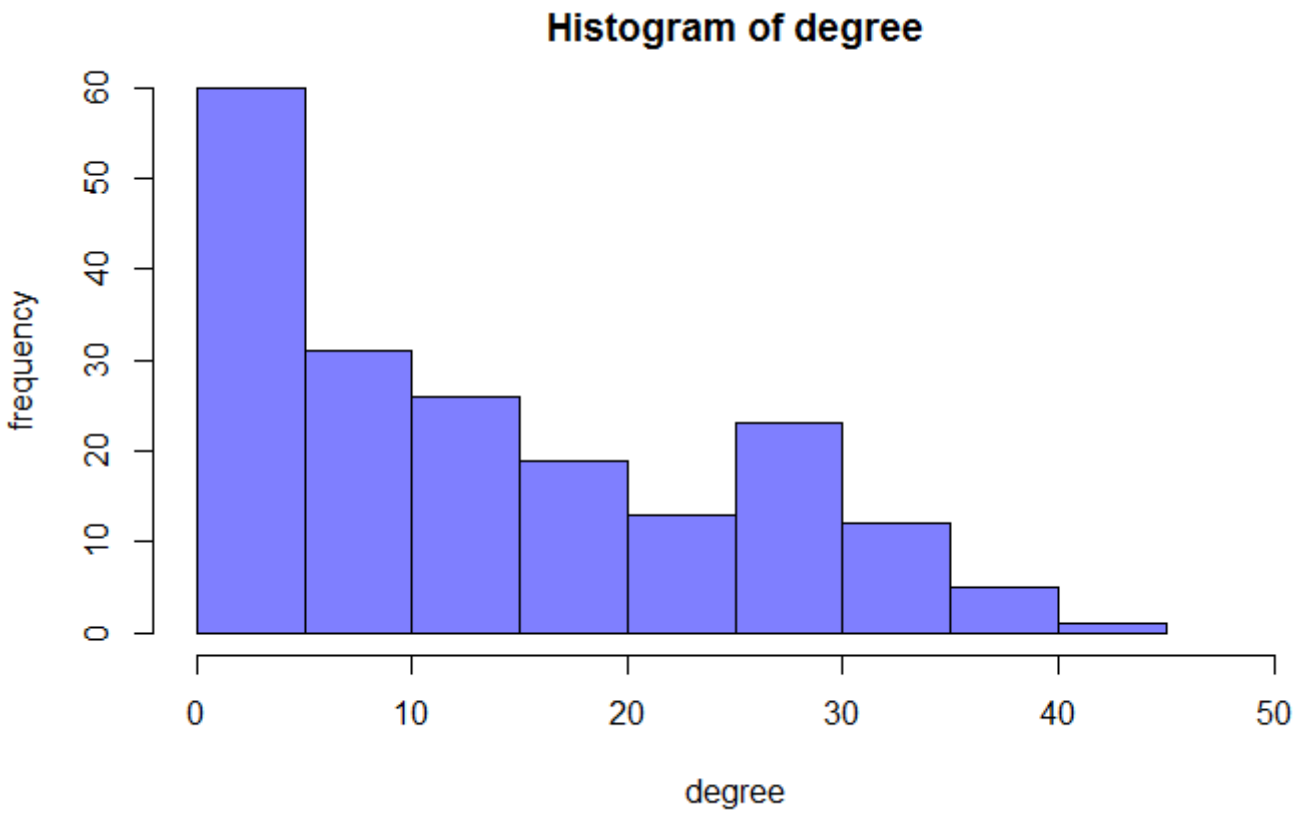
```
deg = degree(g)
```

```
summary(degrees)
```

```
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
```

```
   1.00    4.00   12.00   14.46   24.00   43.00
```

```
hist(degree, col=rgb(0, 0, 1,.5), xlim=c(0, 50), xlab="degree", ylab="frequency")
```



Из гистограммы видно распределение степени вершин. Степенью узла называется количество узлов, связанных с данным узлом. Максимальная степень равна 43, а минимальная - 1. Медиана степеней вершин составляет 12, в то время как среднее значение равно 14.46. Из гистограммы видно, что большинство вершин имеет степень от 0 до 5, и только малая часть - выше 40.

Diameter

```
#the longest shortest path
diameter(g)
```

```
[1] 10
```

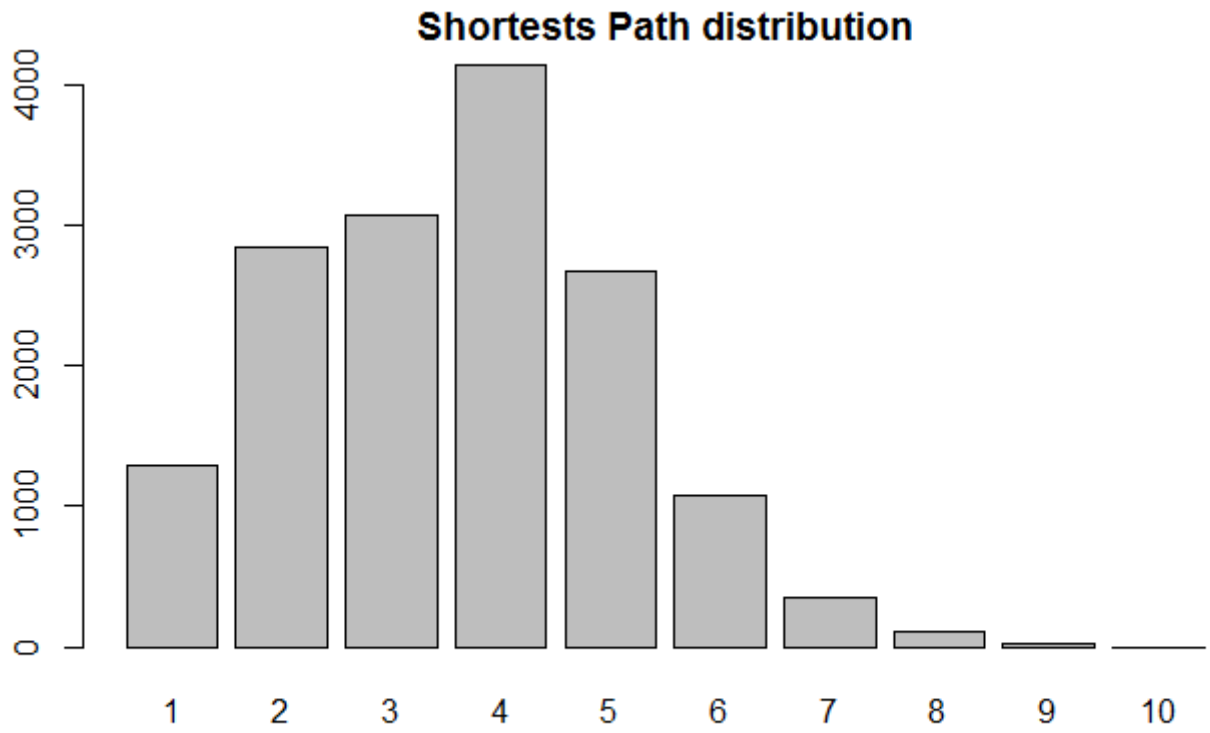
Radius

```
#the shortest shortests path
radius(g)
```

```
[1] 1
```

Shortest Path distribution

```
tab <- as.table(path.length.hist(g)$res)
names(tab) <- 1: length(tab)
barplot(tab, main = 'Shortests Path distribution')
```



Clustering Coefficients

```
transitivity(g, type="localaverage")
```

```
[1] 0.5903219
```

```
transitivity(g, type="global")
```

```
[1] 0.5597836
```

Коэффициент кластеризации является мерой степени, с которой узлы в графе стремятся сгруппироваться.

Structural Analysis

Degree/Closeness/Betweenness centralities. Top nodes interpretation

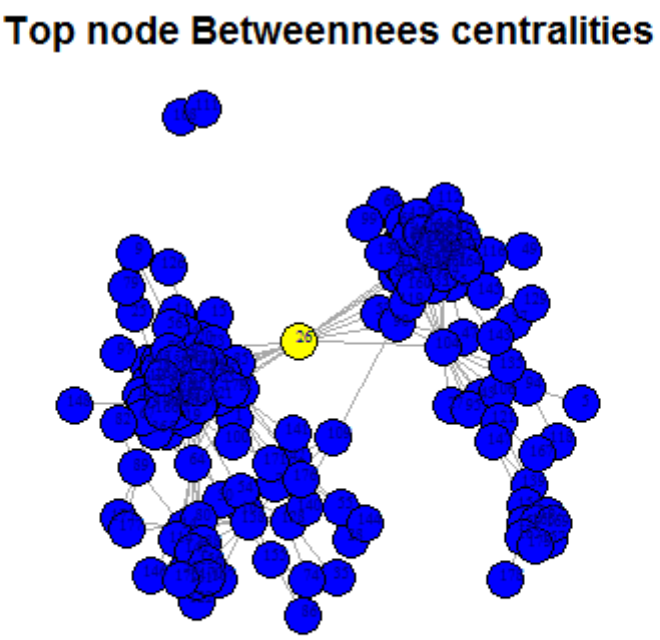
Нагрузка узла (Betweenness centrality) характеризует долю проходящих через узел кратчайших путей и узлы с высоким значением betweeness centrality являются наиболее загруженными. Эту величину можно считать индикатором наиболее общительных людей в

социальной сети. Узел под номером 26 имеет максимальное значение данной характеристики, отметим её на графе.

```
betw <- betweenness(g)

summary(betw)
```

```
    Min.  1st Qu.   Median     Mean  3rd Qu.     Max.

   0.000    3.387   29.727  226.279  218.710 6384.425
```

```
V(g)$color <- ifelse(betw>=max(betw), "yellow", "blue")

plot(g, vertex.label.font = 5, vertex.label.cex = 0.5, vertex.label.dist = 0.
5, main = "Top node Betweennees centralities")
```



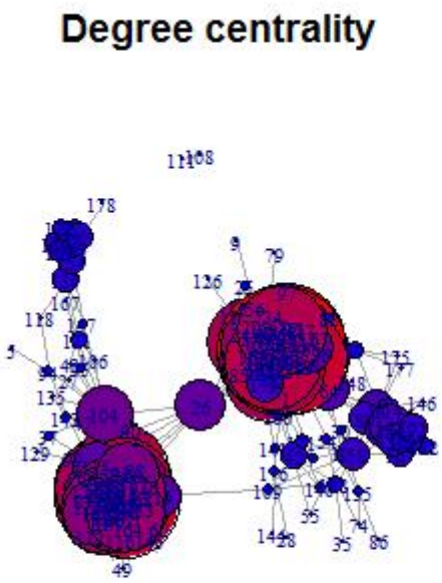
Центральность по степени (Degree centrality) – это отношение количества связей определённого узла к общему количеству других узлов. Для центральности по степени мы имеем: минимальное = 1; медиана = 12; среднее значение = 14.46.

Closeness centrality — это средняя длина кратчайшего пути между узлом и всеми другими узлами графика. Таким образом, чем больше closeness centrality узла тем ближе он ко всем остальным узлам.

```
deg = degree(g)

summary(deg)
```

```
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.

   1.00    4.00   12.00   14.46   24.00   43.00
```

```
f = 500

palette = colorRampPalette(c('blue','red'))

degCol = palette(f)[as.numeric(cut(deg,breaks = fine))]

plot(g, layout=layout.fruchterman.reingold(g), vertex.color=degCol, vertex.size=deg*1.5, vertex.label.cex=0.6, main="Degree centrality")
```

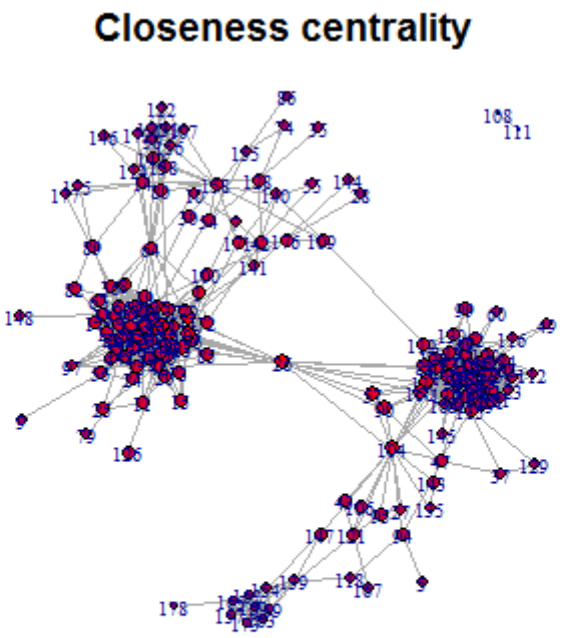



```
close = closeness(g)
```

```
summary(close)
```

```
     Min.   1st Qu.    Median      Mean   3rd Qu.      Max.
3.156e-05 9.565e-04 1.041e-03 1.010e-03 1.090e-03 1.280e-03
```

```
closn = palette(f)[as.numeric(cut(close,breaks = f))]

plot(g,layout =layout.fruchterman.reingold(g) , vertex.color=closn, vertex.size=close*5000, vertex.label.cex=0.6, main="Closeness centrality")
```

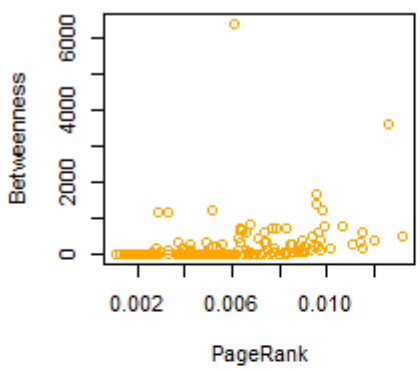


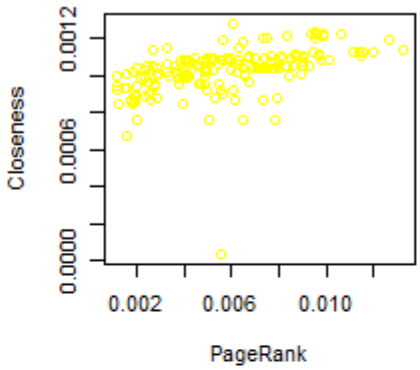
Page-Rank. Comparison with centralities

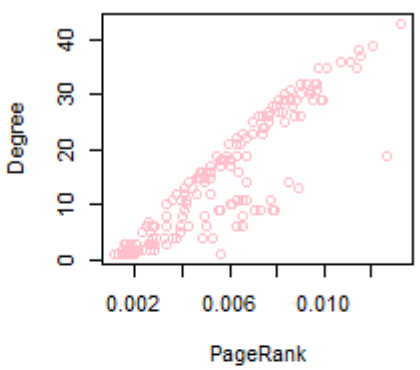
```
pr=page.rank(g)$vector
```

```
op <- par(mfrow = c(2, 3))
plot(pr, betw, xlab = 'PageRank' , ylab = 'Betweenness' , col = 'orange' )
plot(pr, close, xlab = 'PageRank' , ylab = 'Closeness' , col = 'yellow' )
```

```
plot(pr, deg, xlab = 'PageRank' , ylab = 'Degree' , col = 'pink' )
```







Из первого графика видно, что переменная PageRank принимает значения больше, чем betweeness. Из этих графиков можно сделать вывод, что, чем больше PageRank тем больше степень узла.

Assortative Mixing according to node attributes

Hide

```
assortativity(g, types1 = (V(g)))
```

```
[1] 0.2009739
```

Hide

```
assortativity.degree(g, directed = F)
```

```
[1] 0.2612559
```

Ассортативное смешивание (assortative mixing)– тенденция узлов сети формировать связи с аналогичными узлами. В сети возможна ситуация, когда узлы, имеющие большую степень, преимущественно связаны с узлами, имеющими большую степень. При такой сети коэффициент ассортативности r>0. А отрицательное значение r показывает о взаимодействии узлов, имеющих разные степени.

Node structural equivalence/similarity

Используем функцию similarity(), которая вычисляет схожесть узлов на основе их соединений.

Hide

```
sim <- similarity(g, vids = V(g))

summary(sim)
```

```
       V1                V2                V3               V4
V5                V6
 Min.   :0.00000   Min.   :0.00000   Min.   :0.0000   Min.   :0.00000   Min.
:0.00000   Min.   :0.0000
 1st Qu.:0.00000   1st Qu.:0.00000   1st Qu.:0.0000   1st Qu.:0.00000   1st Q
u.:0.00000   1st Qu.:0.0000
 Median :0.00000   Median :0.00000   Median :0.0000   Median :0.00000   Media
n :0.00000   Median :0.0000
 Mean   :0.03977   Mean   :0.08061   Mean   :0.1127   Mean   :0.07552   Mean
:0.01007   Mean   :0.1128
 3rd Qu.:0.06573   3rd Qu.:0.17446   3rd Qu.:0.2000   3rd Qu.:0.15000   3rd Q
u.:0.00000   3rd Qu.:0.1402
       V7                V8                V9               V10
V11               V12
 Min.   :0.00000   Min.   :0.00000   Min.   :0.00000   Min.   :0.00000   Min.
:0.00000   Min.   :0.000
 1st Qu.:0.00000   1st Qu.:0.00000   1st Qu.:0.00000   1st Qu.:0.00000   1st
Qu.:0.00000   1st Qu.:0.000
 Median :0.00000   Median :0.00000   Median :0.00000   Median :0.00000   Medi
an :0.00000   Median :0.000
 Mean   :0.01498   Mean   :0.07187   Mean   :0.00774   Mean   :0.01193   Mean
:0.03194   Mean   :0.103
 3rd Qu.:0.00000   3rd Qu.:0.08514   3rd Qu.:0.00000   3rd Qu.:0.00000   3rd
Qu.:0.03322   3rd Qu.:0.164
      V13               V14               V15               V16               V
17               V18
 Min.   :0.00000   Min.   :0.0000   Min.   :0.00000   Min.   :0.0000   Min.
:0.00000   Min.   :0.0000
 1st Qu.:0.00000   1st Qu.:0.0000   1st Qu.:0.00000   1st Qu.:0.0000   1st Qu
.:0.00000   1st Qu.:0.0000
 Median :0.00000   Median :0.0000   Median :0.00000   Median :0.0000   Median
:0.00000   Median :0.0000
 Mean   :0.09768   Mean   :0.0349   Mean   :0.03177   Mean   :0.1090   Mean
:0.08938   Mean   :0.1071
 3rd Qu.:0.13485   3rd Qu.:0.0000   3rd Qu.:0.00000   3rd Qu.:0.1101   3rd Qu
.:0.12772   3rd Qu.:0.1802
      V19               V20               V21               V22
V23               V24
 Min.   :0.00000   Min.   :0.00000   Min.   :0.00000   Min.   :0.0000   Min.
:0.0000   Min.   :0.00000
 1st Qu.:0.00000   1st Qu.:0.00000   1st Qu.:0.00000   1st Qu.:0.0000   1st Q
u.:0.0000   1st Qu.:0.00000
 Median :0.00000   Median :0.00000   Median :0.00000   Median :0.0000   Media
n :0.0000   Median :0.00000
 Mean   :0.06822   Mean   :0.05167   Mean   :0.09644   Mean   :0.1031   Mean
:0.1140   Mean   :0.04400
 3rd Qu.:0.12019   3rd Qu.:0.08167   3rd Qu.:0.17108   3rd Qu.:0.1766   3rd Q
u.:0.1968   3rd Qu.:0.07825
```

```
      V25                V26                V27              V28
V29              V30

 Min.   :0.00000   Min.   :0.00000   Min.   :0.0000   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   1st Q
u.:0.0000   1st Qu.:0.00000

 Median :0.00000   Median :0.05000   Median :0.0000   Median :0.00000   Media
n :0.0000   Median :0.00000

 Mean   :0.02287   Mean   :0.06892   Mean   :0.0227   Mean   :0.01276   Mean
:0.1122   Mean   :0.02450

 3rd Qu.:0.00000   3rd Qu.:0.09524   3rd Qu.:0.0000   3rd Qu.:0.00000   3rd Q
u.:0.1041   3rd Qu.:0.02598

      V31              V32               V33               V34              V3
5               V36

 Min.   :0.0000   Min.   :0.0000   Min.   :0.00000   Min.   :0.0000   Min.
:0.00000   Min.   :0.00000

 1st Qu.:0.0000   1st Qu.:0.0000   1st Qu.:0.00000   1st Qu.:0.0000   1st Qu.
:0.00000   1st Qu.:0.00000

 Median :0.0000   Median :0.0000   Median :0.00000   Median :0.0000   Median
:0.00000   Median :0.00000

 Mean   :0.1039   Mean   :0.1137   Mean   :0.09329   Mean   :0.1178   Mean
:0.01222   Mean   :0.06110

 3rd Qu.:0.1633   3rd Qu.:0.1827   3rd Qu.:0.11966   3rd Qu.:0.1879   3rd Qu.
:0.00000   3rd Qu.:0.08333

      V37               V38              V39             V40              V41
V42

 Min.   :0.00000   Min.   :0.0000   Min.   :0.000   Min.   :0.0000   Min.   :
0.0000   Min.   :0.00000

 1st Qu.:0.00000   1st Qu.:0.0000   1st Qu.:0.000   1st Qu.:0.0000   1st Qu.:
0.0000   1st Qu.:0.00000

 Median :0.00000   Median :0.0000   Median :0.000   Median :0.0000   Median :
0.0000   Median :0.00000

 Mean   :0.01233   Mean   :0.1044   Mean   :0.109   Mean   :0.1165   Mean   :
0.1004   Mean   :0.01848

 3rd Qu.:0.00000   3rd Qu.:0.1673   3rd Qu.:0.200   3rd Qu.:0.1811   3rd Qu.:
0.1065   3rd Qu.:0.00000

      V43               V44               V45              V46
V47               V48

 Min.   :0.00000   Min.   :0.00000   Min.   :0.0000   Min.   :0.00000   Min.
:0.00000   Min.   :0.00000

 1st Qu.:0.00000   1st Qu.:0.00000   1st Qu.:0.0000   1st Qu.:0.00000   1st Q
u.:0.00000   1st Qu.:0.00000

 Median :0.00000   Median :0.00000   Median :0.0000   Median :0.00000   Media
n :0.00000   Median :0.00000

 Mean   :0.03104   Mean   :0.08255   Mean   :0.1077   Mean   :0.09329   Mean
:0.02537   Mean   :0.07639

 3rd Qu.:0.00000   3rd Qu.:0.14352   3rd Qu.:0.1766   3rd Qu.:0.16667   3rd Q
u.:0.00000   3rd Qu.:0.15000
```

```
      V49                V50                V51              V52
V53                V54

 Min.   :0.00000   Min.   :0.00000   Min.   :0.0000   Min.   :0.00000   Min.
:0.00000   Min.   :0.00000

 1st Qu.:0.00000   1st Qu.:0.00000   1st Qu.:0.0000   1st Qu.:0.00000   1st Q
u.:0.00000   1st Qu.:0.00000

 Median :0.00000   Median :0.00000   Median :0.0000   Median :0.00000   Media
n :0.00000   Median :0.00000

 Mean   :0.01709   Mean   :0.04218   Mean   :0.1109   Mean   :0.11634   Mean
:0.07867   Mean   :0.02996

 3rd Qu.:0.00000   3rd Qu.:0.00000   3rd Qu.:0.1898   3rd Qu.:0.07806   3rd Q
u.:0.11513   3rd Qu.:0.03125

      V55                V56                V57                V58
V59                V60

 Min.   :0.00000   Min.   :0.00000   Min.   :0.00000   Min.   :0.00000   Min.
:0.0000   Min.   :0.00000

 1st Qu.:0.00000   1st Qu.: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 :0.00000   Median :0.00000   Medi
an :0.0000   Median :0.00000

 Mean   :0.01561   Mean   :0.04258   Mean   :0.03592   Mean   :0.08125   Mean
:0.1158   Mean   :0.02766

 3rd Qu.:0.00000   3rd Qu.:0.07692   3rd Qu.:0.05263   3rd Qu.:0.15476   3rd
Qu.:0.1807   3rd Qu.:0.00000

      V61                V62                V63                V64
V65                V66

 Min.   :0.00000   Min.   :0.00000   Min.   :0.00000   Min.   :0.00000   Min.
:0.0000   Min.   :0.0000

 1st Qu.:0.00000   1st Qu.:0.00000   1st Qu.:0.00000   1st Qu.:0.00000   1st
Qu.:0.0000   1st Qu.:0.0000

 Median :0.00000   Median :0.00000   Median :0.00000   Median :0.00000   Medi
an :0.0000   Median :0.0000

 Mean   :0.09680   Mean   :0.07767   Mean   :0.09774   Mean   :0.04509   Mean
:0.1086   Mean   :0.1090

 3rd Qu.:0.09839   3rd Qu.:0.13393   3rd Qu.:0.16398   3rd Qu.:0.07500   3rd
Qu.:0.1202   3rd Qu.:0.1166

      V67                V68                V69                V70
V71                V72

 Min.   :0.00000   Min.   :0.00000   Min.   :0.00000   Min.   :0.0000   Min.
:0.0000   Min.   :0.00000

 1st Qu.:0.00000   1st Qu.:0.00000   1st Qu.:0.00000   1st Qu.:0.0000   1st Q
u.:0.0000   1st Qu.:0.00000

 Median :0.00000   Median :0.00000   Median :0.00000   Median :0.0000   Media
n :0.0000   Median :0.00000

 Mean   :0.05498   Mean   :0.06405   Mean   :0.08035   Mean   :0.0811   Mean
:0.1139   Mean   :0.04859

 3rd Qu.:0.08514   3rd Qu.:0.08893   3rd Qu.:0.12250   3rd Qu.:0.1583   3rd Q
u.:0.2082   3rd Qu.:0.07846
```

```
      V73                V74                V75                V76
V77               V78
 Min.   :0.00000   Min.   :0.00000   Min.   :0.00000   Min.   :0.0000   Min.
:0.0000   Min.   :0.0000
 1st Qu.:0.00000   1st Qu.:0.00000   1st Qu.:0.00000   1st Qu.:0.0000   1st Q
u.:0.0000   1st Qu.:0.0000
 Median :0.00000   Median :0.00000   Median :0.00000   Median :0.0000   Media
n :0.0000   Median :0.0000
 Mean   :0.05205   Mean   :0.01744   Mean   :0.07784   Mean   :0.1111   Mean
:0.1036   Mean   :0.1144
 3rd Qu.:0.08392   3rd Qu.:0.00000   3rd Qu.:0.12702   3rd Qu.:0.1154   3rd Q
u.:0.1647   3rd Qu.:0.1040
      V79                V80                V81                V82
V83                V84
 Min.   :0.00000   Min.   :0.00000   Min.   :0.0000   Min.   :0.00000   Min.
:0.00000   Min.   :0.00000
 1st Qu.:0.00000   1st Qu.:0.00000   1st Qu.:0.0000   1st Qu.:0.00000   1st Q
u.:0.00000   1st Qu.:0.00000
 Median :0.00000   Median :0.00000   Median :0.0000   Median :0.00000   Media
n :0.00000   Median :0.00000
 Mean   :0.01388   Mean   :0.04728   Mean   :0.1034   Mean   :0.02074   Mean
:0.09197   Mean   :0.09935
 3rd Qu.:0.00000   3rd Qu.:0.02857   3rd Qu.:0.1145   3rd Qu.:0.00000   3rd Q
u.:0.16905   3rd Qu.:0.09214
      V85                V86                V87                V88
V89                V90
 Min.   :0.00000   Min.   :0.00000   Min.   :0.00000   Min.   :0.00000   Min.
:0.00000   Min.   :0.00000
 1st Qu.:0.00000   1st Qu.:0.00000   1st Qu.:0.00000   1st Qu.:0.00000   1st
Qu.:0.00000   1st Qu.:0.00000
 Median :0.00000   Median :0.00000   Median :0.00000   Median :0.00000   Medi
an :0.00000   Median :0.00000
 Mean   :0.04722   Mean   :0.01164   Mean   :0.08719   Mean   :0.08635   Mean
:0.02717   Mean   :0.03715
 3rd Qu.:0.09233   3rd Qu.:0.00000   3rd Qu.:0.10263   3rd Qu.:0.14550   3rd
Qu.:0.04712   3rd Qu.:0.05635
      V91                V92                V93                V94                V
95                V96
 Min.   :0.0000   Min.   :0.00000   Min.   :0.0000   Min.   :0.00000   Min.
:0.00000   Min.   :0.00000
 1st Qu.:0.0000   1st Qu.:0.00000   1st Qu.:0.0000   1st Qu.:0.00000   1st Qu
.:0.00000   1st Qu.:0.00000
 Median :0.0000   Median :0.00000   Median :0.0000   Median :0.00000   Median
:0.00000   Median :0.00000
 Mean   :0.1052   Mean   :0.11272   Mean   :0.1175   Mean   :0.01941   Mean
:0.02631   Mean   :0.08441
 3rd Qu.:0.1176   3rd Qu.:0.09203   3rd Qu.:0.1051   3rd Qu.:0.00000   3rd Qu
.:0.00000   3rd Qu.:0.16065
```

```
      V97                V98               V99               V100
V101              V102
 Min.   :0.00000   Min.   :0.0000   Min.   :0.00000   Min.   :0.00000   Min.
:0.0000   Min.   :0.0000
 1st Qu.:0.00000   1st Qu.:0.0000   1st Qu.:0.00000   1st Qu.:0.00000   1st Q
u.:0.0000   1st Qu.:0.0000
 Median :0.00000   Median :0.0000   Median :0.00000   Median :0.00000   Media
n :0.0000   Median :0.0000
 Mean   :0.03531   Mean   :0.1113   Mean   :0.02457   Mean   :0.03289   Mean
:0.1062   Mean   :0.0711
 3rd Qu.:0.03750   3rd Qu.:0.1909   3rd Qu.:0.00000   3rd Qu.:0.05480   3rd Q
u.:0.1099   3rd Qu.:0.1319
      V103               V104               V105               V106
V107               V108
 Min.   :0.00000   Min.   :0.00000   Min.   :0.00000   Min.   :0.00000   Min.
:0.00000   Min.   :0.000000
 1st Qu.:0.00000   1st Qu.:0.00000   1st Qu.:0.00000   1st Qu.:0.00000   1st
Qu.:0.00000   1st Qu.:0.000000
 Median :0.00000   Median :0.00000   Median :0.00000   Median :0.00000   Medi
an :0.00000   Median :0.000000
 Mean   :0.09152   Mean   :0.04028   Mean   :0.11433   Mean   :0.03104   Mean
:0.04127   Mean   :0.005587
 3rd Qu.:0.16173   3rd Qu.:0.06822   3rd Qu.:0.08973   3rd Qu.:0.00000   3rd
Qu.:0.00000   3rd Qu.:0.000000
      V109               V110               V111               V112
V113               V114
 Min.   :0.00000   Min.   :0.0000   Min.   :0.000000   Min.   :0.00000   Min.
:0.00000   Min.   :0.0000
 1st Qu.:0.00000   1st Qu.:0.0000   1st Qu.:0.000000   1st Qu.:0.00000   1st
Qu.:0.00000   1st Qu.:0.0000
 Median :0.00000   Median :0.0000   Median :0.000000   Median :0.00000   Medi
an :0.00000   Median :0.0000
 Mean   :0.02521   Mean   :0.1049   Mean   :0.005587   Mean   :0.04222   Mean
:0.07965   Mean   :0.0423
 3rd Qu.:0.00000   3rd Qu.:0.1140   3rd Qu.:0.000000   3rd Qu.:0.00000   3rd
Qu.:0.15395   3rd Qu.:0.0000
      V115               V116               V117               V118
V119               V120
 Min.   :0.00000   Min.   :0.00000   Min.   :0.00000   Min.   :0.00000   Min.
:0.00000   Min.   :0.00000
 1st Qu.:0.00000   1st Qu.:0.00000   1st Qu.:0.00000   1st Qu.:0.00000   1st
Qu.:0.00000   1st Qu.:0.00000
 Median :0.00000   Median :0.00000   Median :0.00000   Median :0.00000   Medi
an :0.00000   Median :0.00000
 Mean   :0.06585   Mean   :0.03339   Mean   :0.09821   Mean   :0.01557   Mean
:0.06785   Mean   :0.08022
 3rd Qu.:0.11765   3rd Qu.:0.03994   3rd Qu.:0.13636   3rd Qu.:0.00000   3rd
Qu.:0.10620   3rd Qu.:0.10317
```

```
      V121              V122              V123              V124
V125              V126
 Min.   :0.00000   Min.   :0.00000   Min.   :0.00000   Min.   :0.00000   Min.
:0.00000   Min.   :0.00000
 1st Qu.:0.00000   1st Qu.:0.00000   1st Qu.:0.00000   1st Qu.:0.00000   1st
Qu.:0.00000   1st Qu.:0.00000
 Median :0.00000   Median :0.00000   Median :0.00000   Median :0.00000   Medi
an :0.00000   Median :0.00000
 Mean   :0.02044   Mean   :0.03425   Mean   :0.08323   Mean   :0.07878   Mean
:0.08507   Mean   :0.01542
 3rd Qu.:0.00000   3rd Qu.:0.00000   3rd Qu.:0.11806   3rd Qu.:0.08995   3rd
Qu.:0.16954   3rd Qu.:0.00000
      V127              V128              V129              V130
V131              V132
 Min.   :0.00000   Min.   :0.00000   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.:0.00000   1st
Qu.:0.00000   1st Qu.:0.0000
 Median :0.00000   Median :0.00000   Median :0.00000   Median :0.00000   Medi
an :0.00000   Median :0.0000
 Mean   :0.08809   Mean   :0.01901   Mean   :0.01302   Mean   :0.06714   Mean
:0.04151   Mean   :0.1141
 3rd Qu.:0.16333   3rd Qu.:0.00000   3rd Qu.:0.00000   3rd Qu.:0.12698   3rd
Qu.:0.00000   3rd Qu.:0.1094
      V133              V134              V135              V136
V137             V138
 Min.   :0.00000   Min.   :0.00000   Min.   :0.00000   Min.   :0.0000   Min.
:0.0000   Min.   :0.00000
 1st Qu.:0.00000   1st Qu.:0.00000   1st Qu.:0.00000   1st Qu.:0.0000   1st Q
u.:0.0000   1st Qu.:0.00000
 Median :0.00000   Median :0.00000   Median :0.00000   Median :0.0000   Media
n :0.0000   Median :0.00000
 Mean   :0.07351   Mean   :0.10795   Mean   :0.02348   Mean   :0.0768   Mean
:0.1052   Mean   :0.04615
 3rd Qu.:0.12019   3rd Qu.:0.09934   3rd Qu.:0.00000   3rd Qu.:0.1519   3rd Q
u.:0.2064   3rd Qu.:0.00000
      V139              V140              V141              V142
V143              V144
 Min.   :0.00000   Min.   :0.00000   Min.   :0.00000   Min.   :0.00000   Min.
:0.00000   Min.   :0.00000
 1st Qu.:0.00000   1st Qu.:0.00000   1st Qu.:0.00000   1st Qu.:0.00000   1st
Qu.:0.00000   1st Qu.:0.00000
 Median :0.00000   Median :0.00000   Median :0.00000   Median :0.00000   Medi
an :0.00000   Median :0.00000
 Mean   :0.03156   Mean   :0.02043   Mean   :0.01804   Mean   :0.04597   Mean
:0.02666   Mean   :0.01276
 3rd Qu.:0.00000   3rd Qu.:0.00000   3rd Qu.:0.00000   3rd Qu.:0.00000   3rd
Qu.:0.02857   3rd Qu.:0.00000
```

```
      V145              V146             V147              V148
V149              V150

 Min.   :0.00000   Min.   :0.0000   Min.   :0.00000   Min.   :0.00000   Min.
:0.00000   Min.   :0.0000

 1st Qu.:0.00000   1st Qu.:0.0000   1st Qu.:0.00000   1st Qu.:0.00000   1st Q
u.:0.00000   1st Qu.:0.0000

 Median :0.00000   Median :0.0000   Median :0.00000   Median :0.00000   Media
n :0.00000   Median :0.0000

 Mean   :0.02895   Mean   :0.0221   Mean   :0.02952   Mean   :0.01528   Mean
:0.09902   Mean   :0.1057

 3rd Qu.:0.00000   3rd Qu.:0.0000   3rd Qu.:0.00000   3rd Qu.:0.00000   3rd Q
u.:0.10428   3rd Qu.:0.1154

      V151             V152             V153             V154              V1
55               V156

 Min.   :0.0000   Min.   :0.0000   Min.   :0.0000   Min.   :0.00000   Min.
:0.000000   Min.   :0.00000

 1st Qu.:0.0000   1st Qu.:0.0000   1st Qu.:0.0000   1st Qu.:0.00000   1st Qu.
:0.000000   1st Qu.:0.00000

 Median :0.0000   Median :0.0000   Median :0.0000   Median :0.00000   Median
:0.000000   Median :0.00000

 Mean   :0.1148   Mean   :0.1119   Mean   :0.1153   Mean   :0.03546   Mean
:0.008107   Mean   :0.04493

 3rd Qu.:0.1731   3rd Qu.:0.1351   3rd Qu.:0.1001   3rd Qu.:0.00000   3rd Qu.
:0.000000   3rd Qu.:0.00000

      V157              V158             V159              V160
V161              V162

 Min.   :0.00000   Min.   :0.00000   Min.   :0.00000   Min.   :0.00000   Min.
:0.00000   Min.   :0.00000

 1st Qu.:0.00000   1st Qu.:0.00000   1st Qu.:0.00000   1st Qu.:0.00000   1st
Qu.:0.00000   1st Qu.:0.00000

 Median :0.00000   Median :0.00000   Median :0.00000   Median :0.00000   Medi
an :0.00000   Median :0.00000

 Mean   :0.03453   Mean   :0.03217   Mean   :0.03797   Mean   :0.09569   Mean
:0.10400   Mean   :0.03797

 3rd Qu.:0.00000   3rd Qu.:0.00000   3rd Qu.:0.00000   3rd Qu.:0.13665   3rd
Qu.:0.09936   3rd Qu.:0.00000

      V163              V164             V165              V166
V167              V168

 Min.   :0.00000   Min.   :0.00000   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.:0.00000   1st
Qu.:0.00000   1st Qu.:0.0000

 Median :0.00000   Median :0.00000   Median :0.00000   Median :0.00000   Medi
an :0.00000   Median :0.0000

 Mean   :0.03797   Mean   :0.07381   Mean   :0.03459   Mean   :0.09109   Mean
:0.01395   Mean   :0.1064

 3rd Qu.:0.00000   3rd Qu.:0.06905   3rd Qu.:0.00000   3rd Qu.:0.15476   3rd
Qu.:0.00000   3rd Qu.:0.1640
```

```
      V169              V170              V171              V172
V173              V174
 Min.   :0.00000   Min.   :0.00000   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.:0.00000   1st
Qu.:0.00000   1st Qu.:0.0000
 Median :0.00000   Median :0.00000   Median :0.00000   Median :0.00000   Medi
an :0.00000   Median :0.0000
 Mean   :0.03797   Mean   :0.04159   Mean   :0.02478   Mean   :0.04325   Mean
:0.03453   Mean   :0.1025
 3rd Qu.:0.00000   3rd Qu.:0.00000   3rd Qu.:0.00000   3rd Qu.:0.00000   3rd
Qu.:0.00000   3rd Qu.:0.1202
      V175              V176              V177              V178
V179
 Min.   :0.00000   Min.   :0.00000   Min.   :0.00000   Min.   :0.00000   Min.
:0.00000
 1st Qu.:0.00000   1st Qu.:0.00000   1st Qu.:0.00000   1st Qu.:0.00000   1st
Qu.:0.00000
 Median :0.00000   Median :0.00000   Median :0.00000   Median :0.00000   Medi
an :0.00000
 Mean   :0.02048   Mean   :0.01285   Mean   :0.02048   Mean   :0.01148   Mean
:0.05470
 3rd Qu.:0.00000   3rd Qu.:0.00000   3rd Qu.:0.00000   3rd Qu.:0.00000   3rd
Qu.:0.09307
 [ reached getOption("max.print") -- omitted 1 row ]
```

Community Detection

Клика — группа, в которой все пользователи имеют «прямые» связи (узлы соединены ребром) друг к другу

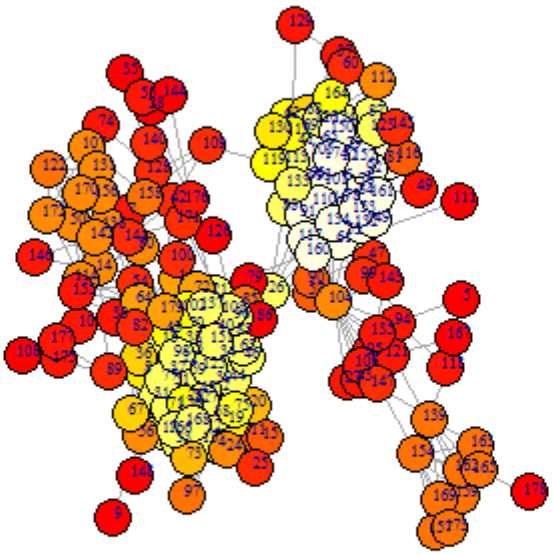
```
largest = largest.cliques(g)
op = par(mfrow = c(1, 2))
labels = rep(0, vcount(g))
labels[largest[[1]]] = 2
plot(g, vertex.color = labels, layout = layout.kamada.kawai(g))
labels = rep(0, vcount(g))
labels[largest[[2]]] = 2
plot(g, vertex.color = labels, layout = layout.kamada.kawai(g))
```

```
largest
```

```
[[1]]
+ 14/179 vertices, from 13ca955:
 [1]  59  51  32  34  98 151  31  23  71  38  13  33 168  77


[[2]]
+ 14/179 vertices, from 13ca955:
 [1]  59  51  32  34  98 151  31  23  71  38  13  33 168  17
```

k-cores k-core – ядро степени k – означает, что степень всех входящих в него узлов не меньше k. (k+1)-core всегда является подграфом k-core

```
coreness <- graph.coreness(g)

max_cor <- max(coreness)

color_bar <- heat.colors(max_cor)

plot(g, vertex.label.font = 5, vertex.label.cex = 0.5, vertex.label.dist = 0.
5, vertex.color = color_bar[coreness], layout = layout.kamada.kawai(g))
```

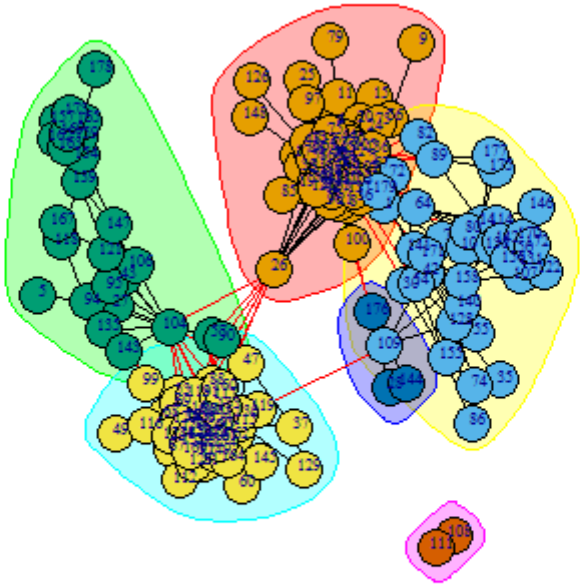


Fast greedy algorithm for cluster

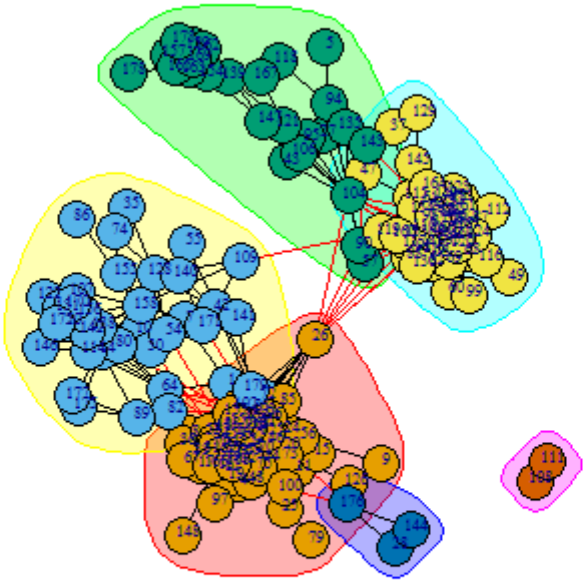
```
o <- cluster_fast_greedy(g)

mm <- fastgreedy.community(g)

length(o)
```

```
[1] 6
```

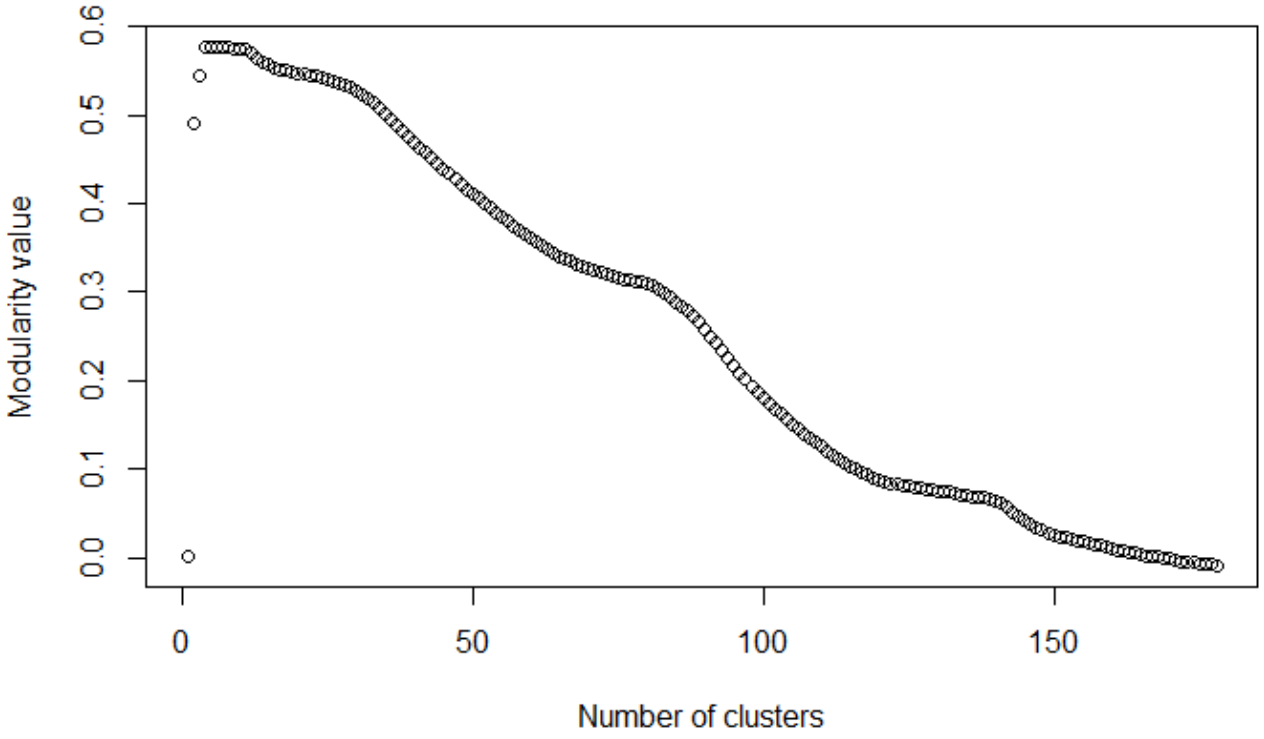
```
plot(mm, g, vertex.label.font = 5, vertex.label.cex = 0.5, vertex.label.dist
= 0.5)
```



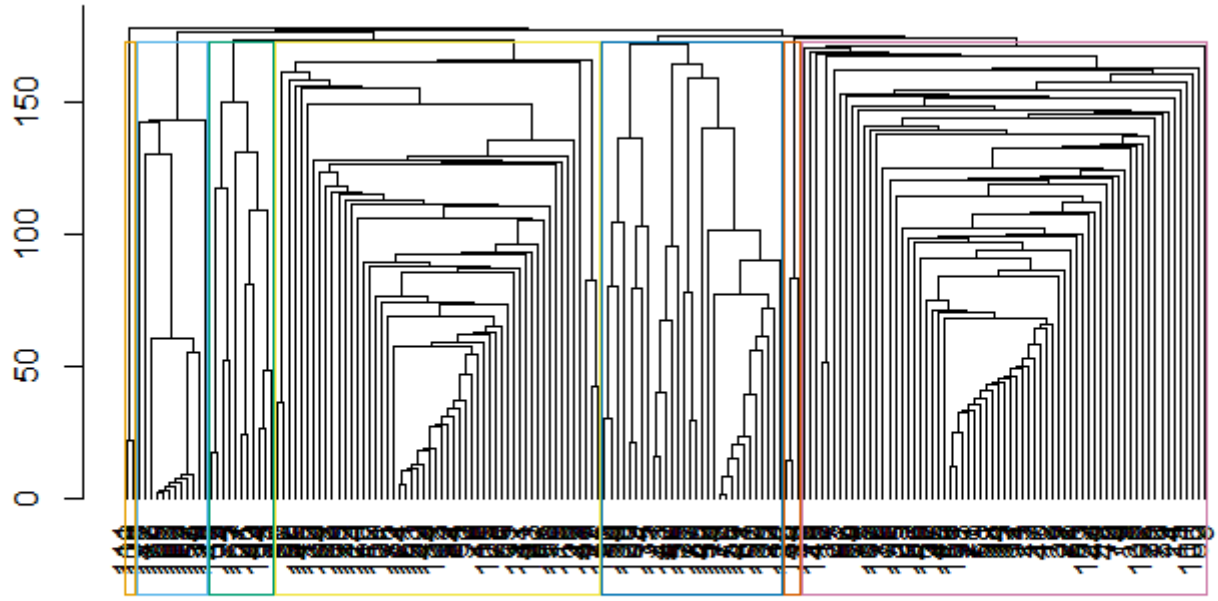
```
plot(o,g,vertex.label.font = 5, vertex.label.cex = 0.5, vertex.label.dist = 0
.5)
```



```
plot(rev(mm$modularity), xlab = 'Number of clusters' , ylab = 'Modularity val
ue' )
```




```
edge_betw <- edge.betweenness.community(g)
cluster_edge_betw <- cluster_edge_betweenness(g)
dendPlot(cluster_edge_betw, mode="hclust")
```




```
plot(cluster_edge_betw, g, vertex.label.font = 5, vertex.label.cex = 0.5, ver
tex.label.dist = 0.5)
```