Associative Rules

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Objective

The objective of this article is to explain how Apriori Algorithm is used in providin recommendations in market basket analysis and, customer purchasing behaviour.

Support(X)= Count(X)/N

confidence(X->Y)= Support(X,Y)/Support(X)

```r
###install.packages("arules")
###install.packages("arulesViz")
###install.packages("fpc")

###library(arules)
###library(arulesViz)
require(arules)
```

```
## Loading required package: arules
```

```
## Warning: package 'arules' was built under R version 3.3.1
```

```
## Loading required package: Matrix
```

```
##
## Attaching package: 'arules'
```

```
## The following objects are masked from 'package:base':
##
##     abbreviate, write
```

```r
require(arulesViz)
```

```
## Loading required package: arulesViz
```

```
## Warning: package 'arulesViz' was built under R version 3.3.1
```

```
## Loading required package: grid
```

```r
data("Groceries")

summary(Groceries)
```

```
## transactions as itemMatrix in sparse format with
##  9835 rows (elements/itemsets/transactions) and
##  169 columns (items) and a density of 0.02609146
##
## most frequent items:
##       whole milk other vegetables       rolls/buns             soda
##             2513             1903             1809             1715
##           yogurt          (Other)
##             1372            34055
##
## element (itemset/transaction) length distribution:
## sizes
##    1    2    3    4    5    6    7    8    9   10   11   12   13   14   15
## 2159 1643 1299 1005  855  645  545  438  350  246  182  117   78   77   55
##   16   17   18   19   20   21   22   23   24   26   27   28   29   32
##   46   29   14   14    9   11    4    6    1    1    1    1    3    1
##
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   1.000   2.000   3.000   4.409   6.000  32.000
##
## includes extended item information - examples:
##        labels  level2           level1
## 1 frankfurter sausage meat and sausage
## 2     sausage sausage meat and sausage
## 3  liver loaf sausage meat and sausage
```

```
class(Groceries)
```

```
## [1] "transactions"
## attr(,"package")
## [1] "arules"
```

```
apply(Groceries@data[,10:20],2, function(r) paste(Groceries@itemInfo[r,"labels"], collapse=", "))
```

```
##  [1] "whole milk, cereals"
##  [2] "tropical fruit, other vegetables, white bread, bottled water, chocolate"
##  [3] "citrus fruit, tropical fruit, whole milk, butter, curd, yogurt, flour, bottled water, dishes"
##  [4] "beef"
##  [5] "frankfurter, rolls/buns, soda"
##  [6] "chicken, tropical fruit"
##  [7] "butter, sugar, fruit/vegetable juice, newspapers"
##  [8] "fruit/vegetable juice"
##  [9] "packaged fruit/vegetables"
## [10] "chocolate"
## [11] "specialty bar"
```

```
itemsets <- apriori(Groceries, parameter = list(minlen=1, maxlen=1, support=0.02, target="frequent item
```

```
## Apriori
##
## Parameter specification:
##  confidence minval smax arem  aval originalSupport maxtime support minlen
##          NA    0.1    1 none FALSE            TRUE       5    0.02      1
##  maxlen            target   ext
##       1 frequent itemsets FALSE
## 
## Algorithmic control:
##  filter tree heap memopt load sort verbose
##     0.1 TRUE TRUE  FALSE TRUE    2    TRUE
## 
## Absolute minimum support count: 196 
## 
## set item appearances ...[0 item(s)] done [0.00s].
## set transactions ...[169 item(s), 9835 transaction(s)] done [0.01s].
## sorting and recoding items ... [59 item(s)] done [0.00s].
## creating transaction tree ... done [0.01s].
## checking subsets of size 1
```

```
## Warning in apriori(Groceries, parameter = list(minlen = 1, maxlen = 1,
## support = 0.02, : Mining stopped (maxlen reached). Only patterns up to a
## length of 1 returned!
```

```
##  done [0.00s].
## writing ... [59 set(s)] done [0.00s].
## creating S4 object  ... done [0.00s].
```

```
summary(itemsets)
```

```
## set of 59 itemsets
## 
## most frequent items:
## frankfurter     sausage         ham        meat     chicken     (Other) 
##           1           1           1           1           1          54 
## 
## element (itemset/transaction) length distribution:sizes
##  1 
## 59 
## 
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max. 
##       1       1       1       1       1       1 
## 
## summary of quality measures:
##     support       
##  Min.   :0.02105  
##  1st Qu.:0.03015  
##  Median :0.04809  
##  Mean   :0.06200  
##  3rd Qu.:0.07666  
##  Max.   :0.25552  
## 
## includes transaction ID lists: FALSE 
## 
## mining info:
##       data ntransactions support confidence
##  Groceries          9835    0.02          1
```

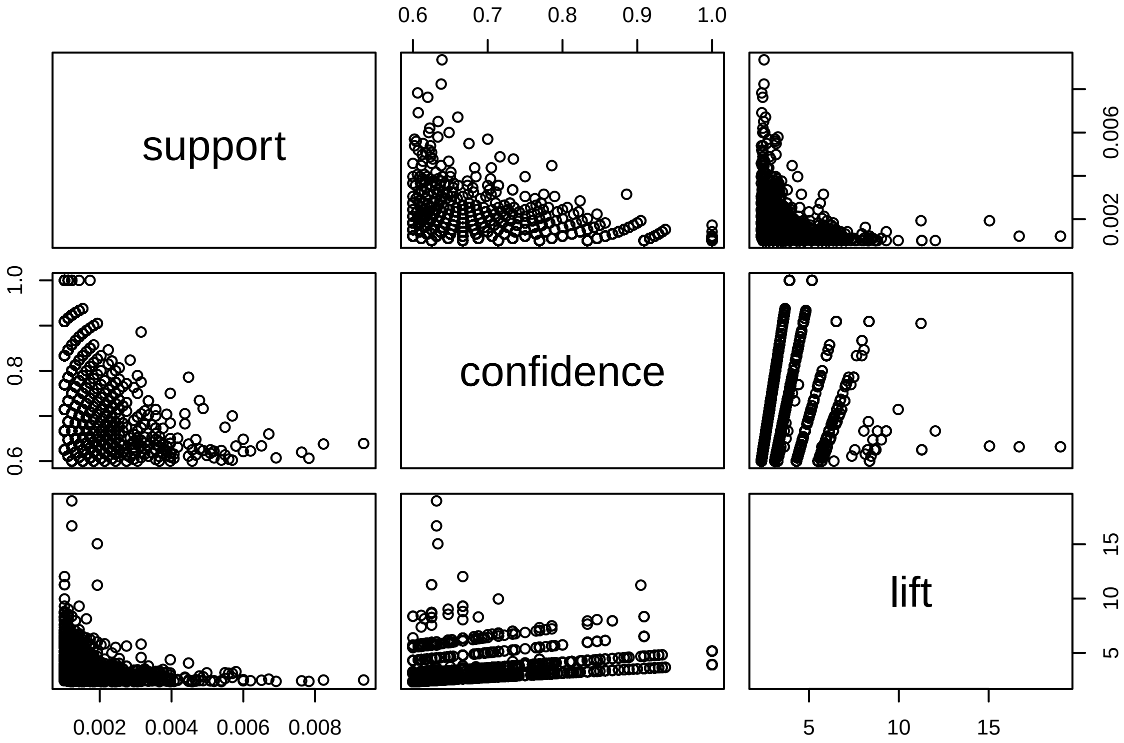
```
inspect(head(sort(itemsets, by = "support"),10))
```

```
##      items               support
## [1]  {whole milk}        0.25551601
## [2]  {other vegetables} 0.19349263
## [3]  {rolls/buns}        0.18393493
## [4]  {soda}              0.17437722
## [5]  {yogurt}            0.13950178
## [6]  {bottled water}     0.11052364
## [7]  {root vegetables}  0.10899847
## [8]  {tropical fruit}   0.10493137
## [9]  {shopping bags}     0.09852567
## [10] {sausage}           0.09395018
```

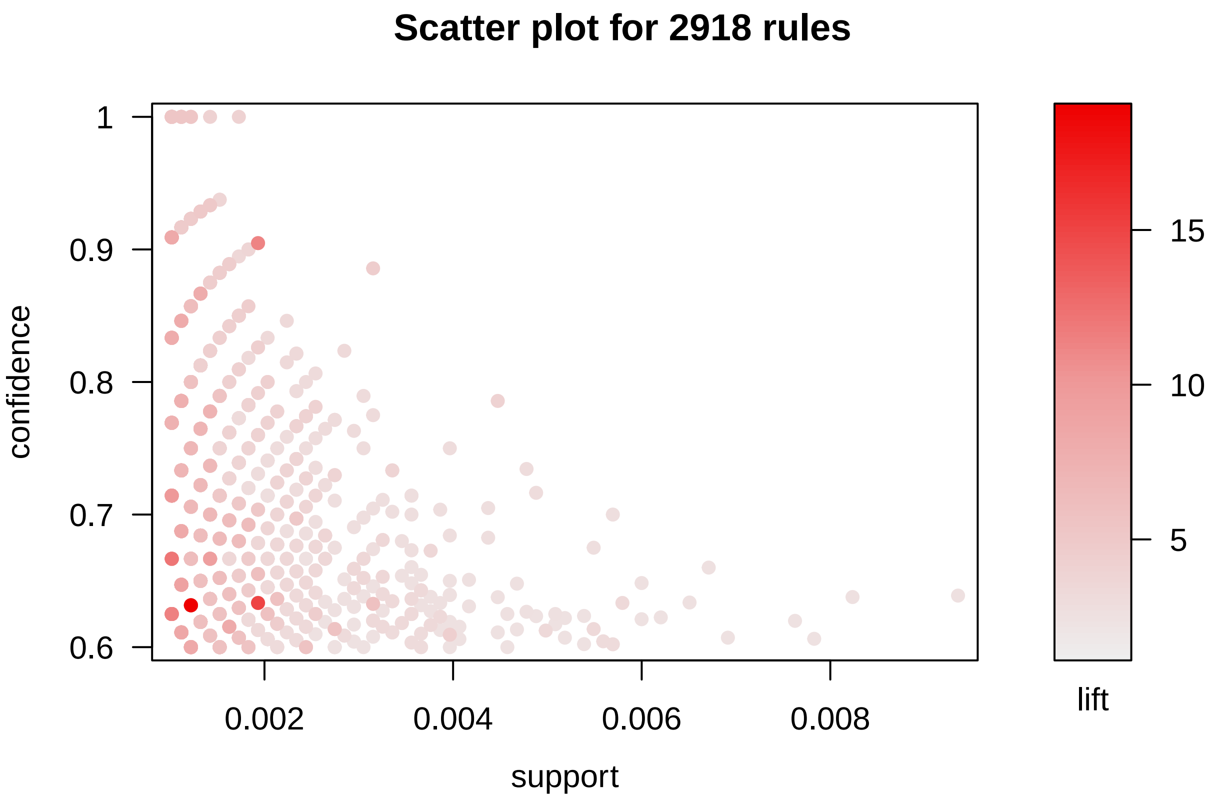
```
rules <- apriori(Groceries, parameter = list(support=0.001, confidence=0.6, target="rules"))
```

```
## Apriori
##
## Parameter specification:
##  confidence minval smax arem  aval originalSupport maxtime support minlen
##         0.6    0.1    1 none FALSE            TRUE       5   0.001      1
##  maxlen target   ext
##      10  rules FALSE
##
## Algorithmic control:
##  filter tree heap memopt load sort verbose
##     0.1 TRUE TRUE  FALSE TRUE    2    TRUE
##
## Absolute minimum support count: 9
##
## set item appearances ...[0 item(s)] done [0.00s].
## set transactions ...[169 item(s), 9835 transaction(s)] done [0.01s].
## sorting and recoding items ... [157 item(s)] done [0.00s].
## creating transaction tree ... done [0.01s].
## checking subsets of size 1 2 3 4 5 6 done [0.04s].
## writing ... [2918 rule(s)] done [0.00s].
## creating S4 object  ... done [0.01s].
```

```
plot(rules@quality)
```


support
confidence
lift
0.6
0.7
0.8
0.9
1.0
0.002
0.006
1.0
0.8
0.6
5
10
15
0.002
0.004
0.006
0.008
5
10
15

```
plot(rules)
```

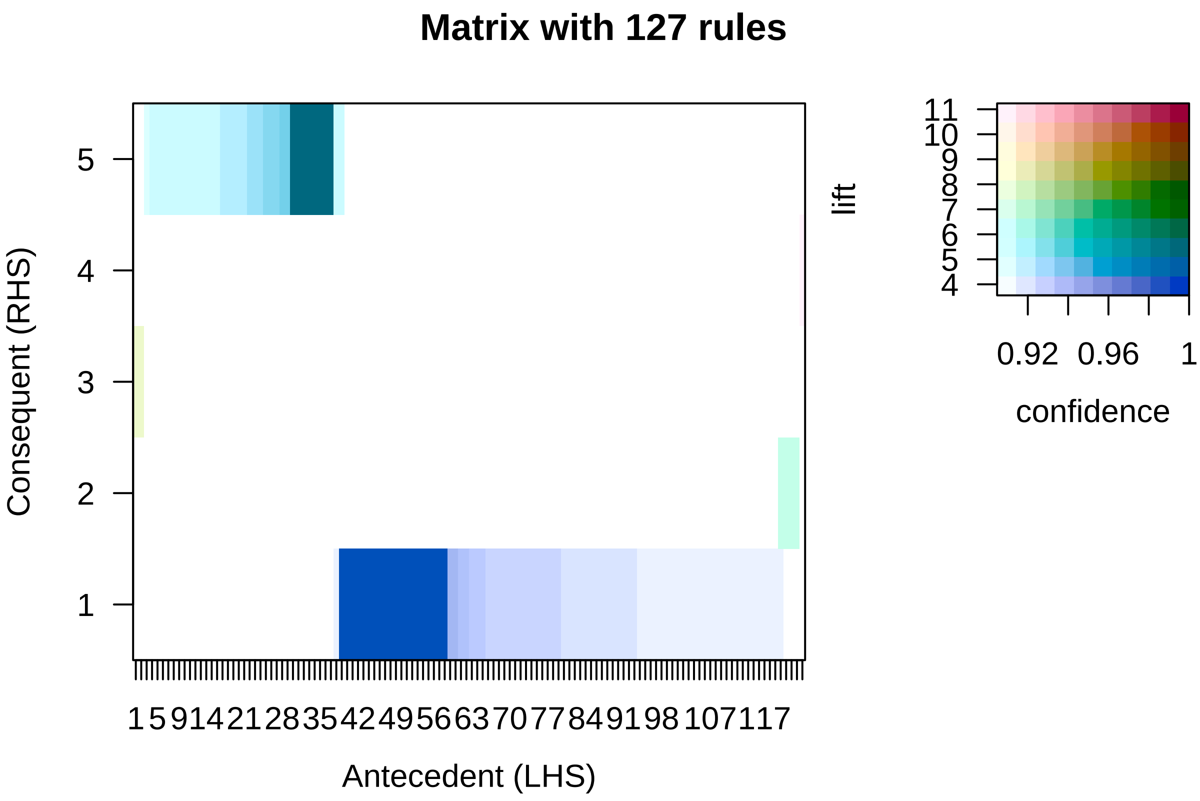


```
confidentRules <- rules[quality(rules)$confidence>0.9]
confidentRules
```

```
## set of 127 rules
```

```
plot(confidentRules, method="matrix", measure=c("lift", "confidence"), control= list(reorder=TRUE))
```

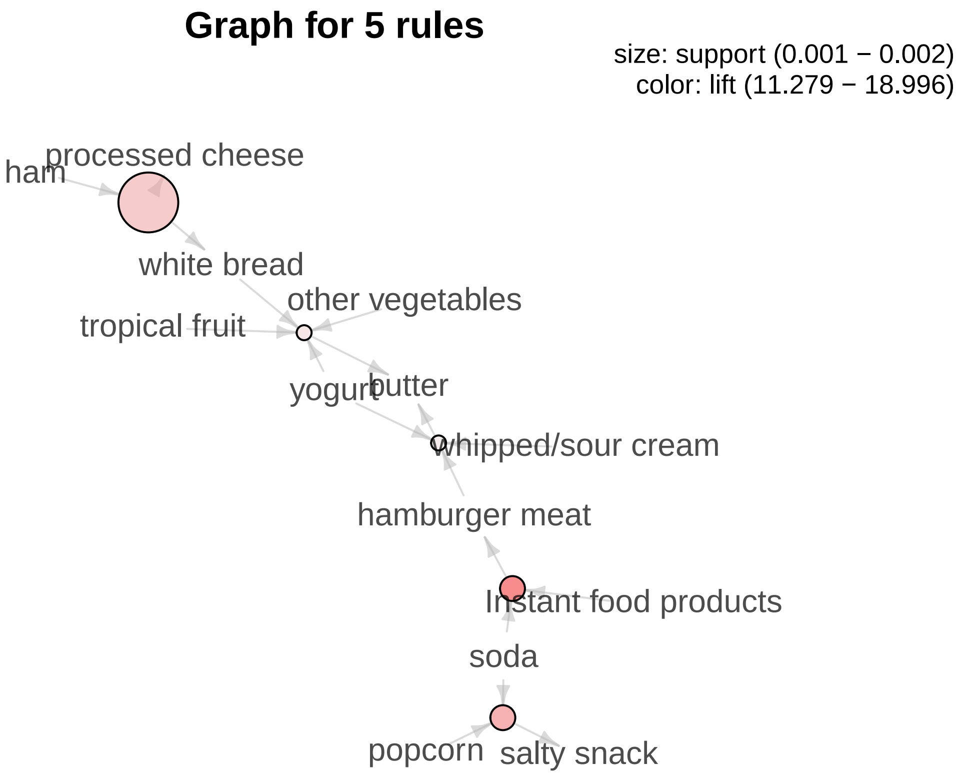
```
## Itemsets in Antecedent (LHS)
##   [1] "{tropical fruit,other vegetables,whole milk,yogurt,oil}"
##   [2] "{citrus fruit,other vegetables,soda,fruit/vegetable juice}"
##   [3] "{tropical fruit,whipped/sour cream,fruit/vegetable juice}"
##   [4] "{whole milk,butter,whipped/sour cream,soda}"
##   [5] "{tropical fruit,root vegetables,whole milk,yogurt,oil}"
##   [6] "{tropical fruit,whipped/sour cream,hard cheese}"
##   [7] "{yogurt,oil,coffee}"
##   [8] "{hamburger meat,tropical fruit,whipped/sour cream}"
##   [9] "{herbs,whole milk,fruit/vegetable juice}"
##  [10] "{root vegetables,whole milk,butter,white bread}"
##  [11] "{tropical fruit,whole milk,whipped/sour cream,fruit/vegetable juice}"
##  [12] "{tropical fruit,butter,yogurt,white bread}"
##  [13] "{pork,whole milk,butter milk}"
##  [14] "{root vegetables,onions,napkins}"
##  [15] "{pip fruit,butter milk,fruit/vegetable juice}"
##  [16] "{citrus fruit,root vegetables,whole milk,yogurt,whipped/sour cream}"
##  [17] "{citrus fruit,whole milk,whipped/sour cream,cream cheese }"
## [18] "{hard cheese,oil}"
## [19] "{tropical fruit,dessert,whipped/sour cream}"
## [20] "{grapes,onions}"
## [21] "{tropical fruit,yogurt,whipped/sour cream,fruit/vegetable juice}"
## [22] "{citrus fruit,whole milk,whipped/sour cream,domestic eggs}"
## [23] "{tropical fruit,whipped/sour cream,soft cheese}"
## [24] "{citrus fruit,root vegetables,cream cheese }"
## [25] "{pip fruit,butter,pastry}"
## [26] "{butter,whipped/sour cream,soda}"
## [27] "{root vegetables,whole milk,yogurt,rice}"
## [28] "{root vegetables,whole milk,yogurt,oil}"
## [29] "{citrus fruit,tropical fruit,root vegetables,whole milk,yogurt}"
## [30] "{citrus fruit,root vegetables,soft cheese}"
## [31] "{pip fruit,whipped/sour cream,brown bread}"
## [32] "{ham,tropical fruit,pip fruit,whole milk}"
## [33] "{tropical fruit,grapes,whole milk,yogurt}"
## [34] "{whole milk,rolls/buns,soda,newspapers}"
## [35] "{citrus fruit,tropical fruit,root vegetables,whipped/sour cream}"
## [36] "{tropical fruit,butter,whipped/sour cream,fruit/vegetable juice}"
## [37] "{ham,tropical fruit,pip fruit,yogurt}"
## [38] "{frankfurter,tropical fruit,frozen meals}"
## [39] "{tropical fruit,root vegetables,yogurt,oil}"
## [40] "{butter,soft cheese,domestic eggs}"
## [41] "{root vegetables,other vegetables,yogurt,oil}"
## [42] "{root vegetables,whipped/sour cream,hygiene articles}"
## [43] "{pork,other vegetables,butter,whipped/sour cream}"
## [44] "{sausage,tropical fruit,root vegetables,rolls/buns}"
## [45] "{curd,domestic eggs,sugar}"
## [46] "{canned fish,hygiene articles}"
## [47] "{citrus fruit,whipped/sour cream,rolls/buns,pastry}"
## [48] "{root vegetables,other vegetables,butter,white bread}"
## [49] "{tropical fruit,root vegetables,other vegetables,yogurt,oil}"
## [50] "{pip fruit,butter,hygiene articles}"
## [51] "{cream cheese ,domestic eggs,napkins}"
## [52] "{pip fruit,root vegetables,hygiene articles}"
## [53] "{other vegetables,butter,whipped/sour cream,domestic eggs}"
## [54] "{rice,sugar}"
## [55] "{cream cheese ,domestic eggs,sugar}"
## [56] "{pip fruit,root vegetables,other vegetables,bottled water}"
## [57] "{root vegetables,whipped/sour cream,flour}"
## [58] "{root vegetables,butter,rice}"
## [59] "{sausage,tropical fruit,root vegetables,yogurt}"
## [60] "{other vegetables,cream cheese ,sugar}"
## [61] "{yogurt,domestic eggs,sugar}"
## [62] "{citrus fruit,domestic eggs,sugar}"
## [63] "{root vegetables,other vegetables,yogurt,rice}"
## [64] "{beef,tropical fruit,yogurt,rolls/buns}"
## [65] "{pip fruit,whipped/sour cream,cream cheese }"
## [66] "{root vegetables,whipped/sour cream,sugar}"
## [67] "{tropical fruit,domestic eggs,hygiene articles}"
## [68] "{pip fruit,other vegetables,whipped/sour cream,domestic eggs}"
## [69] "{pip fruit,root vegetables,other vegetables,brown bread}"
## [70] "{frankfurter,tropical fruit,root vegetables,yogurt}"
## [71] "{root vegetables,whipped/sour cream,soft cheese}"
##  [72] "{tropical fruit,butter,hygiene articles}"
##  [73] "{root vegetables,other vegetables,yogurt,hard cheese}"
##  [74] "{tropical fruit,long life bakery product,napkins}"
##  [75] "{rice,bottled water}"
##  [76] "{butter,whipped/sour cream,sliced cheese}"
##  [77] "{butter,whipped/sour cream,coffee}"
##  [78] "{tropical fruit,butter,yogurt,domestic eggs}"
##  [79] "{whipped/sour cream,house keeping products}"
##  [80] "{root vegetables,butter,white bread}"
##  [81] "{citrus fruit,tropical fruit,herbs}"
##  [82] "{tropical fruit,yogurt,whipped/sour cream,domestic eggs}"
##  [83] "{citrus fruit,butter,curd}"
##  [84] "{domestic eggs,margarine,fruit/vegetable juice}"
##  [85] "{tropical fruit,other vegetables,whipped/sour cream,domestic eggs}"
##  [86] "{pip fruit,other vegetables,yogurt,cream cheese }"
##  [87] "{tropical fruit,curd,yogurt,domestic eggs}"
##  [88] "{tropical fruit,root vegetables,rolls/buns,bottled water}"
##  [89] "{butter,curd,domestic eggs}"
##  [90] "{root vegetables,butter,yogurt,domestic eggs}"
##  [91] "{pip fruit,root vegetables,yogurt,fruit/vegetable juice}"
##  [92] "{soups,bottled beer}"
##  [93] "{tropical fruit,domestic eggs,sugar}"
##  [94] "{tropical fruit,root vegetables,yogurt,pastry}"
##  [95] "{root vegetables,other vegetables,rolls/buns,brown bread}"
##  [96] "{citrus fruit,other vegetables,yogurt,frozen vegetables}"
##  [97] "{pork,rolls/buns,waffles}"
##  [98] "{sausage,butter,long life bakery product}"
##  [99] "{pip fruit,root vegetables,other vegetables,cream cheese }"
## [100] "{citrus fruit,other vegetables,butter,bottled water}"
## [101] "{root vegetables,domestic eggs,coffee}"
## [102] "{tropical fruit,pip fruit,yogurt,frozen meals}"
## [103] "{sausage,pip fruit,cream cheese }"
## [104] "{whipped/sour cream,long life bakery product,napkins}"
## [105] "{tropical fruit,butter,yogurt,sliced cheese}"
## [106] "{sausage,berries,butter}"
## [107] "{root vegetables,other vegetables,yogurt,waffles}"
## [108] "{tropical fruit,other vegetables,butter,yogurt,domestic eggs}"
## [109] "{butter,hygiene articles,napkins}"
## [110] "{tropical fruit,butter,frozen meals}"
## [111] "{citrus fruit,tropical fruit,other vegetables,domestic eggs}"
## [112] "{domestic eggs,margarine,bottled beer}"
## [113] "{other vegetables,butter,whipped/sour cream,napkins}"
## [114] "{tropical fruit,root vegetables,herbs,other vegetables}"
## [115] "{citrus fruit,tropical fruit,curd,yogurt}"
## [116] "{frankfurter,root vegetables,sliced cheese}"
## [117] "{curd,cereals}"
## [118] "{pork,root vegetables,other vegetables,butter}"
## [119] "{pastry,sweet spreads}"
## [120] "{root vegetables,butter,cream cheese }"
## [121] "{other vegetables,curd,whipped/sour cream,cream cheese }"
## [122] "{tropical fruit,other vegetables,butter,white bread}"
## [123] "{tropical fruit,whole milk,butter,sliced cheese}"
## [124] "{liquor,red/blush wine}"
## Itemsets in Consequent (RHS)
## [1] "{whole milk}"       "{yogurt}"           "{root vegetables}"
## [4] "{bottled beer}"     "{other vegetables}"
```



```r
highLiftRules <- head(sort(rules, by="lift"),5)
plot(highLiftRules, method = "graph", control = list(types="items"))
```

```
## Warning: Unknown control parameters: types

## Available control parameters (with default values):
## main  =  Graph for 5 rules
## nodeColors    =  c("#66CC6680", "#9999CC80")
## nodeCol   =  c("#EE0000FF", "#EE0303FF", "#EE0606FF", "#EE0909FF", "#EE0C0CFF", "#EE0F0FFF", "#EE121
## edgeCol   =  c("#474747FF", "#494949FF", "#4B4B4BFF", "#4D4D4DFF", "#4F4F4FFF", "#515151FF", "#53535
## alpha     =  0.5
## cex   =  1
## itemLabels    =  TRUE
## labelCol  =  #000000B3
## measureLabels     =  FALSE
## precision     =  3
## type  =  items
## layout    =  NULL
## layoutParams  =  list()
## arrowSize     =  0.5
## interactive   =  FALSE
## engine    =  igraph
## plot  =  TRUE
## verbose   =  FALSE
```


Graph for 5 rules
size: support (0.001 − 0.002)
color: lift (11.279 − 18.996)
ham
processed cheese
white bread
other vegetables
tropical fruit
yogurt
butter
whipped/sour cream
hamburger meat
Instant food products
soda
popcorn
salty snack