> library(igraph)

Attaching package: ‘igraph’

The following objects are masked from ‘package:network’:

%c%, %s%, add.edges, add.vertices, delete.edges, delete.vertices, get.edge.attribute,

get.edges, get.vertex.attribute, is.bipartite, is.directed, list.edge.attributes,

list.vertex.attributes, set.edge.attribute, set.vertex.attribute

The following objects are masked from ‘package:stats’:

decompose, spectrum

The following object is masked from ‘package:base’:

union

> library(network)

> library(intergraph)

>

> # ----------------------------------------------------------

> # Read in list of links... (from-node, to-node) pairs

> # ----------------------------------------------------------

>

> all\_enron\_links <- read.table('enron\_email\_links.txt', header = FALSE)

> cat("\n\nNumber of Links on Input: ", nrow(all\_enron\_links))

Number of Links on Input: 367662

> print(str(all\_enron\_links))

'data.frame': 367662 obs. of 2 variables:

$ V1: int 0 1 1 1 1 1 1 1 1 1 ...

$ V2: int 1 0 2 3 4 5 6 7 8 9 ...

NULL

> non\_zero\_enron\_links <- subset(all\_enron\_links, subset = (V1 != 0))

> non\_zero\_enron\_links <- subset(non\_zero\_enron\_links, subset = (V2 != 0))

> enron\_links <- subset(non\_zero\_enron\_links, subset = (V1 != V2))

> cat("\n\nNumber of Valid Links: ", nrow(enron\_links))

Number of Valid Links: 367660

> enron\_net <- network(as.matrix(enron\_links), matrix.type = "edgelist", directed = TRUE, multiple = TRUE)

> enron\_graph <- asIgraph(enron\_net)

> node\_index <- as.numeric(V(enron\_graph))

> V(enron\_graph)$name <- node\_name <- as.character(V(enron\_graph))

> node\_name <- as.character(node\_index)

> node\_reference\_table <- data.frame(node\_index, node\_name)

> ego\_1\_mail <- induced.subgraph(enron\_graph)

Error in inherits(v, "igraph.vs") :

argument "vids" is missing, with no default

> ego\_1\_mail <- induced.subgraph(enron\_graph, neighborhood(enron\_graph, order = 1, nodes = 1)[[1]])

> pdf(file = "fig\_ego\_1\_mail\_network\_four\_ways.pdf", width = 5.5, height = 5.5)

> par(mfrow = c(1,1))

> set.seed(9999)

> plot(ego\_1\_mail, vertex.size = 10, vertex.color = "yellow", vertex.label = NA, edge.arrow.size = 0.25, layout = layout.fruchterman.reingold)

> title("Fruchterman-Reingold Layout")

> set.seed(9999)

> plot(ego\_1\_mail, vertex.size = 10, vertex.color = "yellow", vertex.label = NA, edge.arrow.size = 0.25, layout = layout.kamada.kawai)

> title("Kamada-Kawai Layout")

> set.seed(9999)

> plot(ego\_1\_mail, vertex.size = 10, vertex.color = "yellow", vertex.label = NA, edge.arrow.size = 0.25, layout = layout.circle)

> title("Circle Layout")

> set.seed(9999)

> plot(ego\_1\_mail, vertex.size = 10, vertex.color = "yellow", vertex.label = NA, edge.arrow.size = 0.25, layout = layout.reingold.tilford)

Warning message:

In .Call("R\_igraph\_layout\_reingold\_tilford", graph, root, mode, :

At structural\_properties.c:3297 :graph contains a cycle, partial result is returned

> title("Reingold-Tilford Layout")

> dev.off()

null device

1

> set.seed(9999)

> pdf(file = "fig\_ego\_1\_mail\_network.pdf", width = 8.5, height = 11)

> plot(ego\_1\_mail, vertex.size = 15, vertex.color = "yellow", vertex.label.cex = 0.9, edge.arrow.size = 0.25, edge.color = "black", layout = layout.kamada.kawai)

> dev.off()

null device

1

> node\_reference\_table$node\_degree <- degree(enron\_graph)

> print(str(node\_reference\_table))

'data.frame': 36691 obs. of 3 variables:

$ node\_index : num 1 2 3 4 5 6 7 8 9 10 ...

$ node\_name : Factor w/ 36691 levels "1","10","100",..: 1 11112 22223 30026 31137 32248 33359 34470 35581 2 ...

$ node\_degree: num 138 2 10 16 124 18 28 2 78 8 ...

NULL

> sorted\_node\_reference\_table <- node\_reference\_table[sort.list(node\_reference\_table$node\_degree, decreasing = TRUE),]

> print(head(sorted\_node\_reference\_table))

node\_index node\_name node\_degree

5038 5038 5038 2766

273 273 273 2734

458 458 458 2522

140 140 140 2490

1028 1028 1028 2488

195 195 195 2286

> print(tail(sorted\_node\_reference\_table))

node\_index node\_name node\_degree

36674 36674 36674 2

36677 36677 36677 2

36678 36678 36678 2

36689 36689 36689 2

36690 36690 36690 2

36691 36691 36691 2

> K <- 50

> top\_node\_indices <- sorted\_node\_reference\_table$node\_index[1:K]

> print(top\_node\_indices)

[1] 5038 273 458 140 1028 195 370 1139 136 566 823 292 588 76 416 286 353 734 851

[20] 1824 478 95 893 516 444 520 647 652 343 543 213 443 155 175 530 127 4063 188

[39] 639 241 93 1768 915 1672 3311 106 308 1031 802 3161

> top\_enron\_graph <- induced.subgraph(enron\_graph, top\_node\_indices)

> pdf(file = "fig\_top\_enron\_graph\_four\_ways.pdf", width = 5.5, height = 5.5)

> par(mfrow = c(1,1))

> set.seed(9999)

> plot(top\_enron\_graph, vertex.size = 10, vertex.color = "yellow", vertex.label = NA, edge.arrow.size = 0.25,layout = layout.fruchterman.reingold)

> title("Fruchterman-Reingold Layout")

> set.seed(9999)

> plot(top\_enron\_graph, vertex.size = 10, vertex.color = "yellow", vertex.label = NA, edge.arrow.size = 0.25, layout = layout.kamada.kawai)

> title("Kamada-Kawai Layout")

> set.seed(9999)

> plot(top\_enron\_graph, vertex.size = 10, vertex.color = "yellow", vertex.label = NA, edge.arrow.size = 0.25, layout = layout.circle)

> title("Circle Layout")

> set.seed(9999)

> plot(top\_enron\_graph, vertex.size = 10, vertex.color = "yellow", vertex.label = NA, edge.arrow.size = 0.25, layout = layout.reingold.tilford)

Warning message:

In .Call("R\_igraph\_layout\_reingold\_tilford", graph, root, mode, :

At structural\_properties.c:3297 :graph contains a cycle, partial result is returned

> title("Reingold-Tilford Layout")

> dev.off()

null device

1

> set.seed(9999)

> pdf(file = "fig\_top\_enron\_graph.pdf", width = 8.5, height = 11)

> plot(top\_enron\_graph, vertex.size = 15, vertex.color = "yellow", vertex.label.cex = 0.9, edge.arrow.size = 0.25, edge.color = "darkgray", layout = layout.kamada.kawai)

> dev.off()

null device

1

> table(sapply(cliques(top\_enron\_graph), length))

1 2 3 4 5 6 7 8 9 10 11 12 13

50 513 2276 5854 9888 11676 10020 6404 3057 1058 247 34 2

Warning message:

In .Call("R\_igraph\_cliques", graph, as.numeric(min), as.numeric(max), :

At cliques.c:192 :directionality of edges is ignored for directed graphs

> two\_cliques <- cliques(top\_enron\_graph)[sapply(cliques(top\_enron\_graph), length) == 13]

Warning messages:

1: In .Call("R\_igraph\_cliques", graph, as.numeric(min), as.numeric(max), :

At cliques.c:192 :directionality of edges is ignored for directed graphs

> print(two\_cliques)

[[1]]

+ 13/50 vertices, named:

[1] 76 136 140 175 188 241 292 353 370 416 444 478 520

[[2]]

+ 13/50 vertices, named:

[1] 76 136 140 175 188 241 292 353 370 416 444 478 734

> core\_node\_indices\_new <- unique(unlist(two\_cliques))

> non\_core\_node\_indices\_new <- setdiff(1:K, core\_node\_indices\_new)

> set\_node\_colors <- rep("white", length = K)

> set\_node\_colors[core\_node\_indices\_new] <- "darkblue"

> set\_label\_colors <- rep("black", length = K)

> set\_label\_colors[core\_node\_indices\_new] <- "white"

> set.seed(9999)

> pdf(file = "fig\_top\_enron\_graph\_with\_core.pdf", width = 8.5, height = 11)

> plot(top\_enron\_graph, vertex.size = 15, vertex.color = set\_node\_colors, vertex.label.color = set\_label\_colors, vertex.label.cex = 0.9, edge.arrow.size = 0.25, edge.color = "darkgray", layout = layout.kamada.kawai)

> dev.off()

null device

1

> set.seed(9999)

> plot(top\_enron\_graph, vertex.size = 15, vertex.color = "white", vertex.label.cex = 0.9, edge.arrow.size = 0.25, layout = layout.reingold.tilford)

Warning message:

In .Call("R\_igraph\_layout\_reingold\_tilford", graph, root, mode, :

At structural\_properties.c:3297 :graph contains a cycle, partial result is returned