In [2]:
```
options(warn=-1)
library("igraph")
library('Matrix')
library('pracma')
library('entropy')
library('infotheo')
```

2. Google+ network

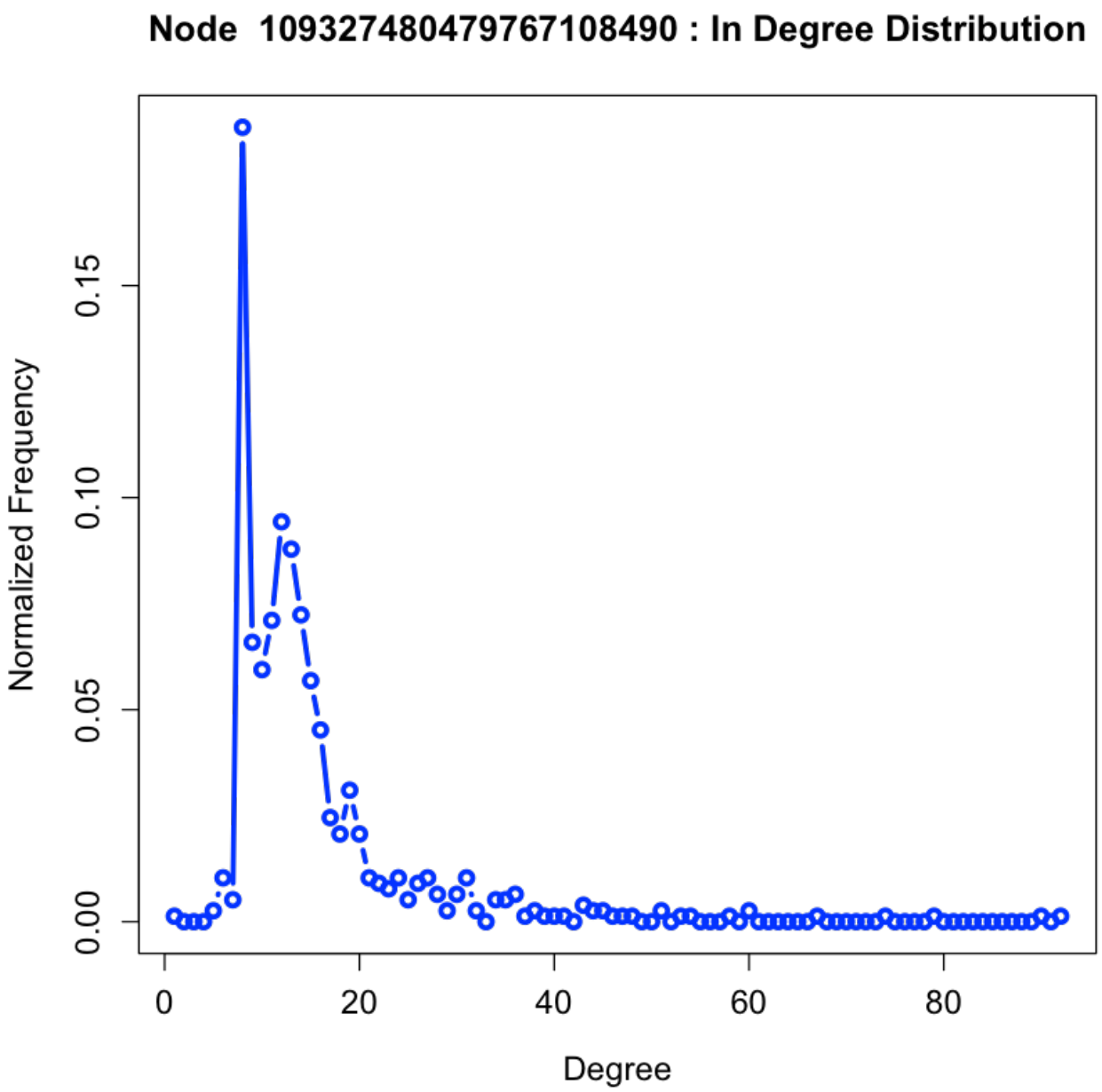
In [2]:
```
# Q)18

# Loop through .circles files, and find those with >2 lines (2 circle members
all_files = list.files(path="gplus", pattern="*.circles")
count = 0
for (iFile in all_files){
  if (length(readLines(paste("gplus", iFile,sep="/"))) > 2){
    count = count + 1
  }
}

print(paste("Number of nodes with > 2 circles: ",count))
```

```
[1] "Number of nodes with > 2 circles:  57"
```

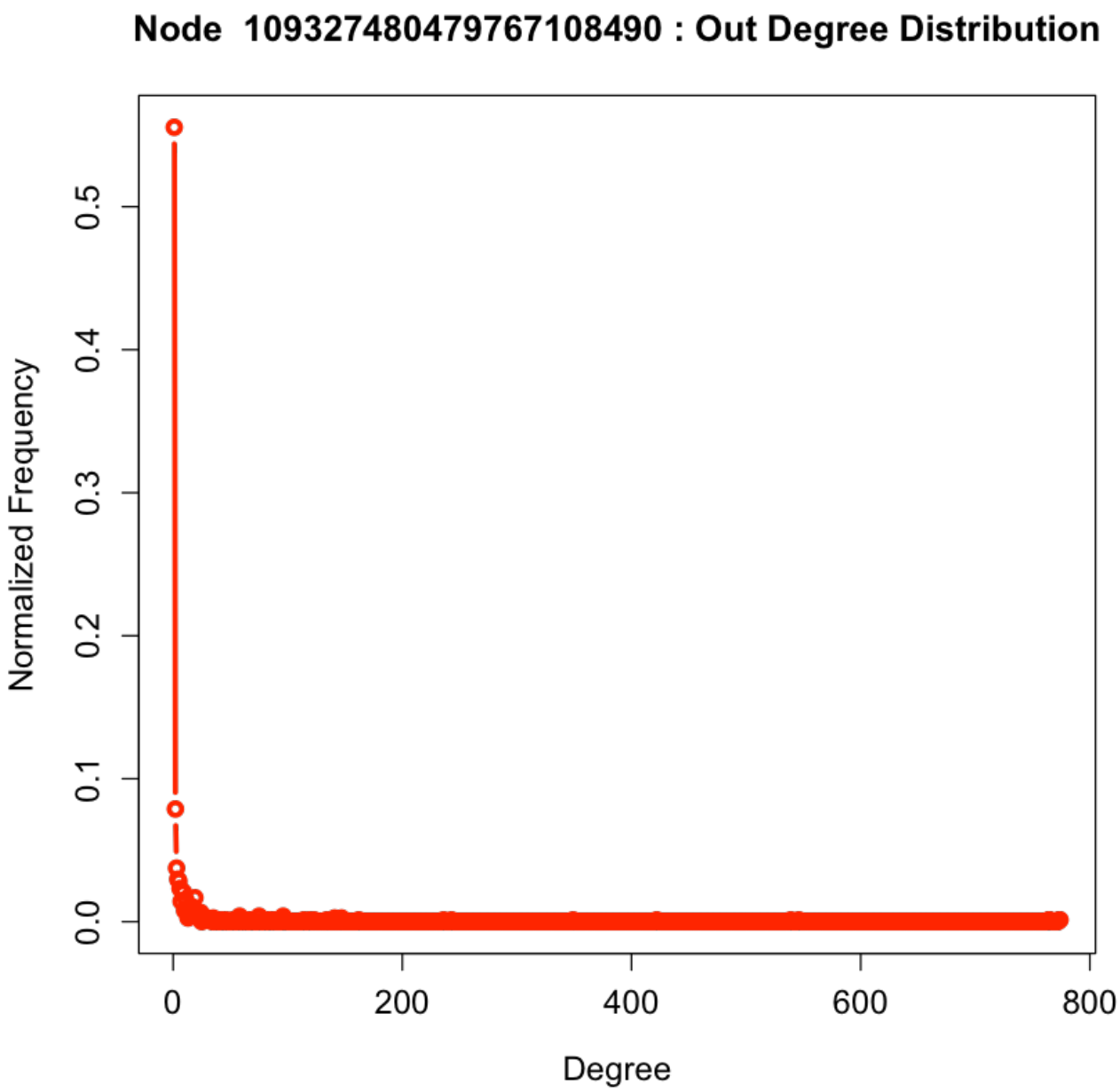
In [8]:

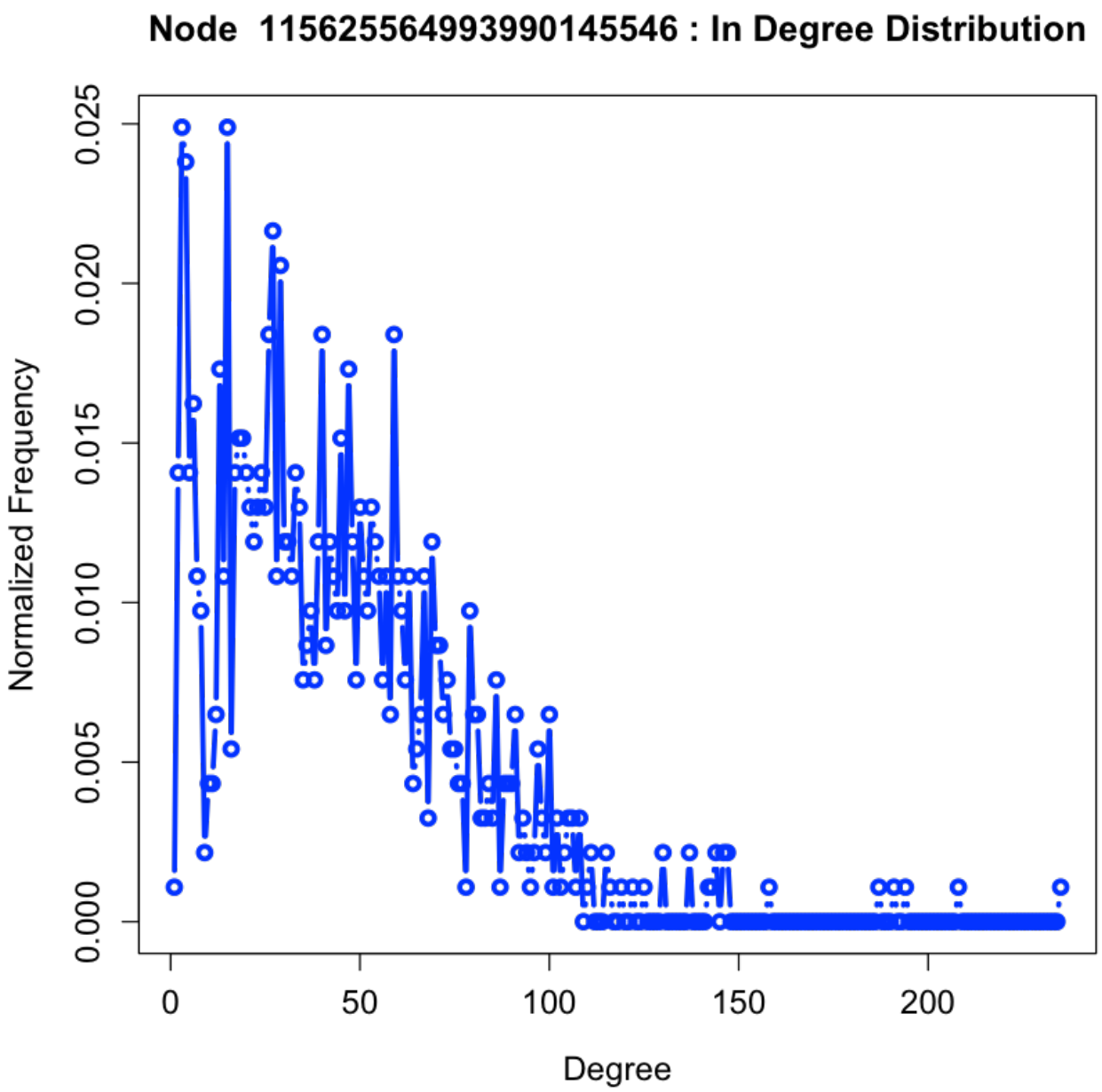
```
# Q19)

# Nodes to analyze
nodes = c("109327480479767108490","115625564993990145546","101373961279443806

for (node in nodes){
    print(sprintf('Working on node %s ...',node))
    # Create file and read in graph
    edgefile = paste("gplus/", node, ".edges", sep = "")
    node_graph = read_graph(edgefile, format="ncol", directed=TRUE)

    # Add vertex and edges for node (not included by default)
    node_graph = add_vertices(node_graph, nv = 1, name = node)
    indexNode = which(V(node_graph)$name==node)

    for (iGNode in seq(1, vcount(node_graph)-1,1)){
      node_graph = node_graph + edge(indexNode, iGNode)
    }


    # Print out mean/var stats
    deg_in = degree(node_graph,mode = "in")
    print(sprintf('In-Degree: Mean=%5.3f, Var=%5.3f',mean(deg_in),var(deg_in)
    deg_out = degree(node_graph,mode = "out")
    print(sprintf('Out-Degree: Mean=%5.3f, Var=%5.3f',mean(deg_out),var(deg_o

    # Plot In/Out deg distirbutions
    hist_in = degree_distribution(node_graph, mode = "in")
    plot(hist_in, type="b", main=paste("Node ", node, ": In Degree Distributi
        xlab="Degree", ylab="Normalized Frequency",col="blue",cex.main = 1.3,

    hist_out = degree_distribution(node_graph, mode = "out")
    plot(hist_out, type="b", main=paste("Node ", node, ": Out Degree Distribu
        xlab="Degree", ylab="Normalized Frequency",col="red",cex.main = 1.3, 
}
```

```
[1] "Working on node 109327480479767108490 ..."
[1] "In-Degree: Mean=14.062, Var=96.001"
[1] "Out-Degree: Mean=14.062, Var=4588.177"
```

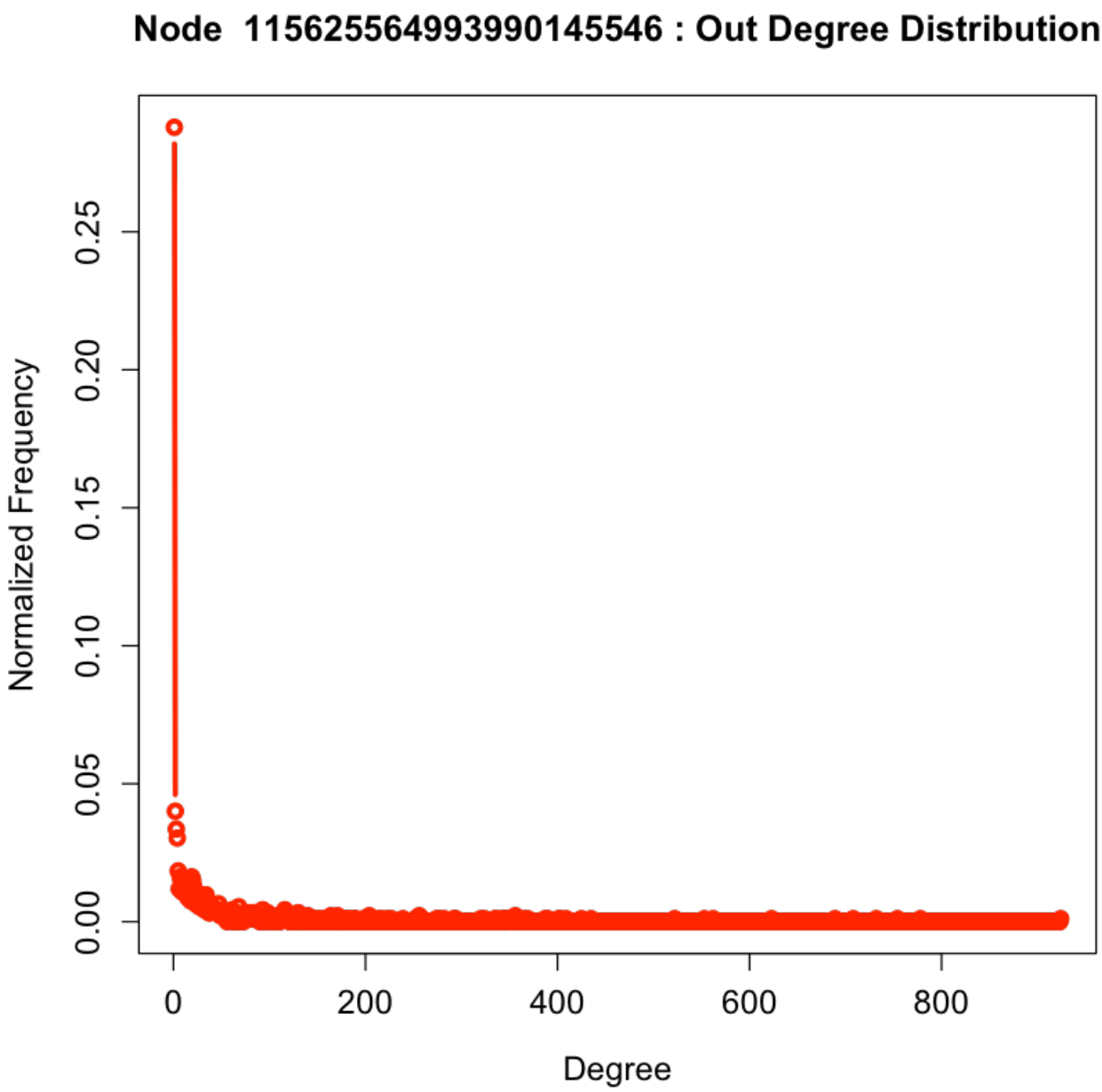


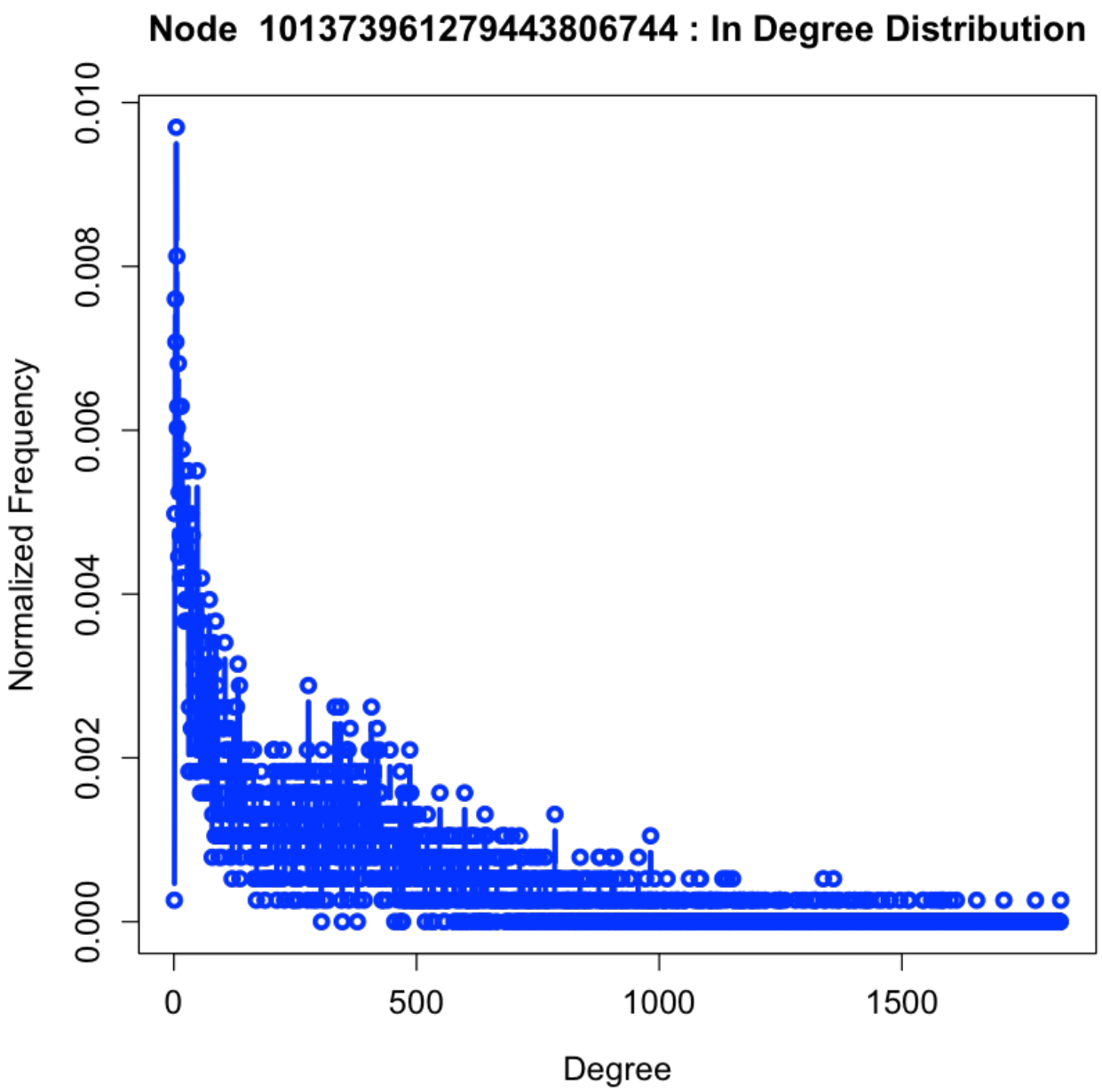

```
[1] "Working on node 115625564993990145546 ..."
[1] "In-Degree: Mean=43.640, Var=1020.621"
[1] "Out-Degree: Mean=43.640, Var=9351.303"
```

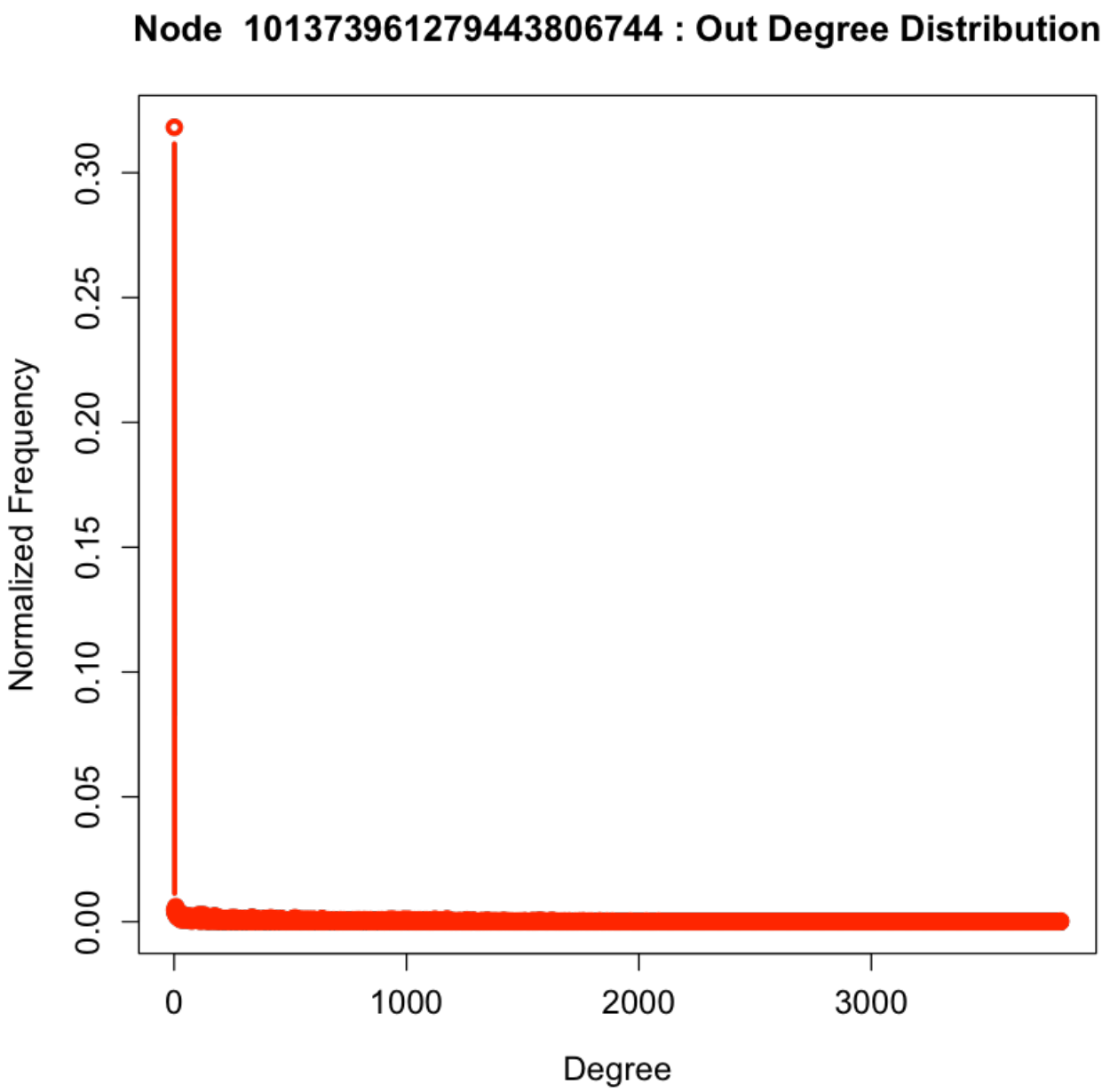

Node 10932748047976710849 0 : Out Degree Distribution
Normalized Frequency
0.0
0.1
0.2
0.3
0.4
0.5
0
200
400
600
800
Degree




```
[1] "Working on node 10137396127944380674 ..."
[1] "In-Degree: Mean=298.118, Var=86408.770"
[1] "Out-Degree: Mean=298.118, Var=166186.737"
```


Node 11562556499399014554 6 : Out Degree Distribution
Normalized Frequency
0.00
0.05
0.10
0.15
0.20
0.25
0
200
400
600
800
Degree


Node 10137396127944380674 : In Degree Distribution
Normalized Frequency
0.000
0.002
0.004
0.006
0.008
0.010
0
500
1000
1500
Degree

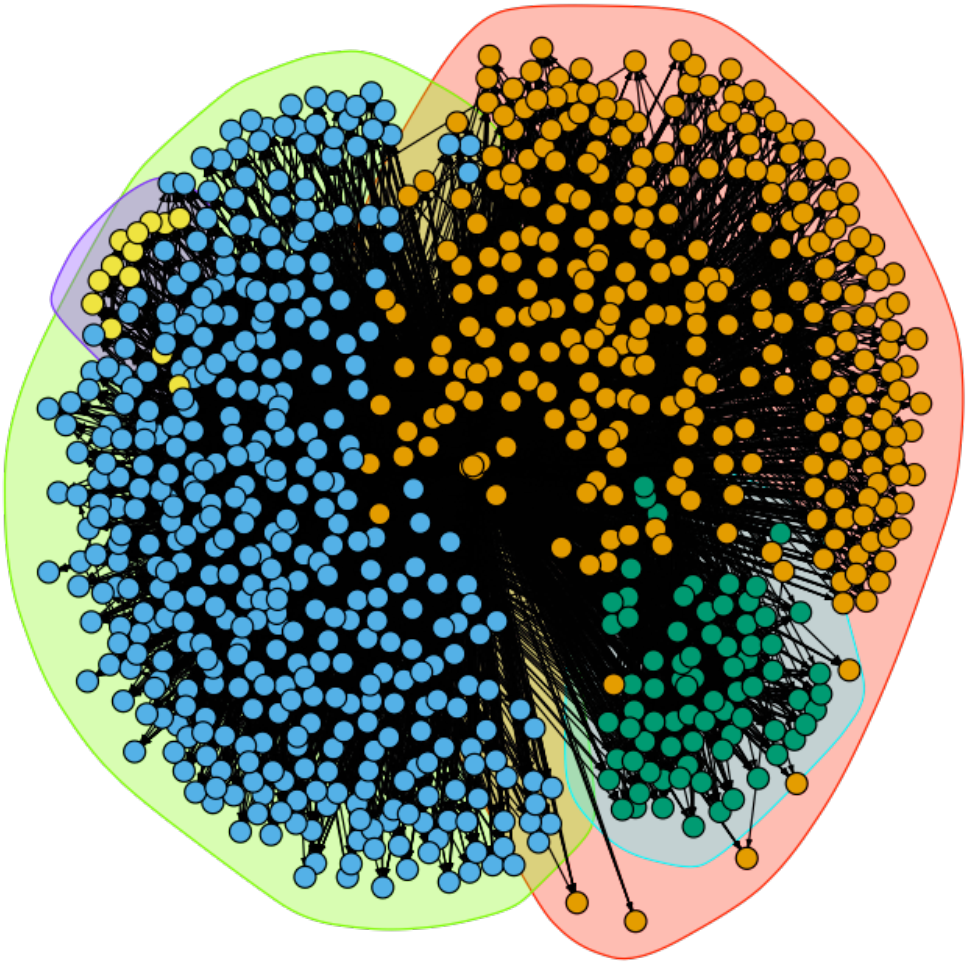


Community structure of personal networks

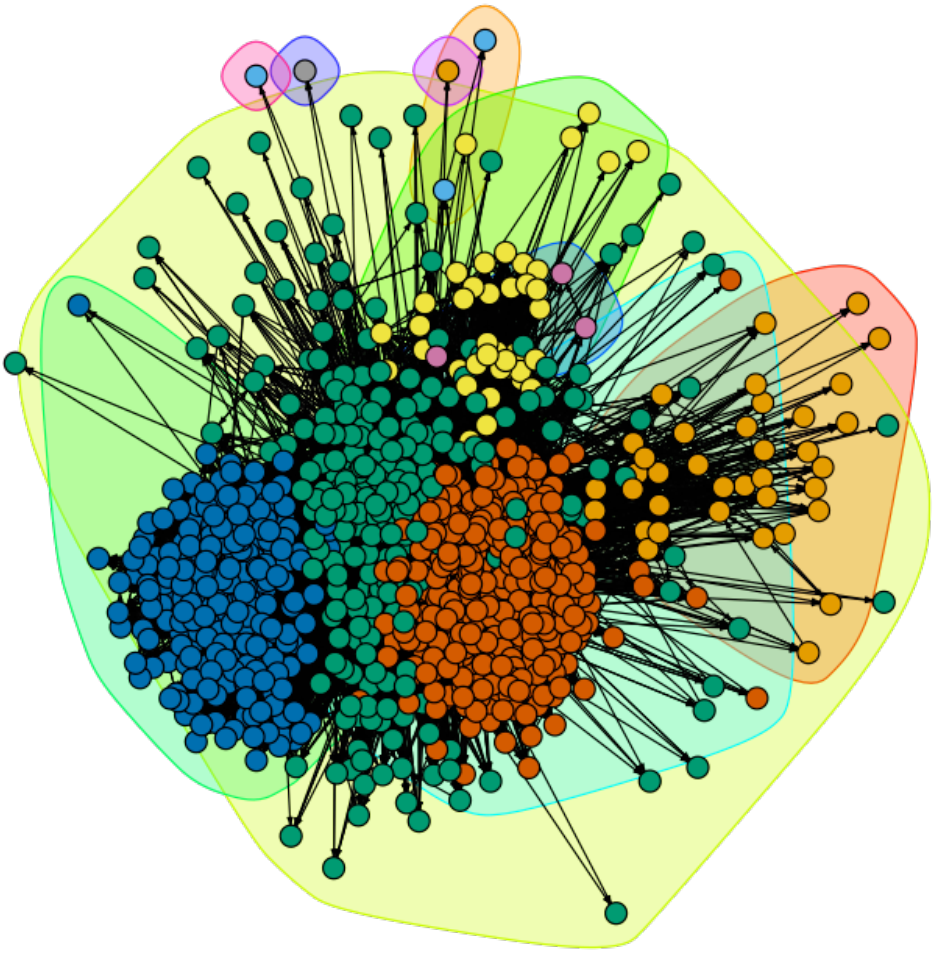
In [5]:

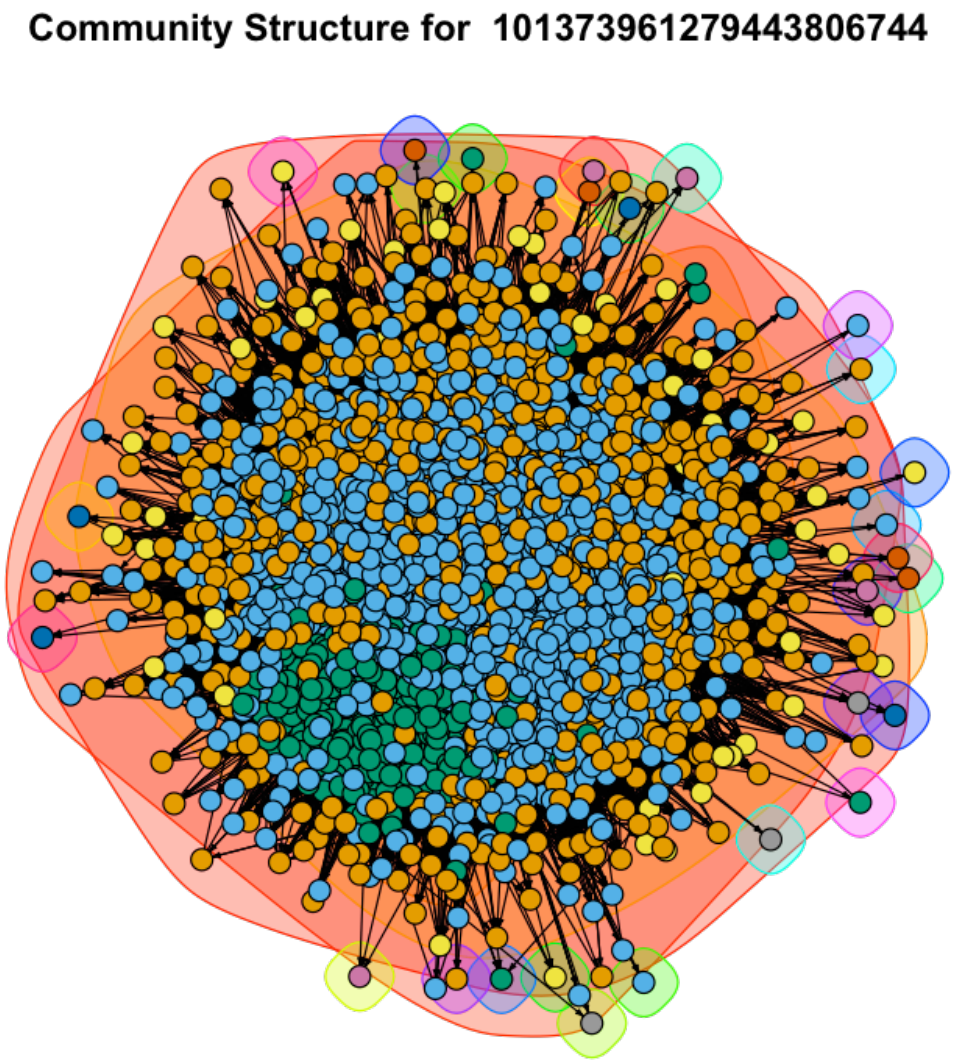
```
# Q20)

# Nodes to analyze
nodes = c("109327480479767108490","115625564993990145546","101373961279443806

for (node in nodes){
    print(sprintf('Working on node %s ...',node))
    # Create file and read in graph
    edgefile = paste("gplus/", node, ".edges", sep = "")
    node_graph = read_graph(edgefile, format="ncol", directed=TRUE)

    # Add vertex and edges for node (not included by default)
    node_graph = add_vertices(node_graph, nv = 1, name = node)
    indexNode = which(V(node_graph)$name==node)

    for (iGNode in seq(1, vcount(node_graph)-1,1)){
      node_graph = node_graph + edge(indexNode, iGNode)
    }


    node_community = cluster_walktrap(node_graph)
    node_modularity = modularity(node_community)
    print(sprintf('Modularity for node %s is %s ...',node,node_modularity))
    print(sprintf('Community Count for node %s is %s ...',node,length(node_co
    plot(node_community, node_graph, edge.color = "black",vertex.label=NA,
         vertex.size=5, edge.arrow.size=.2,
         main=paste("Community Structure for ", node))
}
```

```
[1] "Working on node 109327480479767108490 ..."
[1] "Modularity for node 109327480479767108490 is 0.252765387296677 ..."
[1] "Community Count for node 109327480479767108490 is 4 ..."
[1] "Working on node 115625564993990145546 ..."
[1] "Modularity for node 115625564993990145546 is 0.319472551345825 ..."
[1] "Community Count for node 115625564993990145546 is 10 ..."
```




```
[1] "Working on node 101373961279443806744 ..."
[1] "Modularity for node 101373961279443806744 is 0.191090270876884 ..."
[1] "Community Count for node 101373961279443806744 is 31 ..."
```


Community Structure for 115625564993990145546



In [11]:

```
# Question 22 Homogeneity and Completeness
node = "109327480479767108490"

nodes_list = c("109327480479767108490","115625564993990145546","1013739612794
for (node in nodes_list){

    # Load in circle file data
    print(sprintf('Working on node %s ...',node))
    circle_file = paste("gplus/", node, ".circles", sep = "")
    node_circle = readLines(file(circle_file, open="r"))

    # Get the circles for this node ID.
    circles = list()
```

```
for (circle_line in 1:length(node_circle)) {
    circle_nodes = strsplit(node_circle[circle_line],"\t")
    circles = c(circles, list(circle_nodes[[1]][-1]))
}

# N: total number of people with circle information
total_circle=c()
for (iCircle in circles)
    total_circle=c(total_circle,iCircle)
total_circle=unique(total_circle)
N=length(total_circle)

# H(C) Entropy Completeness
HC =0
for (iCircle in circles){
    a_i = length(iCircle)
    HC=HC-((a_i/N)* log10(a_i/N))
}

# Find the community structure
edgefile = paste("gplus/", node, ".edges", sep = "")
node_graph = read_graph(edgefile, format="ncol", directed=TRUE)

# Add vertex and edges for node (not included by default)
node_graph = add_vertices(node_graph, nv = 1, name = node)
indexNode = which(V(node_graph)$name==node)

for (iGNode in seq(1, vcount(node_graph)-1,1)){
  node_graph = node_graph + edge(indexNode, iGNode)
}

node_community  = walktrap.community(node_graph)

# Community based measures
HCK=0
HKC=0
HK=0

# check percentage of match for walktrap community
for(m in 1:max(node_community$membership)){

    community_nodes = V(node_graph)$name[which(node_community$membership
    b_i=length(intersect(community_nodes,all_circle))
    if(b_i!=0) {
        HK <- HK - ((b_i/N) * log10(b_i/N))
        for (n in 1:length(circles)) {
            common_nodes = intersect(community_nodes, circles[[n]])
            c_ij<-length(unique(common_nodes))
            A_i<-length(circles[[n]])
            if(c_ij!=0){
                HCK=HCK- ((c_ij/N)*log10(c_ij/b_i))
                HKC = HKC - ((c_ij/N)*log10(c_ij/A_i))
            }
```

```
            }
        }
    }

    # Calculate homogenity, completeness and V-measure.
    homogenity =  1-(HCK/HC)
    completeness = 1- (HKC/HK)

    print(sprintf("Entropy H(C) = %s",HC))
    print(sprintf("Entropy H(K) = %s",HK))
    print(sprintf("Conditional Entropy H(C|K) = %s",HCK))
    print(sprintf("Conditional Entropy H(K|C) = %s",HKC))

    print(sprintf("Homogeneity h= %s", homogenity))
    print(sprintf("Completeness c= %s", completeness))
}
```

```
[1] "Working on node 109327480479767108490 ..."
[1] "Entropy H(C) = 0.45634767"
[1] "Entropy H(K) = 0.43655637"
[1] "Conditional Entropy H(C|K) = 0.06759188"
[1] "Conditional Entropy H(K|C) = 0.29254781"
[1] "Homogeneity h= 0.85188512"
[1] "Completeness c= 0.32987391"
[1] "V-measure V= 0.47558710"

[1] "Working on node 115625564993990145546 ..."
[1] "Entropy H(C) = 3.67636649"
[1] "Entropy H(K) = 0.46955527"
[1] "Conditional Entropy H(C|K) = 2.01505212"
[1] "Conditional Entropy H(K|C) = 2.07729483"
[1] "Homogeneity h= 0.45189030"
[1] "Completeness c= -3.42396235"
[1] "V-measure V= 1.04119642"

[1] "Working on node 101373961279443806744 ..."
[1] "Entropy H(C) = 0.16690804"
[1] "Entropy H(K) = 0.21425076"
[1] "Conditional Entropy H(C|K) = 0.16626265"
[1] "Conditional Entropy H(K|C) = 0.53653499"
[1] "Homogeneity h= 0.00386671"
[1] "Completeness c= -1.50423839"
[1] "V-measure V= 0.00775334"
```