Networks in R - Project 3 - R Package Dependencies

Project Description

The network chosen for the project is the set of R packages built from two subsets

- the base packages
- the packages available on CRAN

with dependencies between them. The network data was gathered by using the 01_build_net.R script.

There are four types of links between packages

- "Depends". Directive attempts to ensure that a function from another package is available by attaching the other package to the main search path (i.e. the list of environments returned by search()). Which sometimes can lead to collisions with names. It's not recommended type of dependency).
- "Imports". Packages listed here must be present for your package to work. In fact, any time your package is installed, those packages will, if not already present, be installed on your computer (devtools::load_all() also checks that the packages are installed). However, it does not mean that it will be attached along with your package. The best practice is to explicitly refer to external functions using the syntax package::function().
- "Suggests". Your package can use these packages, but doesn't require them. You might use suggested packages for example datasets, to run tests, build vignettes, or maybe there's only one function that needs the package. Packages listed in Suggests are not automatically installed along with your package.
- "Enhances". Packages listed here are "enhanced" by your package. Typically, this means you provide methods for classes defined in another package (a sort of reverse Suggests). But it's hard to define what that means, so I don't recommend using Enhances.

The "Suggests" and "Enhances" relations are out of scope for the project as they don't impose hard dependency i.e. a package may work without them. Further, we consider only the "Depends" and "Imports" relations and consider them equal from our research's point of view.

The motivation is to investigate into what are the most 'powerful' R packages in terms of their relations to the rest of packages.

Data Format

The network data is saved in two formats:

- the GML format in the r_packages.gml file,
- the Pajek format in the r_packages.net file.

Basic Network Characteristics

The nodes represent web pages, each page describes some Wikipedia social norm. The links are the HTTP reference from one page to another.

It's a directed graph by its nature, no weights assigned to the links.

Property	Value
Vertices	12014
Edges	44474

Property	Value
Directed	Yes
Weighted	No
Average degree	7.4
Diameter	24
Acyclic	No
Edge density	0.000308153487403795
Average Path Length	7.42077189595423
Transitivity (global)	0.00329920190110913

Interesting to note there are isolated packages i.e. without any relations to any other packages, their percentage is

```
## [1] 13.3
```

Top Nodes

The most popular packages in terms of others depending on them, the

The first 50 nodes with the largest number of in-degree. The high number of total degree for a node is expectedly provided by incoming dependecies.

```
## [1] Page Name                                Type        In-degree Out-degree     Total Degree
## [1] ---------------------------------------------------------------------------------------------
## [1] stats                                   base             2812          7             2819
## [1] methods                                 base             2263          4             2267
## [1] utils                                   base             1721          0             1721
## [1] graphics                                base             1503          0             1503
## [1] Rcpp                                    CRAN             1213          0             1213
## [1] MASS                                    CRAN             1144          6             1150
## [1] ggplot2                                 CRAN             1129          3             1132
## [1] grDevices                               base              913          3              916
## [1] dplyr                                   CRAN              693          6              699
## [1] Matrix                                  CRAN              665         13              678
## [1] parallel                                base              652          4              656
## [1] plyr                                    CRAN              551          1              552
## [1] mvtnorm                                 CRAN              481         20              501
## [1] stringr                                 CRAN              485          4              489
## [1] magrittr                                CRAN              441          2              443
## [1] survival                                CRAN              429          2              431
## [1] httr                                    CRAN              413         10              423
## [1] jsonlite                                CRAN              417          5              422
## [1] sp                                      CRAN              404          2              406
## [1] lattice                                 CRAN              393          0              393
## [1] data.table                              CRAN              379          8              387
## [1] foreach                                 CRAN              351          5              356
## [1] grid                                    base              351          1              352
## [1] reshape2                                CRAN              346          4              350
## [1] igraph                                  CRAN              341          4              345
## [1] shiny                                   CRAN              279          2              281
## [1] tibble                                  CRAN              263         10              273
## [1] tidyr                                   CRAN              256          3              259
```

```
## [1] doParallel                          CRAN             240           6             246
## [1] RColorBrewer                        CRAN             242           3             245
## [1] coda                                CRAN             226           3             229
## [1] raster                              CRAN             229           0             229
## [1] XML                                 CRAN             219           2             221
## [1] zoo                                 CRAN             214           0             214
## [1] RCurl                               CRAN             192           7             199
## [1] scales                              CRAN             192           4             196
## [1] purrr                               CRAN             193           1             194
## [1] nlme                                CRAN             176           6             182
## [1] lubridate                           CRAN             178           2             180
## [1] gridExtra                           CRAN             174           4             178
## [1] numDeriv                            CRAN             172           3             175
## [1] xml2                                CRAN             169           3             172
## [1] ape                                 CRAN             170           0             170
## [1] rgl                                 CRAN             168           1             169
## [1] tools                               base             166           0             166
## [1] splines                             base             163           1             164
## [1] tcltk                               base             158           4             162
## [1] boot                                CRAN             161           1             162
## [1] digest                              CRAN             156           0             156
## [1] mgcv                                CRAN             153           2             155
```

The most dependent packages (sorted in the descending order of out-degree)

```
## [1] Page Name                           Type        In-degree Out-degree     Total Degree
## [1] ----------------------------------------------------------------------------------------
## [1] ggnetwork                           CRAN                3         40               43
## [1] dHSIC                               CRAN                1         39               40
## [1] seriation                           CRAN               11         37               48
## [1] Tcomp                               CRAN                0         36               36
## [1] uqr                                 CRAN                0         32               32
## [1] dagR                                CRAN                0         31               31
## [1] merror                              CRAN                0         30               30
## [1] sisVIVE                             CRAN                0         30               30
## [1] pumilioR                            CRAN                0         29               29
## [1] qboxplot                            CRAN                0         29               29
```

Components

The nodes along the first found path of the diameter distance.

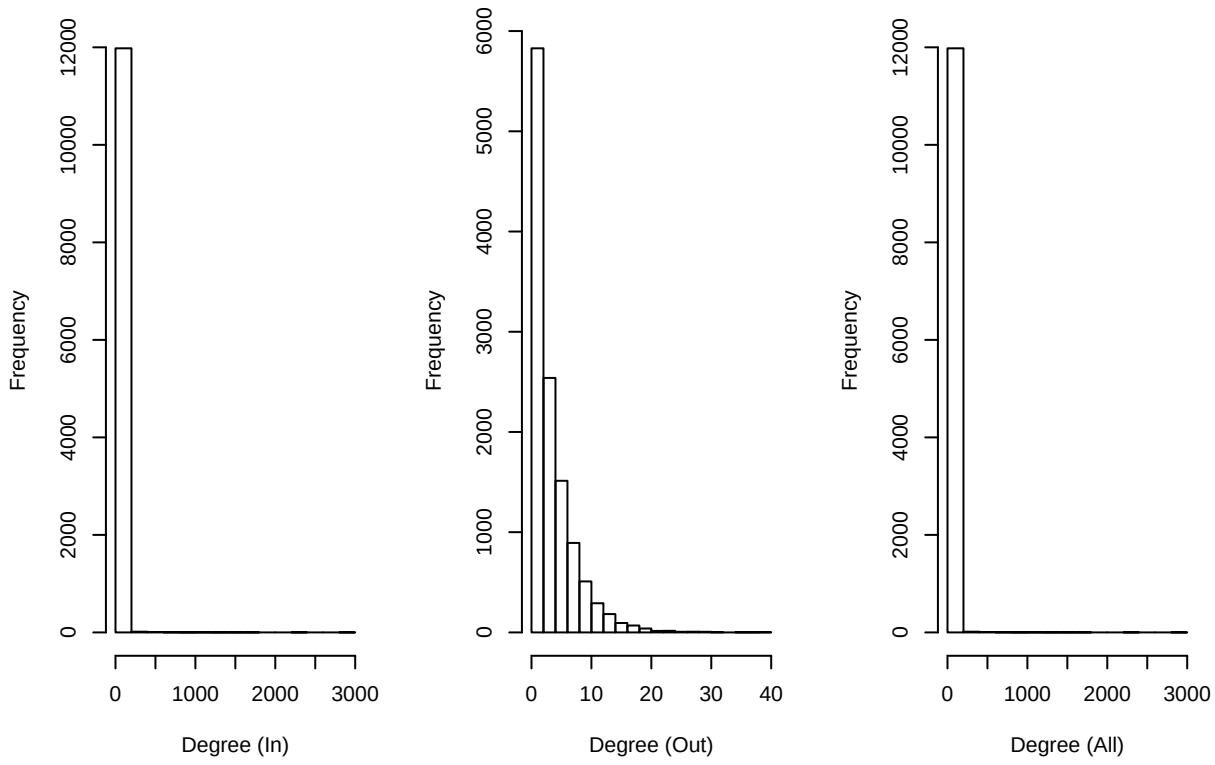
```
V(net)$name[get.diameter(net)]
```

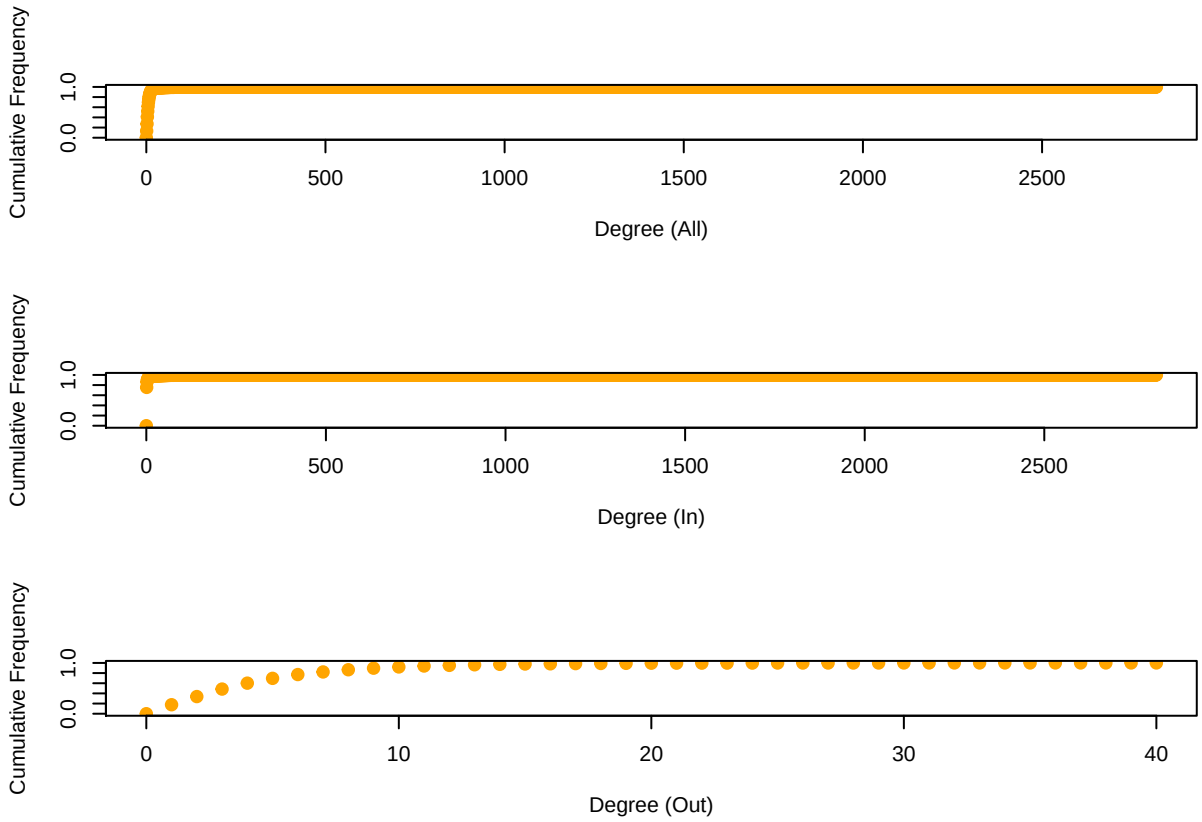
```
##  [1] "adhoc"      "ade4"       "methods"    "corrplot"   "wavethresh"
##  [6] "data.table" "reshape2"   "jsonlite"   "checkmate"  "pls"
## [11] "httpuv"     "fastmatch"  "kinship2"   "ddR"        "Rlibeemd"
## [16] "googleVis"  "sqldf"      "tcltk"      "mosaic"     "move"
## [21] "BiasedUrn"  "mitools"    "daewr"      "picante"    "uuid"
```

Degree

The degree distribution (in-degree, out-degree, total)

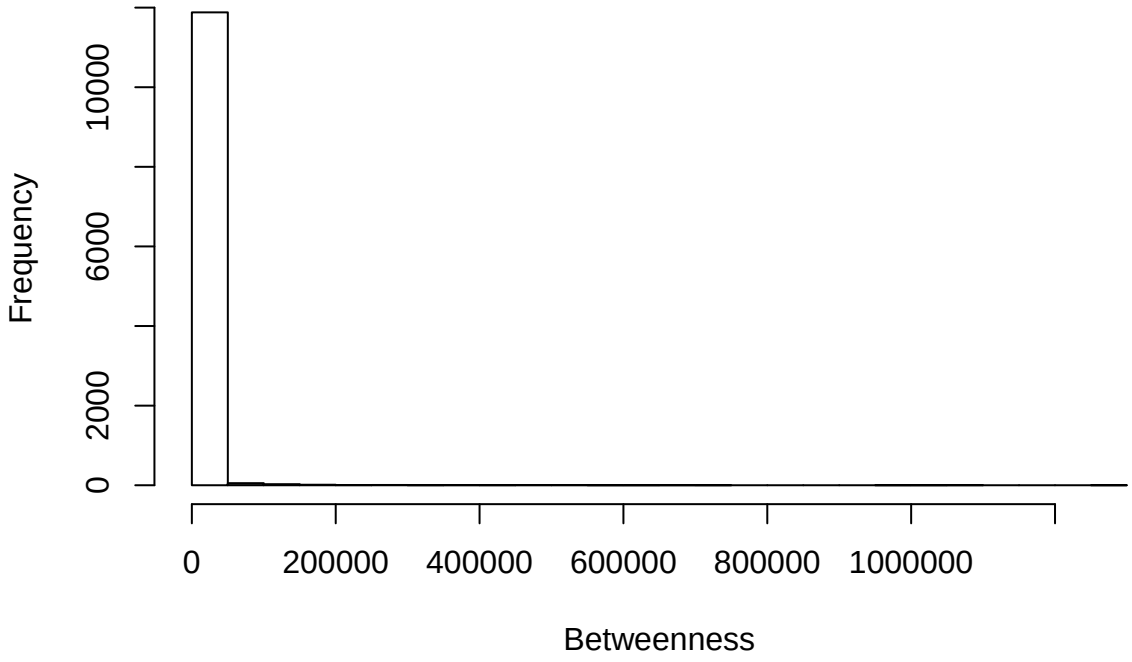
```
# Degree
net_deg_in  <- degree(net, mode = "in")
net_deg_out <- degree(net, mode = "out")
net_deg_all <- degree(net, mode = "all")

par(mfrow = c(1,3))
hist(net_deg_in,  breaks = 20, freq = T, main = "", xlab = "Degree (In)")
hist(net_deg_out, breaks = 20, freq = T, main = "", xlab = "Degree (Out)")
hist(net_deg_all, breaks = 20, freq = T, main = "", xlab = "Degree (All)")
```





Betweenness

```
net_bt = betweenness(net, v = V(net), directed = TRUE)
hist(net_bt, breaks = 30, freq = T, main = "", xlab = "Betweenness")
```




```
# net_eb <- cluster_edge_betweenness(net, directed = TRUE)
# plot_dendrogram(net_eb)
```

Eigen values

Identify key nodes using eigenvector centrality

```
net_ec <- eigen_centrality(net)
which.max(net_ec$vector)
```

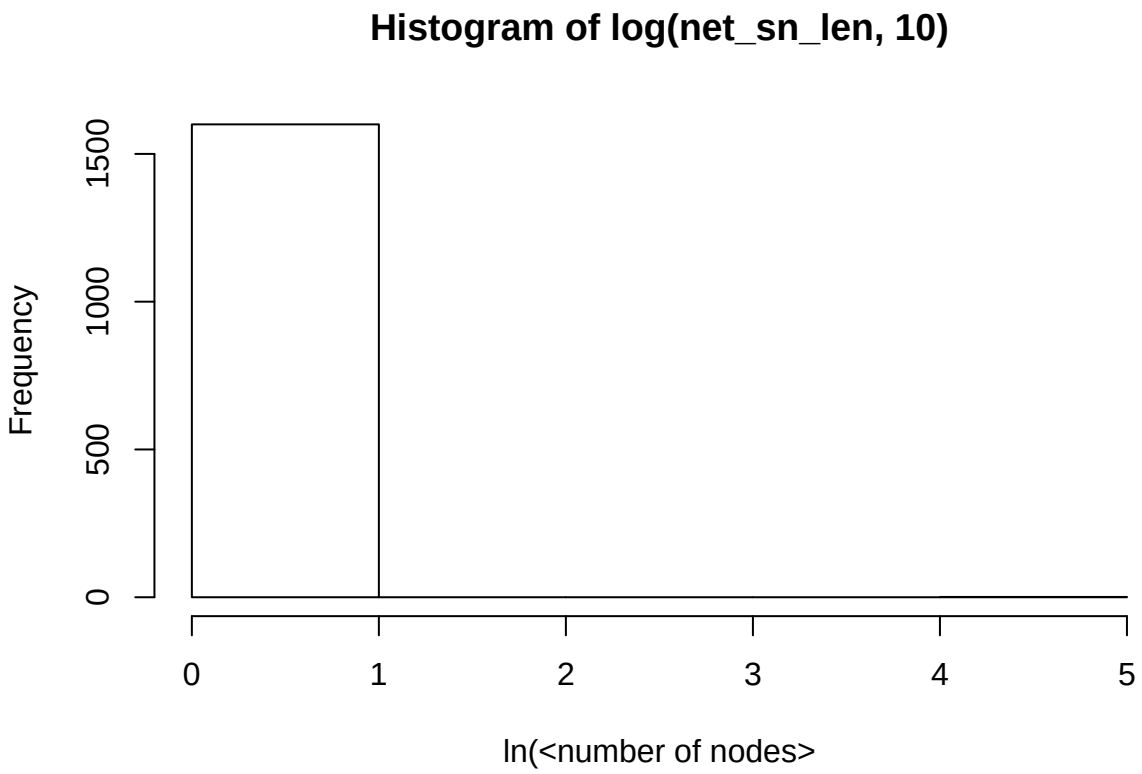
```
## stats
##    10
```

–>

Subnetworks

In trying to determine subnetworks with the we find there are hundrends of one node networks (isolated nodes) and one large subnetwork of 10406 nodes.

That's shown on the histogram below where x is ln of the size of each of those networks



"Do birds of a feather flock together?" (Communities)

TBC...

Determine communities using walktrap algorithm (igraph)

Randomization Tests

We generate 100 random graphs with the same node numbers and the edge density as our network, then compare the average path length of those generated networks with the average path length of our network on the frequency historgram.

TBC...

```
# Calculate the proportion of graphs with an average path length lower than our observed
sum(gr.apls < mean_distance(net))/1000
```

```
## [1] 0.01
```

–>

Visualization

The full network visualization without clustering is not informative. It's all full of nodes and lines.

A partial visualization was made in Gephi with manual configuration for nodes with more than 50 other packages depeding on them. The visual size of nodes reflects the number of in-degrees for that node. The color of node reflects which type ('base', 'CRAN') it belongs to.

This kind of visualization helps to understand what the most referenced packages are, and what are links between themselves.

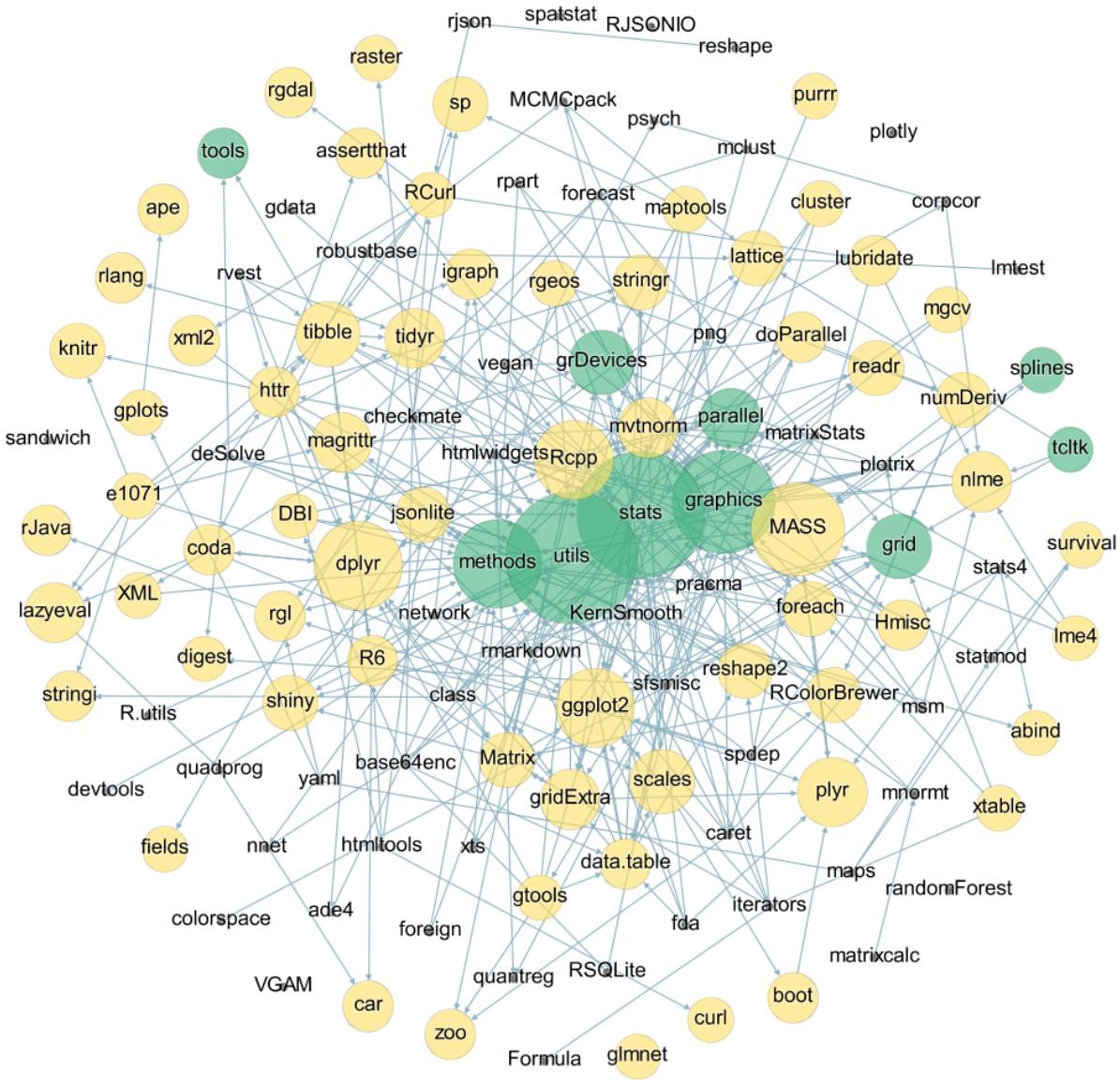


image:

The partial visualization also saved as cran_dep_vis.pdf.

Ideas to Improve Report

1. Give graphs a more elegant look with ggplot2.
2. Dendrogram? Will it work for such a large network?
3. Try the hierarchical clustering.
4. Color the network according the last change date of a package (on the year level).
5. Add additional attribution for nodes like the last change date.
6. Provide more contexual interpretaion of the network.

References

1. The Comprehensive R Archive Network (CRAN): link
2. DataCamp course "Network Analysis in R": link

Appendix A Technical Details of Report

This version of the report was built with:

```
devtools::session_info()
```

```
## Session info -------------------------------------------------------------
```

```
##  setting  value
##  version  R version 3.4.3 (2017-11-30)
##  system   x86_64, mingw32
##  ui       RTerm
##  language en
##  collate  Russian_Russia.1251
##  tz       Europe/Moscow
##  date     2018-01-12
```

```
## Packages -----------------------------------------------------------------
```

```
##  package   * version date       source
##  backports   1.1.2   2017-12-13 CRAN (R 3.4.3)
##  base      * 3.4.3   2017-12-06 local
##  compiler    3.4.3   2017-12-06 local
##  datasets  * 3.4.3   2017-12-06 local
##  devtools    1.13.4  2017-11-09 CRAN (R 3.4.3)
##  digest      0.6.13  2017-12-14 CRAN (R 3.4.3)
##  evaluate    0.10.1  2017-06-24 CRAN (R 3.4.3)
##  graphics  * 3.4.3   2017-12-06 local
##  grDevices * 3.4.3   2017-12-06 local
##  htmltools   0.3.6   2017-04-28 CRAN (R 3.4.3)
##  igraph    * 1.1.2   2017-07-21 CRAN (R 3.4.3)
##  knitr       1.18    2017-12-27 CRAN (R 3.4.3)
##  magrittr    1.5     2014-11-22 CRAN (R 3.4.3)
##  memoise     1.1.0   2017-04-21 CRAN (R 3.4.3)
##  methods   * 3.4.3   2017-12-06 local
##  pkgconfig   2.0.1   2017-03-21 CRAN (R 3.4.3)
##  Rcpp        0.12.14 2017-11-23 CRAN (R 3.4.3)
##  rmarkdown   1.8     2017-11-17 CRAN (R 3.4.3)
##  rprojroot   1.3-1   2017-12-18 CRAN (R 3.4.3)
```

```
##  stats     * 3.4.3   2017-12-06 local
##  stringi     1.1.6   2017-11-17 CRAN (R 3.4.2)
##  stringr     1.2.0   2017-02-18 CRAN (R 3.4.3)
##  tools       3.4.3   2017-12-06 local
##  utils     * 3.4.3   2017-12-06 local
##  withr       2.1.1   2017-12-19 CRAN (R 3.4.3)
##  yaml        2.1.16  2017-12-12 CRAN (R 3.4.3)
```