Social Network Analysis with R *

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R and Data Mining Course

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*Chapter 11: Social Network Analysis, in *R and Data Mining: Examples and Case Studies*. http://www.rdatamining.com/docs/RDataMining-book.pdf

Contents

Graph and Social Network Analysis

Graph Construction

Graph Visualization

Graph Query

Centrality Measures

Advanced Graph Visualization

R Packages

Wrap Up

Further Readings and Online Resources

Network and Graph

- Nodes, vertices or entities
- Edges, links or relationships
- Network analysis, graph mining
- Link prediction, community/group detection, entity resolution, recommender system, information propogation modeling

Graph Databases

- Neo4j: `https://neo4j.com`
- Giraph on Hadoop: `http://giraph.apache.org`
- GraphX on Spark: `http://spark.apache.org/graphx/`

Social Network Analysis

- Graph construction
- Graph query
- Centrality measures
- Graph visualization
- Clustering and community detection

Contents

Graph and Social Network Analysis

Graph Construction

Graph Visualization

Graph Query

Centrality Measures

Advanced Graph Visualization

R Packages

Wrap Up

Further Readings and Online Resources

Graph Construction

- Tom, Ben, Bob and Mary are friends of John.
- Alice and Wendy are friends of Mary.
- Wendy is a friend of David.

```
library(igraph)
# nodes
nodes <- data.frame(
  name = c("Tom","Ben","Bob","John","Mary","Alice","Wendy","David"),
  gender = c("M", "M", "M", "M", "F", "F", "F", "M"),
  age =    c( 16,  30,  42,  29,  26,  32,  18,  22)
)
# relations
edges <- data.frame(
  from = c("Tom", "Ben",  "Bob", "Mary", "Alice", "Wendy", "Wendy"),
  to   =  c("John", "John", "John", "John","Mary", "Mary", "David")
)
# build a graph object
g <- graph.data.frame(edges, directed=F, vertices=nodes)
```

Contents

Graph and Social Network Analysis

Graph Construction

Graph Visualization

Graph Query

Centrality Measures

Advanced Graph Visualization

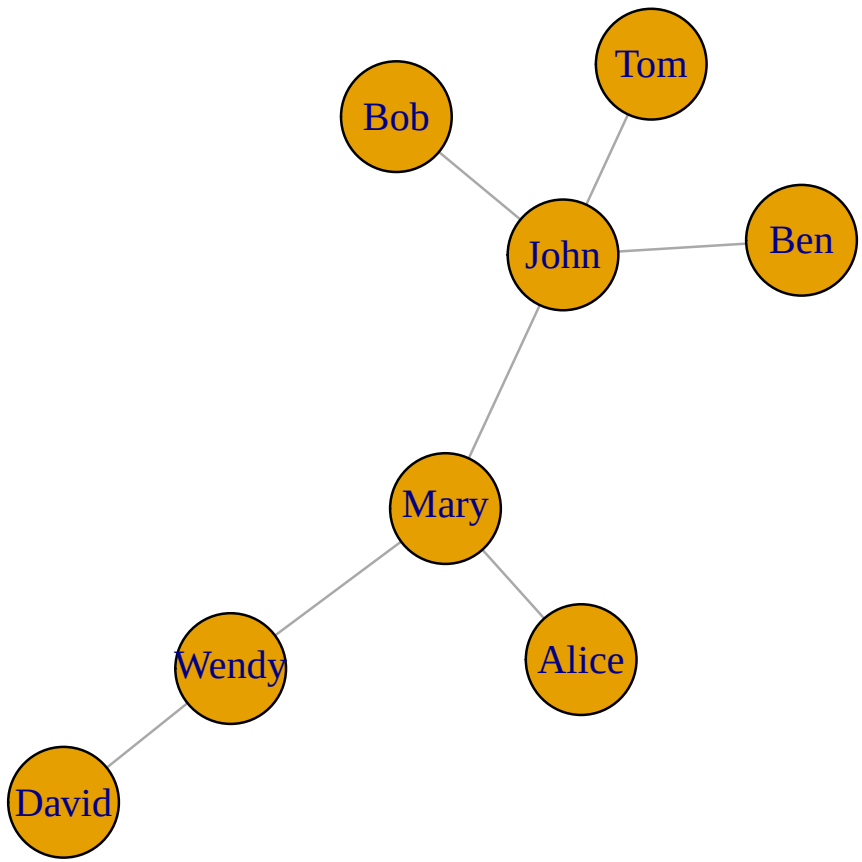
R Packages

Wrap Up

Further Readings and Online Resources

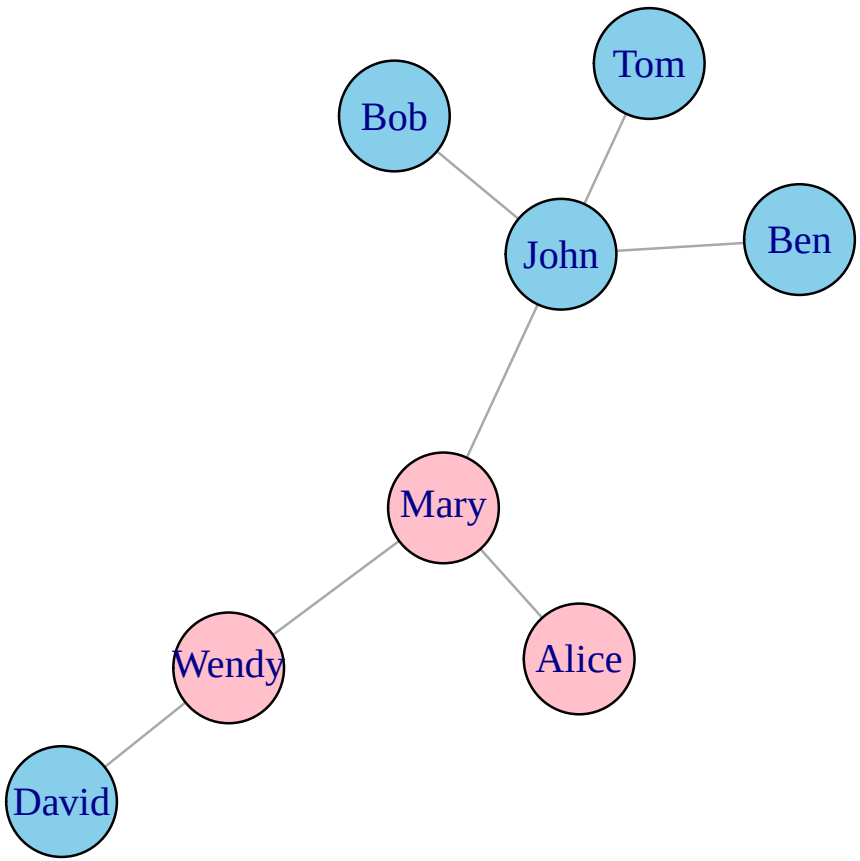
Graph Visualization

```
layout1 <- g %>% layout_nicely()  ## save layout for reuse
g %>% plot(vertex.size = 30, layout = layout1)
```



Graph Visualization (cont.)

```
## use blue for male and pink for female
colors <-  ifelse(V(g)$gender=="M", "skyblue", "pink")
g %>% plot(vertex.size=30, vertex.color=colors, layout=layout1)
```



Contents

Graph and Social Network Analysis

Graph Construction

Graph Visualization

Graph Query

Centrality Measures

Advanced Graph Visualization

R Packages

Wrap Up

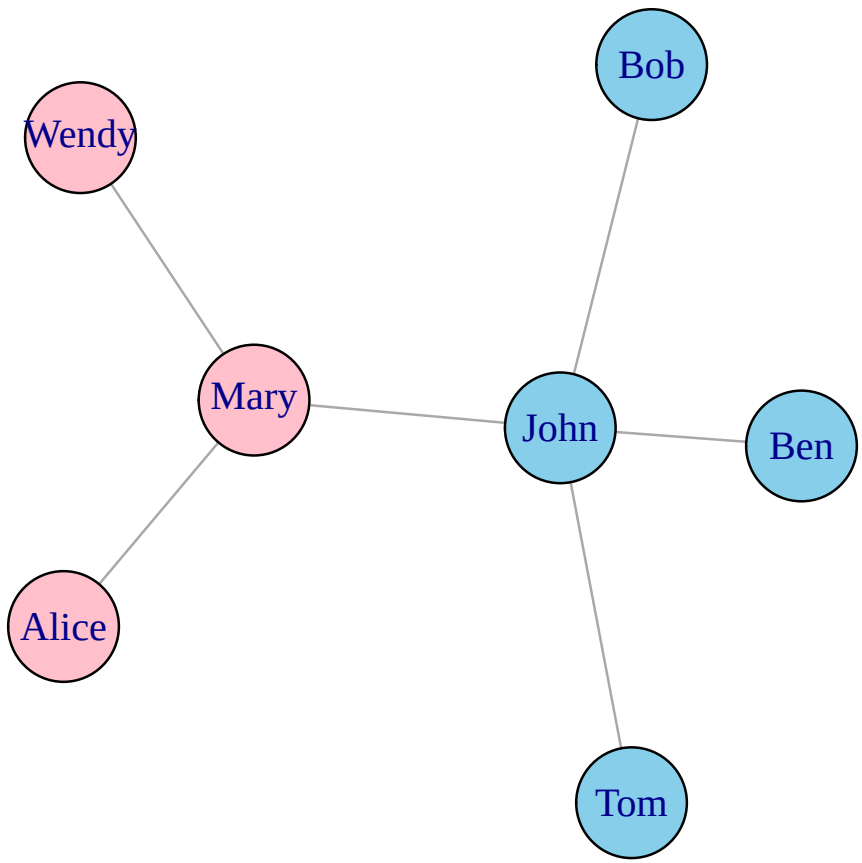
Further Readings and Online Resources

Graph Query

```
## nodes
V(g)
## + 8/8 vertices, named, from 8dfec3f:
## [1] Tom   Ben   Bob   John  Mary  Alice Wendy David

## edges
E(g)
## + 7/7 edges from 8dfec3f (vertex names):
## [1] Tom  --John  Ben  --John  Bob  --John  John --Mary
## [5] Mary --Alice Mary --Wendy Wendy--David

## immediate neighbors (friends) of John
friends <- ego(g,order=1,nodes="John",mindist=1)[[1]] %>% print()
## + 4/8 vertices, named, from 8dfec3f:
## [1] Tom  Ben  Bob  Mary

## female friends of John
friends[friends$gender == "F"]
## + 1/8 vertex, named, from 8dfec3f:
## [1] Mary
```

Graph Query (cont.)

```
## 1- and 2-order neighbors (friends) of John
g2 <- make_ego_graph(g, order=2, nodes="John")[[1]]
g2 %>% plot(vertex.size=30, vertex.color=colors)
```



Contents

Graph and Social Network Analysis

Graph Construction

Graph Visualization

Graph Query

Centrality Measures

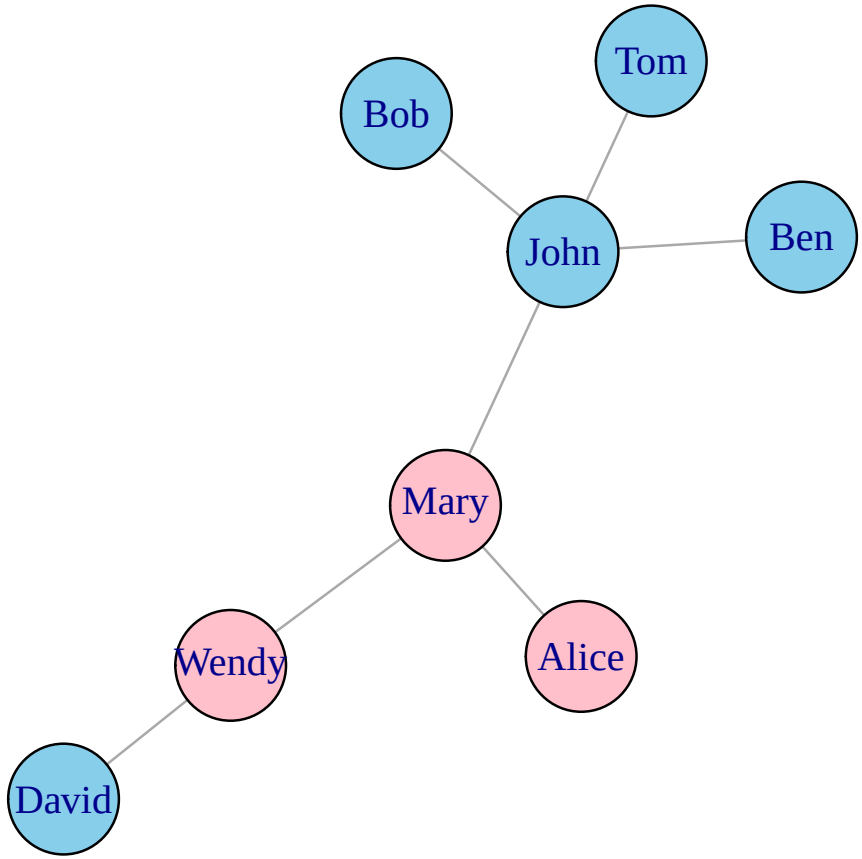
Advanced Graph Visualization

R Packages

Wrap Up

Further Readings and Online Resources

Friendship Graph



Centrality Measures

- Degree: the number of adjacent edges; indegree and outdegree for directed graphs
- Closeness: the inverse of the average length of the shortest paths to/from all other nodes
- Betweenness: the number of shortest paths going through a node

```
degree <- g %>% degree() %>% print()
##   Tom   Ben   Bob  John  Mary Alice Wendy David
##     1     1     1     4     3     1     2     1

closeness <- g %>% closeness() %>% round(2) %>% print()
##   Tom   Ben   Bob  John  Mary Alice Wendy David
##  0.06  0.06  0.06  0.09  0.09  0.06  0.07  0.05

betweenness <- g %>% betweenness() %>% print()
##   Tom   Ben   Bob  John  Mary Alice Wendy David
##     0     0     0    15    14     0     6     0
```

Centrality Measures (cont.)

- Eigenvector centrality: the values of the first eigenvector of the graph adjacency matrix
- Transivity, a.k.a clustering coefficient, measures the probability that the adjacent nodes of a node are connected.

```
eigenvector <- evcent(g)$vector %>% round(2) %>% print()
##   Tom   Ben   Bob  John  Mary Alice Wendy David
##  0.45  0.45  0.45  1.00  0.85  0.38  0.48  0.22

transitivity <- g %>% transitivity(type = "local") %>% print()
## [1] NaN NaN NaN   0   0 NaN   0 NaN
```

Contents

Graph and Social Network Analysis

Graph Construction

Graph Visualization

Graph Query

Centrality Measures

Advanced Graph Visualization

R Packages

Wrap Up

Further Readings and Online Resources

Static Network Visualization

- Static network visualization
- Fast in rendering big graphs
- For very big graphs, the most efficient way is to save visualization result into a file, instead of directly to screen.
- Save network diagram into files: `pdf()`, `bmp()`, `jpeg()`, `png()`, `tiff()`

```
library(igraph)

## plot directly to screen when graph is small
plot(g)

## for big graphs, save visualization to a PDF file
pdf("mygraph.pdf")
plot(g)
graphics.off()  ## or dev.off()
```

Interactive Network Visualization

- Coordinates of other nodes are not adjusted when moving a node.
- Can be slow when rendering big graphs
- Save network diagram into files: `visSave()`, `visExport()`

```
visIgraph(g, idToLabel=T) %>%
  ## highlight nodes connected to a selected node
  visOptions(highlightNearest=T) %>%
  ## use different icons for different types (groups) of nodes
  visGroups(groupname="person", shape="icon",
            icon=list(code="f007")) %>%
  ... %>%
  ## use FontAwesome icons
  addFontAwesome() %>%
  ## add legend of nodes
  visLegend() %>%
  ## to save to file
  visSave(file = "network.html")
```

Interactive Network Visualization (cont.)

- Dynamically adjusting coordinates for better visualization
- Very slow when rendering big graphs

```
x <- toVisNetworkData(g)
visNetwork(nodes=x$nodes, edges=x$edges)%>%
  ## use different icons for different types (groups) of nodes
  visGroups(groupname="person", shape="icon",
            icon=list(code="f007")) %>%
  ... %>%
  ## use FontAwesome icons
  addFontAwesome() %>%
  ## add legend of nodes
  visLegend()
```

Load Graph Data

```
## download graph data
url <- "http://www.rdatamining.com/data/graph.rdata"
download.file(url, destfile = "./data/graph.rdata")
```

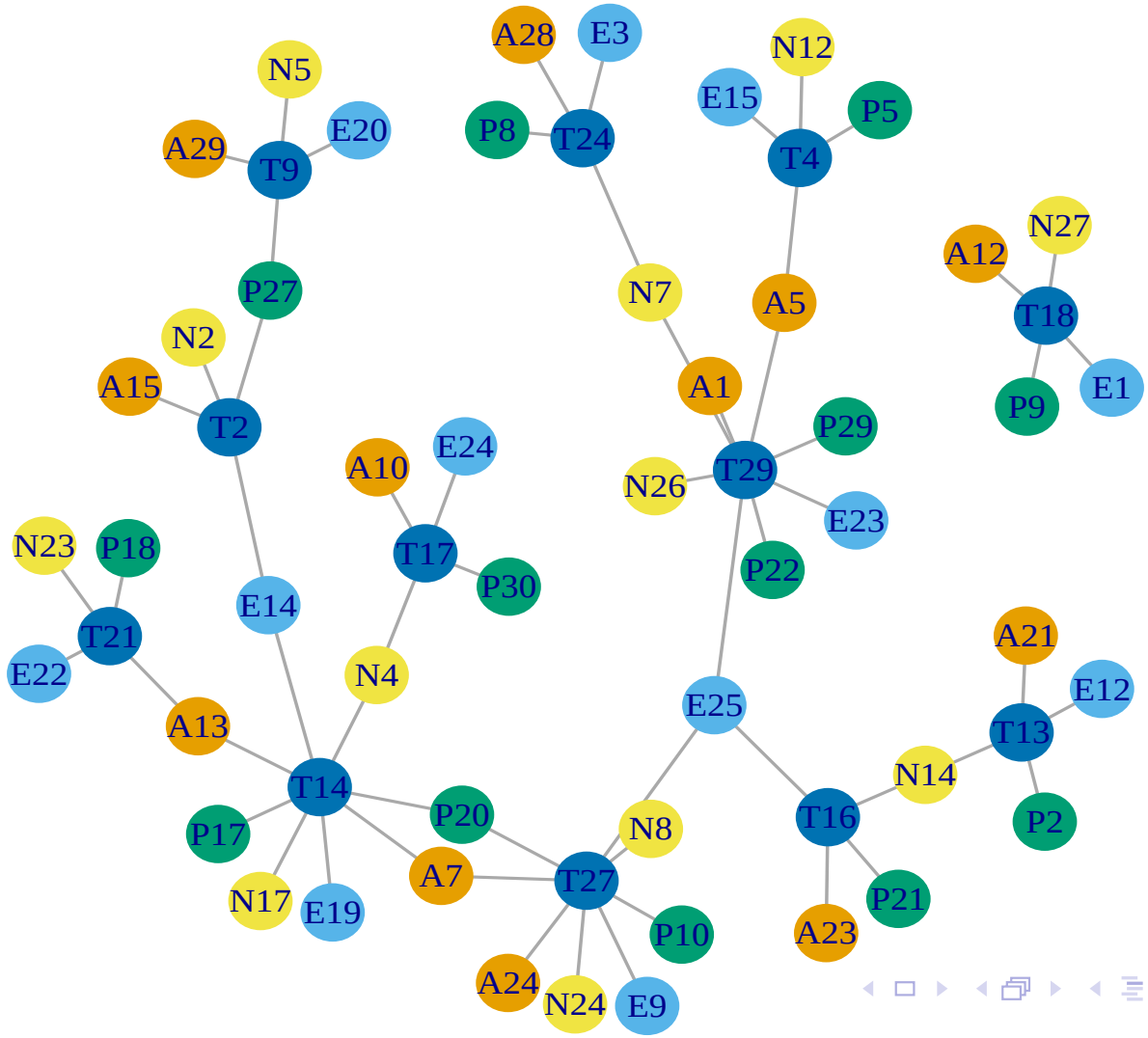
```
library(igraph)
# load graph data into R
# what will be loaded: g, nodes, edges
load("../data/graph.rdata")
```

Build a Graph

```
head(nodes, 3)
##   name type
## 1   T9  tid
## 2  T24  tid
## 3  T13  tid

head(edges, 3)
##   from  to
## 1   T9 P27
## 2  T24  P8
## 3  T13  P2

## buid a graph object
g <- graph.data.frame(edges, directed = F, vertices = nodes)
g
## IGRAPH 9597c42 UN-B 61 60 --
## + attr: name (v/c), type (v/c)
## + edges from 9597c42 (vertex names):
##  [1] T9 --P27 T24--P8  T13--P2  T27--P10 T29--P29 T2 --P27
##  [7] T16--P21 T27--P20 T17--P30 T14--P20 T29--P22 T14--P17
## [13] T21--P18 T18--P9  T4 --P5  T9 --A29 T24--A28 T13--A21
```

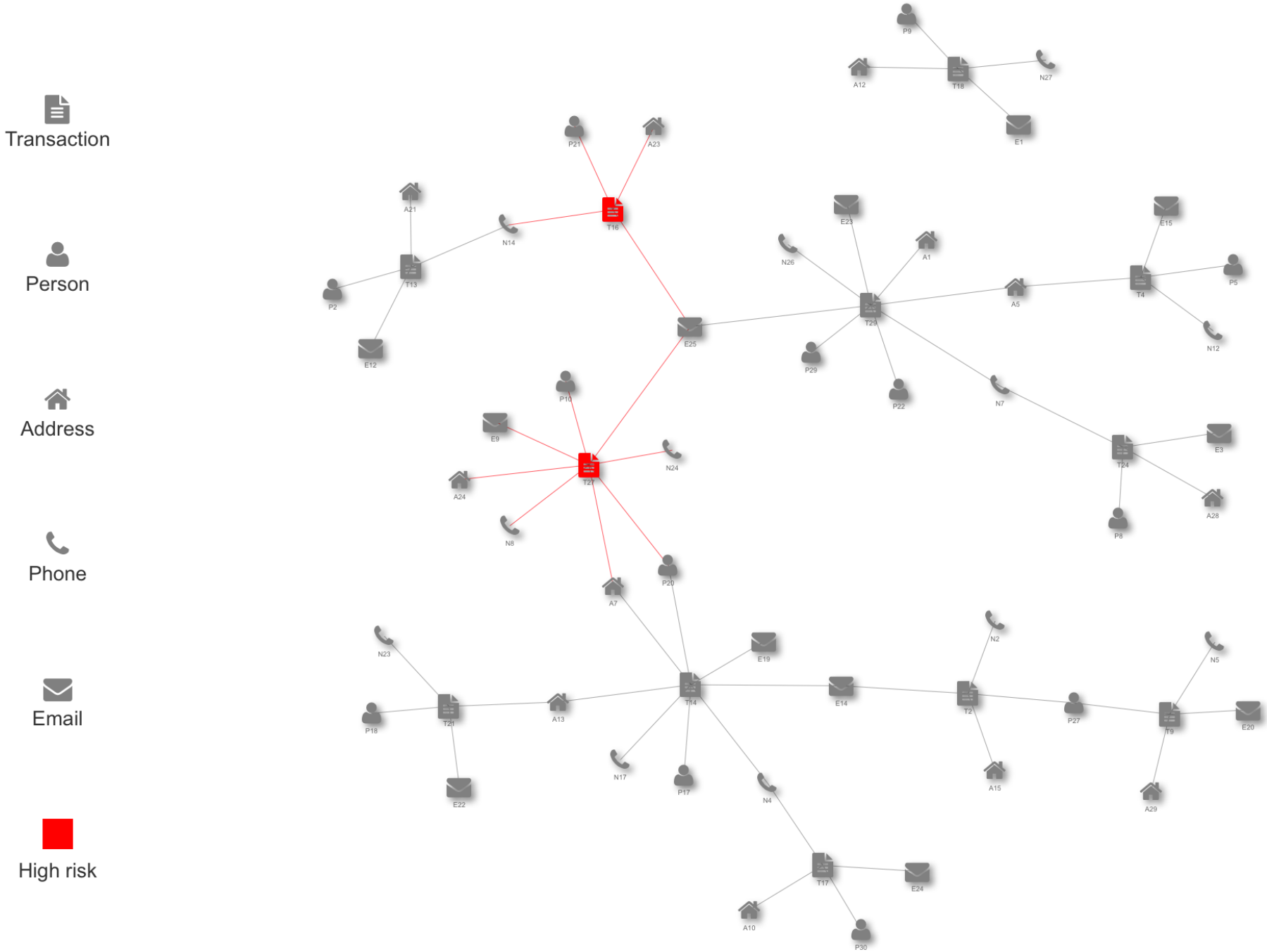
Example of Static Network Visualization

```
library(igraph)
plot(g, vertex.size=12, vertex.label.cex=0.7,
     vertex.color=as.factor(V(g)$type), vertex.frame.color=NA)
```



Example of Interactive Network Visualization

```
library(visNetwork)
V(g)$group <- V(g)$type
## visualization
data <- toVisNetworkData(g)
visNetwork(nodes=data$nodes, edges=data$edges) %>%
visGroups(groupname="tid",shape="icon",icon=list(code="f15c")) %>%
visGroups(groupname="person",shape="icon",icon=list(code="f007")) %>%
visGroups(groupname="addr",shape="icon",icon=list(code="f015")) %>%
visGroups(groupname="phone",shape="icon",icon=list(code="f095")) %>%
visGroups(groupname="email",shape="icon",icon=list(code="f0e0")) %>%
addFontAwesome() %>%
visLegend()
```


Transaction
Person
Address
Phone
Email
High risk

Contents

Graph and Social Network Analysis

Graph Construction

Graph Visualization

Graph Query

Centrality Measures

Advanced Graph Visualization

R Packages

Wrap Up

Further Readings and Online Resources

R Packages

- Network analysis: *igraph*, *sna*, *statnet*
- Network visualization: *visNetwork*
- Interface with graph databases: *RNeo4j*

Package *igraph* †

- `V(g)`, `E(g)`: nodes and edges of graph `g`
- `degree`, `betweenness`, `closeness`, `transitivity`: various centrality scores
- `neighborhood`: neighborhood of graph vertices
- `cliques`, `largest.cliques`, `maximal.cliques`, `clique.number`: find cliques, ie. complete subgraphs
- `clusters`, `no.clusters`: maximal connected components of a graph and the number of them
- `fastgreedy.community`, `spinglass.community`: community detection
- `cohesive.blocks`: calculate cohesive blocks
- `induced.subgraph`: create a subgraph of a graph (*igraph*)
- `read.graph`, `write.graph`: read and writ graphs from and to files of various formats

† https://cran.r-project.org/package=igraph

Contents

Graph and Social Network Analysis

Graph Construction

Graph Visualization

Graph Query

Centrality Measures

Advanced Graph Visualization

R Packages

Wrap Up

Further Readings and Online Resources

Wrap Up

- Package *igraph* and *sna*
  - Static visualization
  - Can visualize nodes with shapes, images and icons
  - Visualise very large graph
  - Support network analysis and graph mining
- Package *visNetwork*
  - Interactive visualization
  - Can visualize nodes with shapes, images and icons
  - Image rendering can be very slow for large graphs
  - Designed for visualization only, and does not support network analysis and graph mining

Contents

Graph and Social Network Analysis

Graph Construction

Graph Visualization

Graph Query

Centrality Measures

Advanced Graph Visualization

R Packages

Wrap Up

Further Readings and Online Resources

Further Readings

- Social network analysis (SNA)

  `https://en.wikipedia.org/wiki/Social_network_analysis`
- igraph – a network analysis package, supporting R, Python and C/C++

  `http://igraph.org`
- sna – an R package for social network analysis

  `https://cran.r-project.org/web/packages/sna/index.html`
- statnet – software tools for the analysis, simulation and visualization of network data; also available as an R package

  `http://www.statnet.org`
- visNetwork – an R package for network visualization

  `http://datastorm-open.github.io/visNetwork/`

Online Resources

- Book titled *R and Data Mining: Examples and Case Studies* [Zhao, 2012]

  `http://www.rdatamining.com/docs/RDataMining-book.pdf`
- R Reference Card for Data Mining

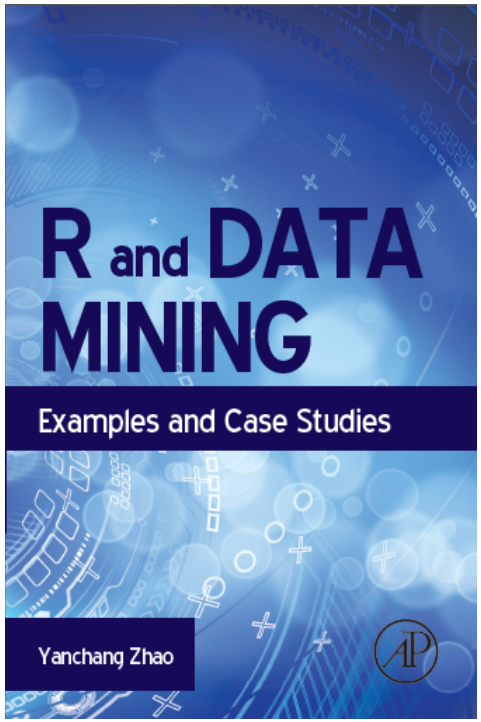
  `http://www.rdatamining.com/docs/RDataMining-reference-card.pdf`
- Free online courses and documents

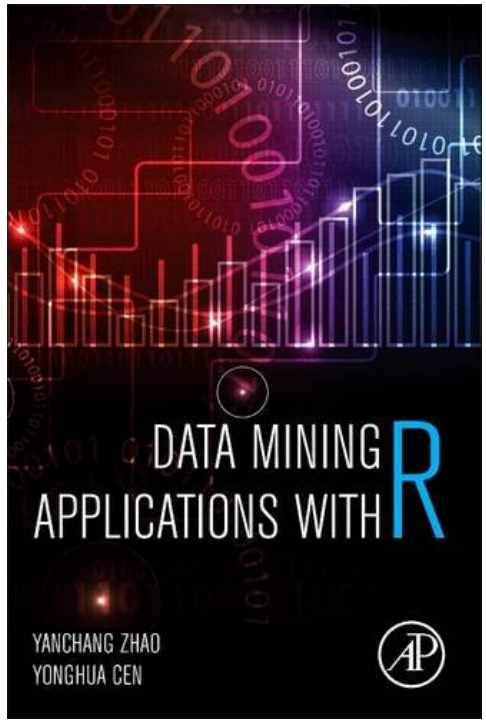
  `http://www.rdatamining.com/resources/`
- RDataMining Group on LinkedIn (27,000+ members)

  `http://group.rdatamining.com`
- Twitter (3,300+ followers)

  @RDataMining

The End





Thanks!

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How to Cite This Work

- Citation

  Yanchang Zhao. R and Data Mining: Examples and Case Studies. ISBN 978-0-12-396963-7, December 2012. Academic Press, Elsevier. 256 pages. URL: http://www.rdatamining.com/docs/RDataMining-book.pdf.

- BibTex

```
@BOOK{Zhao2012R,
        title = {R and Data Mining: Examples and Case Studies},
        publisher = {Academic Press, Elsevier},
        year = {2012},
        author = {Yanchang Zhao},
        pages = {256},
        month = {December},
        isbn = {978-0-123-96963-7},
        keywords = {R, data mining},
        url = {http://www.rdatamining.com/docs/RDataMining-book.pdf}
}
```

References I

Zhao, Y. (2012).

R and Data Mining: Examples and Case Studies, ISBN 978-0-12-396963-7.
Academic Press, Elsevier.