MAX 503 Exam Project | Elizabeth and Rosemary | 5-1-23

1 a

```
data(iris)
str(iris)
```

```
## 'data.frame':    150 obs. of  5 variables:
##  $ Sepal.Length: num  5.1 4.9 4.7 4.6 5 5.4 4.6 5 4.4 4.9 ...
##  $ Sepal.Width : num  3.5 3 3.2 3.1 3.6 3.9 3.4 3.4 2.9 3.1 ...
##  $ Petal.Length: num  1.4 1.4 1.3 1.5 1.4 1.7 1.4 1.5 1.4 1.5 ...
##  $ Petal.Width : num  0.2 0.2 0.2 0.2 0.2 0.4 0.3 0.2 0.2 0.1 ...
##  $ Species     : Factor w/ 3 levels "setosa","versicolor",..: 1 1 1 1 1 1 1 1 1 1 ...
```

b The steps in classification are (1) collect data with predictors and outcome, (2) divide the observations into training and test cases, the training data set is used to train the model, while the test data set used to evaluate the model's performance, (3) use training cases to fit a model predicting the outcomes, (4) confirm that the model works well for test cases,also referred to evaluating the performance using metrics such as accuracy,precision,recall, and F1 score to assess how the model performs of unseen data,and (5) apply the model to new data to obtain predictions which involves using untrained model classify new instances based on their input variables.

c

```
species.summ <- function(data, groups) {
  aggregate(data, list(groups), function(x) mean(as.numeric(x)))
}
```

d

```
# make it repeatable
set.seed(04625)

# train on 65% of data. Hold 35% for testing
train.prop <- 0.65
train.cases <- sample(nrow(iris), nrow(iris)*train.prop)

species.df.train <- iris[ train.cases, ]
species.df.test  <- iris[-train.cases, ]
```

e Naive Bayes classification method uses training data in order to learn the probability of class membership as a function of each predictor variable considered independently. Basically, it computes conditional probabilities in the training data.

f

```
library(e1071)
```

```
## Warning: package 'e1071' was built under R version 4.2.3
```

```
(species.nb <- naiveBayes(Species~.,data=species.df.train))
```

```
##
## Naive Bayes Classifier for Discrete Predictors
##
## Call:
## naiveBayes.default(x = X, y = Y, laplace = laplace)
##
## A-priori probabilities:
## Y
##     setosa versicolor  virginica
##  0.3092784  0.3402062  0.3505155
##
## Conditional probabilities:
##             Sepal.Length
## Y                [,1]      [,2]
##   setosa     5.053333 0.3626848
##   versicolor 5.903030 0.5462857
##   virginica  6.591176 0.6215170
##
##             Sepal.Width
## Y                [,1]      [,2]
##   setosa     3.543333 0.3654787
##   versicolor 2.800000 0.3344772
##   virginica  3.002941 0.3019987
##
##             Petal.Length
## Y                [,1]      [,2]
##   setosa     1.476667 0.1654322
##   versicolor 4.260606 0.5302944
##   virginica  5.526471 0.5478934
##
##             Petal.Width
## Y                 [,1]      [,2]
##   setosa     0.2466667 0.1008014
##   versicolor 1.3151515 0.2237761
##   virginica  2.0529412 0.2537420
```

```
# predicting species membership
species.nb.class<-predict(species.nb,species.df.train)

prop.table(table(species.nb.class))
```

```
## species.nb.class
##     setosa versicolor  virginica
##  0.3092784  0.3298969  0.3608247
```

This means that in the train data prediction, 30.93% are setosa, 32.99% are versicolor, and 36.08% are virginica.

g

```
mean(species.df.train$Species==species.nb.class)
```

```
## [1] 0.9690722
```

```
library(mclust)
```

```
## Warning: package 'mclust' was built under R version 4.2.3

## Package 'mclust' version 6.0.0
## Type 'citation("mclust")' for citing this R package in publications.
```

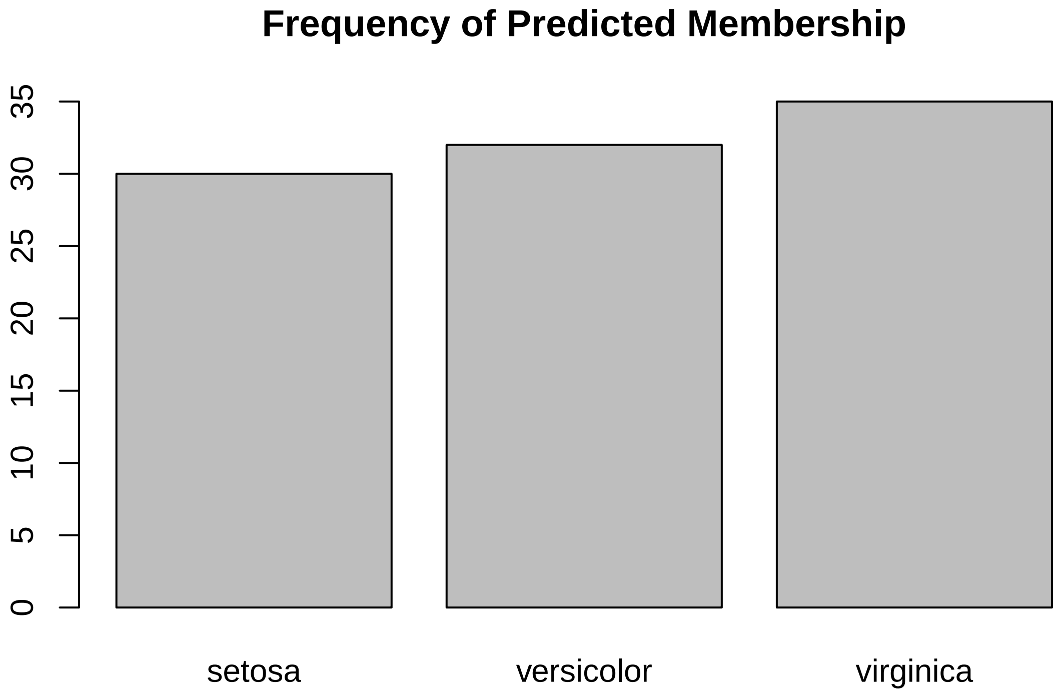
```
adjustedRandIndex(species.nb.class,species.df.train$Species)
```

```
## [1] 0.9063881
```

The results are very high for both as they are in the 90th percent. This means there was excellent data recovery and the two data clusters match almost perfectly.

h

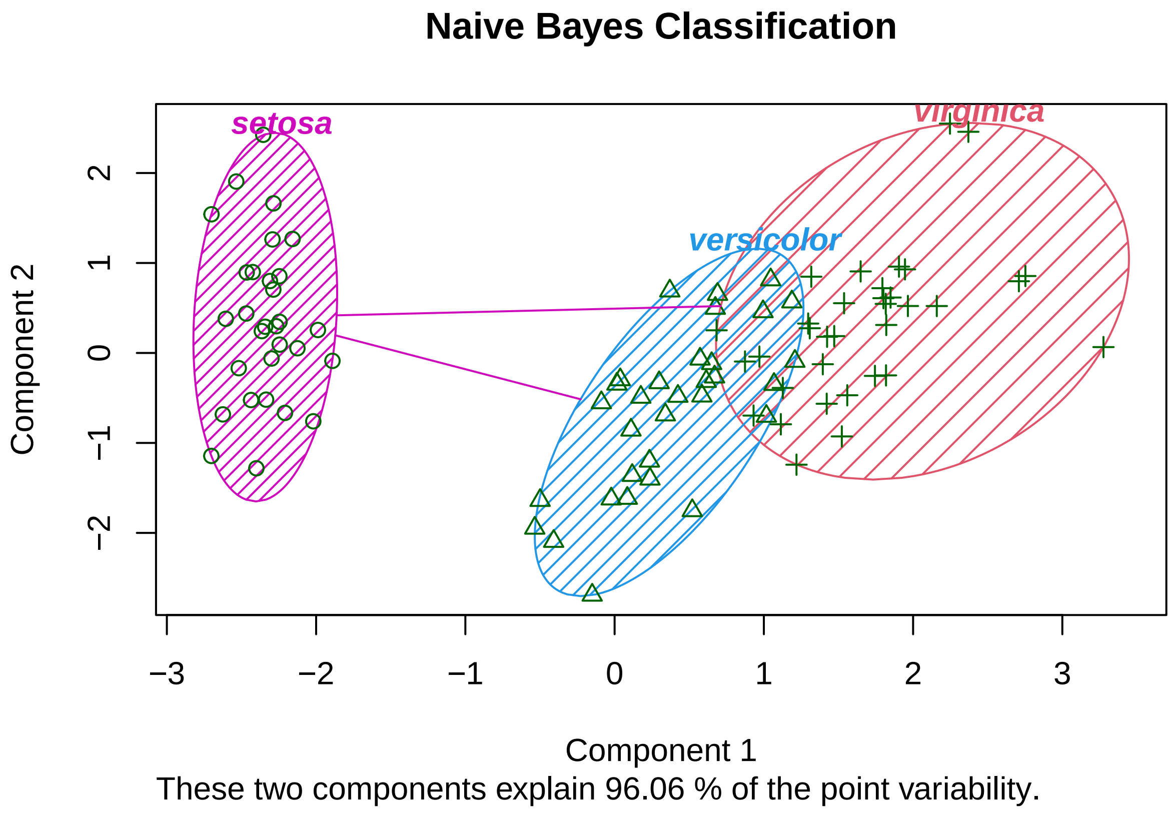
```
barplot(table(species.nb.class),
        main = "Frequency of Predicted Membership")
```



They are all very close together, with virginica having the highest count.

i

```
library(cluster)
clusplot(species.df.train[, -5],
         species.nb.class,
         color = TRUE,
         shade = TRUE,
         labels = 4,
         main = "Naive Bayes Classification")
```



j1

```
# raw correct proportions
species.nb.class.test<-predict(species.nb,species.df.test)
mean(species.df.test$Species == species.nb.class.test)
```

```
## [1] 0.9433962
```

The predicted membership is very close to the known species as there is a 94% agreement between predicted and actual species membership.

j2

```
library(mclust)
adjustedRandIndex(species.nb.class.test, species.df.test$Species)
```

```
## [1] 0.8518591
```

The adjusted random index yields 85% which isn't as high but it's a better indicator and is still high.

j3

```
#confusion matrix
table(species.nb.class.test, species.df.test$Species)
```

```
##
## species.nb.class.test setosa versicolor virginica
##            setosa         20          0         0
##            versicolor      0         17         3
##            virginica       0          0        13
```

Setosa was predicted correctly 20 out of 20 times. Versicolor was predicted 17 out of 17 times. However, virginica was predicted correctly 13 out of 16 times, which is an 81.25% success rate.

j4

```
species.summ(species.df.test,species.nb.class.test)
```

```
##      Group.1 Sepal.Length Sepal.Width Petal.Length Petal.Width Species
## 1     setosa     4.935000    3.255000     1.440000    0.245000    1.00
## 2 versicolor     5.950000    2.670000     4.375000    1.375000    2.15
## 3  virginica     6.792308    3.023077     5.738462    2.069231    3.00
```

```
species.summ(species.df.test,species.df.test$Species)
```

```
##      Group.1 Sepal.Length Sepal.Width Petal.Length Petal.Width Species
## 1     setosa      4.93500    3.255000     1.440000    0.245000       1
## 2 versicolor      6.00000    2.711765     4.258824    1.347059       2
## 3  virginica      6.58125    2.912500     5.606250    1.968750       3
```

j5

```
mean(species.df.test$Species == species.nb.class.test)
```

```
## [1] 0.9433962
```

This is very high as it means there is a 94% agreement between actual and predicted values in the test data.

k

```
predict(species.nb,species.df.test,type = "raw")
```

```
##              setosa   versicolor    virginica
##  [1,]  1.000000e+00 1.382240e-13 1.228564e-26
##  [2,]  1.000000e+00 1.180140e-13 1.359806e-26
##  [3,]  1.000000e+00 3.709144e-14 9.233836e-27
##  [4,]  1.000000e+00 4.759290e-14 3.833709e-27
##  [5,]  1.000000e+00 8.195480e-14 2.387935e-26
##  [6,]  1.000000e+00 2.865063e-14 1.231276e-27
##  [7,]  1.000000e+00 6.323988e-12 2.099984e-23
##  [8,]  1.000000e+00 1.458226e-15 4.987077e-29
##  [9,]  1.000000e+00 2.767393e-14 6.082124e-27
## [10,]  1.000000e+00 2.448785e-11 4.031202e-23
## [11,]  1.000000e+00 1.883127e-13 2.844692e-26
## [12,]  1.000000e+00 2.345325e-14 1.573437e-27
## [13,]  1.000000e+00 2.793732e-14 7.080749e-27
## [14,]  1.000000e+00 4.427492e-14 1.822954e-27
## [15,]  1.000000e+00 1.667236e-11 2.451299e-25
## [16,]  1.000000e+00 4.147900e-08 3.126962e-19
## [17,]  1.000000e+00 5.494669e-10 3.362963e-21
## [18,]  1.000000e+00 9.828742e-13 1.552929e-25
## [19,]  1.000000e+00 2.608771e-14 2.444105e-27
## [20,]  1.000000e+00 2.843786e-14 4.426494e-27
## [21,]  3.415948e-76 9.999860e-01 1.399747e-05
## [22,] 1.263282e-114 9.549057e-01 4.509432e-02
## [23,] 4.734906e-105 9.931738e-01 6.826196e-03
## [24,]  1.766340e-75 9.999390e-01 6.098779e-05
## [25,]  1.252706e-93 9.961365e-01 3.863490e-03
## [26,] 3.952617e-100 9.832728e-01 1.672721e-02
## [27,] 5.072023e-110 9.970336e-01 2.966354e-03
## [28,] 6.177117e-130 9.500520e-01 4.994795e-02
## [29,] 5.758707e-100 9.888023e-01 1.119766e-02
## [30,]  1.540545e-45 9.999998e-01 2.370173e-07
## [31,]  1.098686e-67 9.999849e-01 1.513397e-05
## [32,] 4.250388e-106 9.937909e-01 6.209060e-03
## [33,]  9.326279e-96 9.996879e-01 3.120651e-04
## [34,]  6.851686e-72 9.999822e-01 1.779191e-05
## [35,]  6.819023e-84 9.998833e-01 1.166708e-04
## [36,]  1.715284e-89 9.991936e-01 8.064462e-04
## [37,]  1.252491e-79 9.998865e-01 1.134839e-04
## [38,] 2.346792e-233 4.337145e-06 9.999957e-01
## [39,] 1.162732e-117 9.865850e-01 1.341502e-02
## [40,] 6.516021e-244 2.255931e-05 9.999774e-01
## [41,] 6.045580e-205 2.876828e-03 9.971232e-01
## [42,] 1.837789e-283 7.414914e-10 1.000000e+00
## [43,] 5.544553e-173 1.436212e-03 9.985638e-01
## [44,] 4.927745e-207 3.798356e-05 9.999620e-01
## [45,] 5.478560e-135 9.827120e-01 1.728801e-02
## [46,] 8.805394e-237 3.995475e-07 9.999996e-01
## [47,] 1.503253e-292 7.654235e-08 9.999999e-01
## [48,] 2.642143e-147 1.878444e-01 8.121556e-01
## [49,] 6.229840e-237 1.329534e-05 9.999867e-01
## [50,] 5.937513e-165 7.635349e-01 2.364651e-01
## [51,] 1.815179e-235 3.967125e-07 9.999996e-01
## [52,] 7.357992e-250 2.060379e-07 9.999998e-01
## [53,] 1.560667e-156 9.928176e-02 9.007182e-01
```

l

```
library(randomForest)
```

```
## Warning: package 'randomForest' was built under R version 4.2.3
```

```
## randomForest 4.7-1.1
```

```
## Type rfNews() to see new features/changes/bug fixes.
```

```
set.seed(98040)
species.rf <- randomForest(Species~.,data=species.df.train,ntree=1500)
```

m

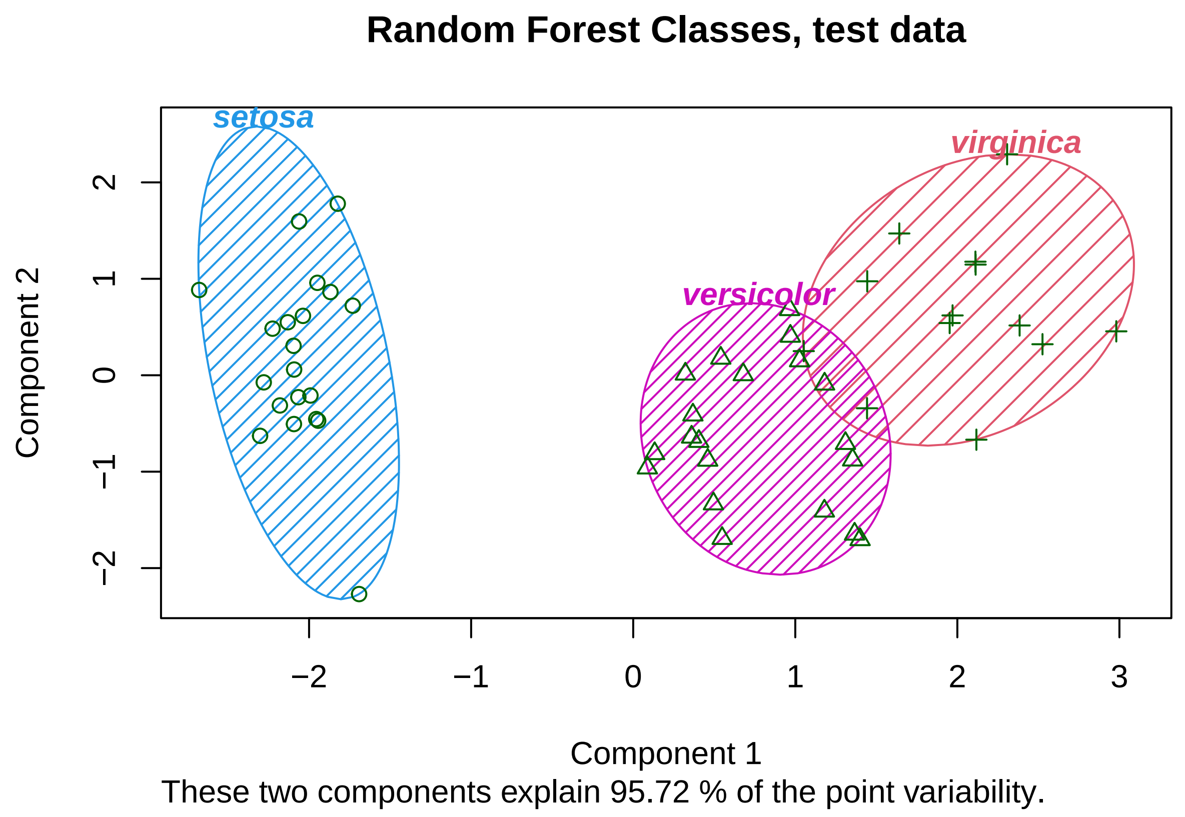
```
species.rf
```

```
##
## Call:
##  randomForest(formula = Species ~ ., data = species.df.train,      ntree = 1500)
##                Type of random forest: classification
##                      Number of trees: 1500
## No. of variables tried at each split: 2
##
##         OOB estimate of  error rate: 6.19%
## Confusion matrix:
##            setosa versicolor virginica class.error
## setosa         30          0         0  0.00000000
## versicolor      0         30         3  0.09090909
## virginica       0          3        31  0.08823529
```

It was correct 94% as the error rate is about 6%. For setosa it was correct 100% and this was the best. It was also nearly perfect for versicolor and virginica, with versicolor being slightly worse.

n

```
species.rf.class <- predict(species.rf, species.df.test)
library(cluster)
clusplot(species.df.test[,-5],species.rf.class, color = TRUE, shade = TRUE, labels = 4, lines = 0, main
```



o1

```
# proposed speciesments
species.summ(species.df.test, species.rf.class)
```

```
##      Group.1 Sepal.Length Sepal.Width Petal.Length Petal.Width Species
## 1     setosa     4.935000    3.255000     1.440000    0.245000    1.00
## 2 versicolor     5.950000    2.670000     4.375000    1.375000    2.15
## 3  virginica     6.792308    3.023077     5.738462    2.069231    3.00
```

```
# actual speciesments
species.summ(species.df.test, species.df.test$Species)
```

```
##      Group.1 Sepal.Length Sepal.Width Petal.Length Petal.Width Species
## 1     setosa      4.93500    3.255000     1.440000    0.245000       1
## 2 versicolor      6.00000    2.711765     4.258824    1.347059       2
## 3  virginica      6.58125    2.912500     5.606250    1.968750       3
```

o2

```
mean(species.df.test$Species == species.rf.class)
```

```
## [1] 0.9433962
```

This is very good as it means there is 94% agreement between actual and predicted species membership.

o3

```
# confusion matrix
table(species.df.test$Species, species.rf.class)
```

```
##             species.rf.class
##              setosa versicolor virginica
##   setosa         20          0         0
##   versicolor      0         17         0
##   virginica       0          3        13
```

Setosa was predicted correctly 20 out of 20 times. Versicolor was predicted 17 out of 20 times with a success rate of 85%. Virginica was predicted correctly 13 out of 13 times.

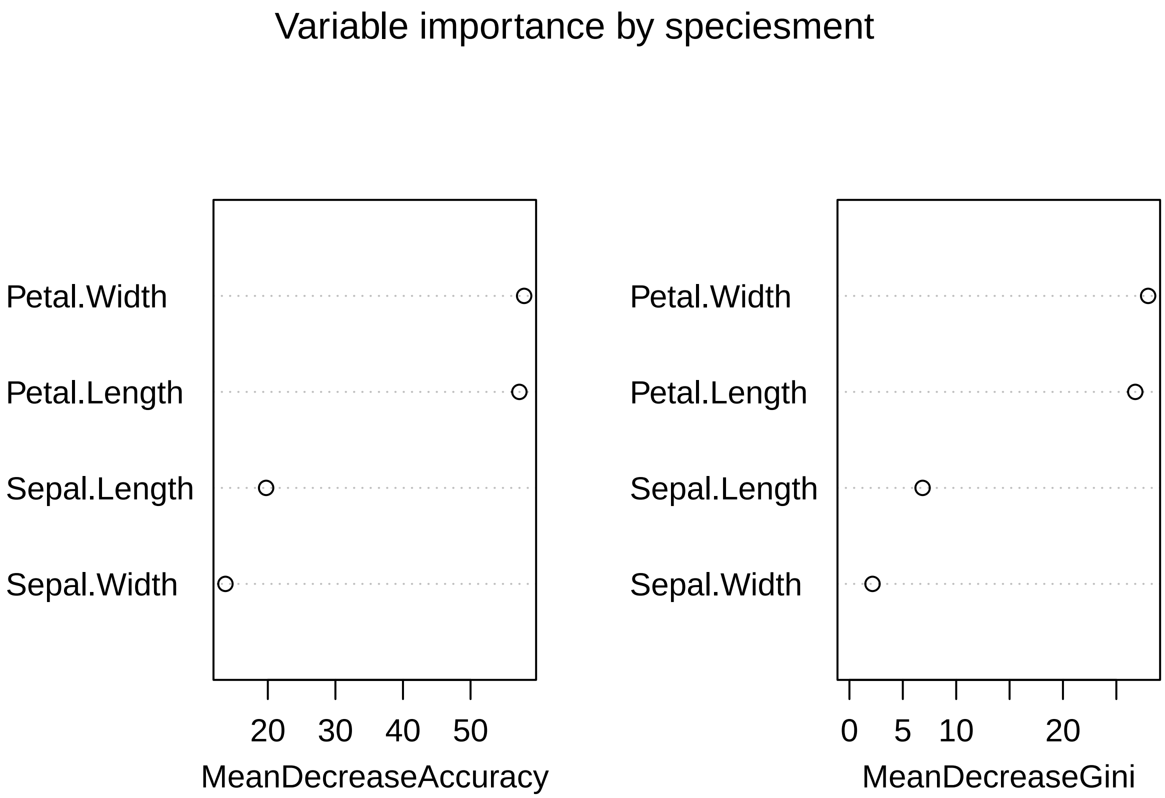
p

```
set.seed(98040)
species.rf<-randomForest(Species~., data = species.df.train, ntree = 1500, importance=TRUE)
importance(species.rf)
```

```
##                setosa versicolor virginica MeanDecreaseAccuracy
## Sepal.Length 12.33893   9.133094 18.955426             19.74545
## Sepal.Width  10.39294   9.014322  9.292696             13.72235
## Petal.Length 39.89980  45.997779 45.347488             57.22617
## Petal.Width  37.92793  45.763906 54.267123             57.93071
##              MeanDecreaseGini
## Sepal.Length         6.855285
## Sepal.Width          2.164326
## Petal.Length        26.772326
## Petal.Width         27.978400
```

q

```
varImpPlot(species.rf, main = "Variable importance by speciesment")
```



The most important variables in this data set are petal width and petal length.

2 Note: the output has been limited to the first 100 lines for the sake of the document length.

```
# upload data
boa.df <- read.csv('boa.csv')

# dimensions of the data set
dim(boa.df)
```

```
## [1] 8950   19
```

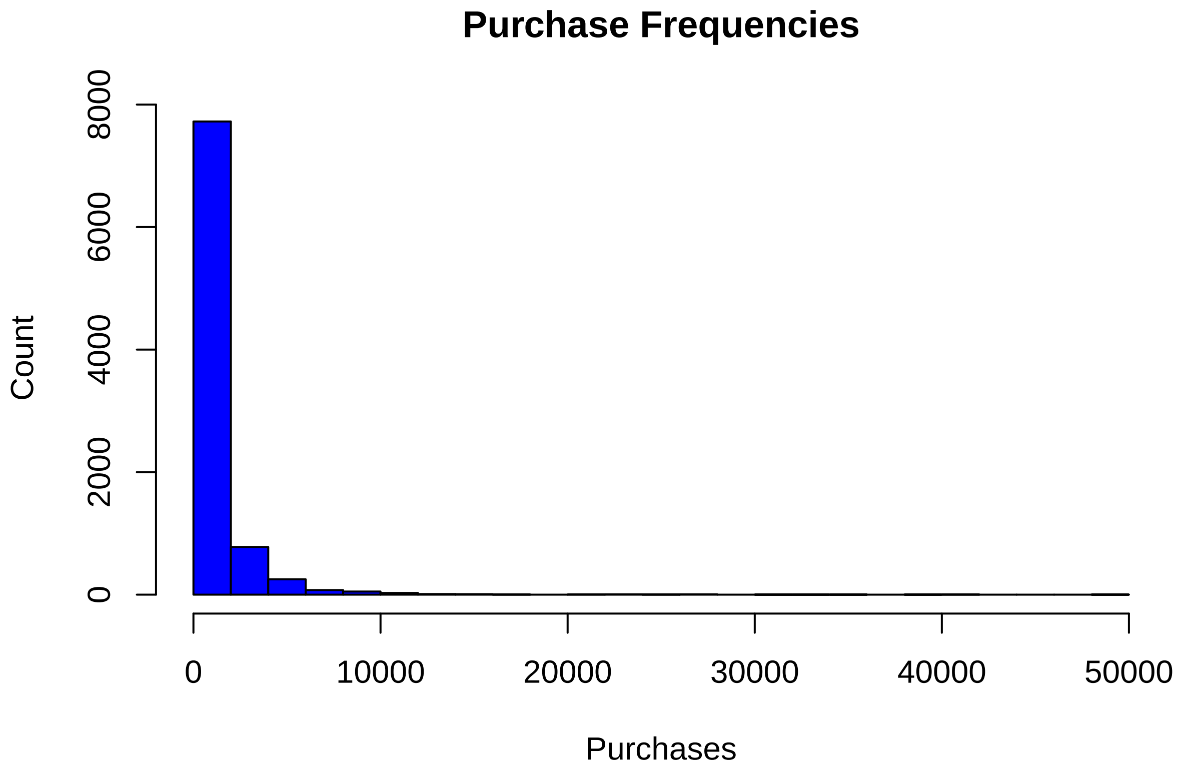
```
# summarize the data set
summary(boa.df)
```

```
##        X           CUST_ID             BALANCE        BALANCE_FREQUENCY
##  Min.   :   1   Length:8950        Min.   :    0.0   Min.   :0.0000
##  1st Qu.:2238   Class :character   1st Qu.:  128.3   1st Qu.:0.8889
##  Median :4476   Mode  :character   Median :  873.4   Median :1.0000
##  Mean   :4476                      Mean   : 1564.5   Mean   :0.8773
##  3rd Qu.:6713                      3rd Qu.: 2054.1   3rd Qu.:1.0000
##  Max.   :8950                      Max.   :19043.1   Max.   :1.0000
##    PURCHASES        ONEOFF_PURCHASES  INSTALLMENTS_PURCHASES  CASH_ADVANCE
##  Min.   :    0.00   Min.   :    0.0   Min.   :    0.0        Min.   :    0.0
##  1st Qu.:   39.63   1st Qu.:    0.0   1st Qu.:    0.0        1st Qu.:    0.0
##  Median :  361.28   Median :   38.0   Median :   89.0        Median :    0.0
##  Mean   : 1003.20   Mean   :  592.4   Mean   :  411.1        Mean   :  978.9
##  3rd Qu.: 1110.13   3rd Qu.:  577.4   3rd Qu.:  468.6        3rd Qu.: 1113.8
##  Max.   :49039.57   Max.   :40761.2   Max.   :22500.0        Max.   :47137.2
##  PURCHASES_FREQUENCY ONEOFF_PURCHASES_FREQUENCY
##  Min.   :0.00000     Min.   :0.00000
##  1st Qu.:0.08333     1st Qu.:0.00000
##  Median :0.50000     Median :0.08333
##  Mean   :0.49035     Mean   :0.20246
##  3rd Qu.:0.91667     3rd Qu.:0.30000
##  Max.   :1.00000     Max.   :1.00000
##  PURCHASES_INSTALLMENTS_FREQUENCY CASH_ADVANCE_FREQUENCY CASH_ADVANCE_TRX
##  Min.   :0.0000                   Min.   :0.0000         Min.   :  0.000
##  1st Qu.:0.0000                   1st Qu.:0.0000         1st Qu.:  0.000
##  Median :0.1667                   Median :0.0000         Median :  0.000
##  Mean   :0.3644                   Mean   :0.1351         Mean   :  3.249
##  3rd Qu.:0.7500                   3rd Qu.:0.2222         3rd Qu.:  4.000
##  Max.   :1.0000                   Max.   :1.5000         Max.   :123.000
##  PURCHASES_TRX     CREDIT_LIMIT      PAYMENTS       MINIMUM_PAYMENTS
##  Min.   :  0.00   Min.   :   50   Min.   :    0.0   Min.   :    0.0
##  1st Qu.:  1.00   1st Qu.: 1600   1st Qu.:  383.3   1st Qu.:  163.0
##  Median :  7.00   Median : 3000   Median :  856.9   Median :  289.6
##  Mean   : 14.71   Mean   : 4494   Mean   : 1733.1   Mean   :  834.0
##  3rd Qu.: 17.00   3rd Qu.: 6500   3rd Qu.: 1901.1   3rd Qu.:  788.7
##  Max.   :358.00   Max.   :30000   Max.   :50721.5   Max.   :76406.2
##  PRC_FULL_PAYMENT     TENURE
##  Min.   :0.0000   Min.   : 6.00
##  1st Qu.:0.0000   1st Qu.:12.00
##  Median :0.0000   Median :12.00
##  Mean   :0.1537   Mean   :11.52
##  3rd Qu.:0.1429   3rd Qu.:12.00
##  Max.   :1.0000   Max.   :12.00
```

```
# structure of the data set
str(boa.df)
```

```
## ’data.frame’:    8950 obs. of  19 variables:
##  $ X                               : int  1 2 3 4 5 6 7 8 9 10 ...
##  $ CUST_ID                         : chr  "C10001" "C10002" "C10003" "C10004" ...
##  $ BALANCE                         : num  40.9 3202.5 2495.1 1666.7 817.7 ...
##  $ BALANCE_FREQUENCY               : num  0.818 0.909 1 0.636 1 ...
##  $ PURCHASES                       : num  95.4 0 773.2 1499 16 ...
##  $ ONEOFF_PURCHASES                : num  0 0 773 1499 16 ...
##  $ INSTALLMENTS_PURCHASES          : num  95.4 0 0 0 0 ...
##  $ CASH_ADVANCE                    : num  0 6443 0 206 0 ...
##  $ PURCHASES_FREQUENCY             : num  0.1667 0 1 0.0833 0.0833 ...
##  $ ONEOFF_PURCHASES_FREQUENCY      : num  0 0 1 0.0833 0.0833 ...
##  $ PURCHASES_INSTALLMENTS_FREQUENCY: num  0.0833 0 0 0 0 ...
##  $ CASH_ADVANCE_FREQUENCY          : num  0 0.25 0 0.0833 0 ...
##  $ CASH_ADVANCE_TRX                : int  0 4 0 1 0 0 0 0 0 0 ...
##  $ PURCHASES_TRX                   : int  2 0 12 1 1 8 64 12 5 3 ...
##  $ CREDIT_LIMIT                    : num  1000 7000 7500 7500 1200 1800 13500 2300 7000 11000 ...
##  $ PAYMENTS                        : num  202 4103 622 0 678 ...
##  $ MINIMUM_PAYMENTS                : num  140 1072 627 0 245 ...
##  $ PRC_FULL_PAYMENT                : num  0 0.222 0 0 0 ...
##  $ TENURE                          : int  12 12 12 12 12 12 12 12 12 12 ...
```

```
# purchases histogram
hist(boa.df$PURCHASES, main = "Purchase Frequencies",
     xlab="Purchases", ylab="Count",
     breaks = 30,
     col = "blue")
```



```
# remove customer id and purchase columns to look at which clusters would emerge when we remove purchas
boa.df.new <- boa.df[,-c(2,5)]
str(boa.df.new)
```

```
## 'data.frame':    8950 obs. of  17 variables:
##  $ X                               : int  1 2 3 4 5 6 7 8 9 10 ...
##  $ BALANCE                         : num  40.9 3202.5 2495.1 1666.7 817.7 ...
##  $ BALANCE_FREQUENCY               : num  0.818 0.909 1 0.636 1 ...
##  $ ONEOFF_PURCHASES                : num  0 0 773 1499 16 ...
##  $ INSTALLMENTS_PURCHASES          : num  95.4 0 0 0 0 ...
##  $ CASH_ADVANCE                    : num  0 6443 0 206 0 ...
##  $ PURCHASES_FREQUENCY             : num  0.1667 0 1 0.0833 0.0833 ...
##  $ ONEOFF_PURCHASES_FREQUENCY      : num  0 0 1 0.0833 0.0833 ...
##  $ PURCHASES_INSTALLMENTS_FREQUENCY: num  0.0833 0 0 0 0 ...
##  $ CASH_ADVANCE_FREQUENCY          : num  0 0.25 0 0.0833 0 ...
##  $ CASH_ADVANCE_TRX                : int  0 4 0 1 0 0 0 0 0 0 ...
##  $ PURCHASES_TRX                   : int  2 0 12 1 1 8 64 12 5 3 ...
##  $ CREDIT_LIMIT                    : num  1000 7000 7500 7500 1200 1800 13500 2300 7000 11000 ...
##  $ PAYMENTS                        : num  202 4103 622 0 678 ...
##  $ MINIMUM_PAYMENTS                : num  140 1072 627 0 245 ...
##  $ PRC_FULL_PAYMENT                : num  0 0.222 0 0 0 ...
##  $ TENURE                          : int  12 12 12 12 12 12 12 12 12 12 ...
```

```
# function to look at mean values by group
boa.summ <- function(data, groups) { aggregate(data, list(groups), function(x) mean(as.numeric(x)))}

head(boa.summ(boa.df.new, boa.df$PURCHASES), 100)
```

```
##     Group.1        X      BALANCE BALANCE_FREQUENCY ONEOFF_PURCHASES
## 1      0.00 4569.760 2151.2029350         0.8825000          0.00000
## 2      0.01 2817.000 1692.2194260         0.6590910          0.01000
## 3      0.05  329.000  850.6301140         1.0000000          0.05000
## 4      0.24 3591.000    1.8694350         0.4545450          0.24000
## 5      0.70 5814.000  212.3061480         0.1818180          0.70000
## 6      1.00 4832.500 2321.6780220         1.0000000          1.00000
## 7      1.40 7002.000   46.7957010         0.2727270          1.40000
## 8      2.00 2045.000 1709.6939560         1.0000000          2.00000
## 9      4.44 3556.000 6744.8456860         1.0000000          0.00000
## 10     4.80 6233.000    7.4569660         0.2727270          0.00000
## 11     4.99 3163.000  793.0052270         1.0000000          4.99000
## 12     6.90 8195.000    0.4372850         0.1818180          6.90000
## 13     7.26 6518.000  644.9339110         0.8333330          0.00000
## 14     8.40 3708.667 2901.6828830         1.0000000          8.40000
## 15     9.28 5929.000    0.0000000         0.0000000          0.00000
## 16     9.68 5260.000    2.6411010         1.0000000          0.00000
## 17     9.87 7640.000    1.6952940         0.0909090          0.00000
## 18     9.90 6643.000 1083.3791710         1.0000000          0.00000
## 19    10.79 7849.000  411.3629690         1.0000000          0.00000
## 20    10.89 7920.000    0.0000000         0.0000000          0.00000
## 21    11.06  615.000 3419.6616760         1.0000000         11.06000
## 22    11.35 4851.000 1074.2584870         1.0000000          0.00000
## 23    11.41 2339.000 3860.2380720         1.0000000         11.41000
## 24    12.00 2794.500   34.2897165         0.6363640          6.00000
## 25    12.22 3932.000 2944.1569960         1.0000000         12.22000
## 26    12.40 6180.000  933.0725190         1.0000000         12.40000
## 27    12.64 2743.000 6784.2582760         1.0000000          0.00000
## 28    12.65 1132.000    0.0000000         0.0000000          0.00000
## 29    13.00 8666.000 1112.9156570         1.0000000         13.00000
## 30    13.66 4756.000  207.2095970         1.0000000          0.00000
## 31    13.69 5911.000   56.0603270         0.1818180          0.00000
## 32    14.28 2593.000  339.4062590         1.0000000          0.00000
## 33    14.72 5553.000 1175.9226280         1.0000000         14.72000
## 34    14.95  321.000 4732.3735400         1.0000000          0.00000
## 35    14.98 3273.000  124.1178380         0.3636360         14.98000
## 36    15.00 7854.500  647.5574050         0.7272725         15.00000
## 37    15.30 7396.000    1.9413280         0.1818180          0.00000
## 38    15.40 1956.000  107.1300200         1.0000000         15.40000
## 39    15.80 5105.000  900.5417510         1.0000000          0.00000
## 40    15.92 5721.000 3881.6795820         1.0000000         15.92000
## 41    16.00 1984.000  410.4281480         0.5909090         16.00000
## 42    16.50  384.000    1.8380840         0.2727270         16.50000
## 43    17.00 6253.000  492.0402230         1.0000000          17.00000
## 44    17.30 6173.000 4198.6180900         0.7272730          17.30000
## 45    17.60 7294.000 1242.8862660         1.0000000          17.60000
## 46    17.70 3169.000    0.6839390         0.1818180          17.70000
## 47    17.80 2589.500  225.7873070         0.4090905          17.80000
## 48    18.00 5487.000 2893.8974870         1.0000000           0.00000
## 49    18.05  859.000  910.0725140         1.0000000           0.00000
## 50    18.35 3909.000 6928.7213770         1.0000000           0.00000
## 51    18.41  600.000  917.7328460         1.0000000           0.00000
## 52    18.77 4402.000    0.0000000         0.0000000           0.00000
## 53    19.08 1582.000    1.3432070         0.1818180           0.00000
## 54    19.25 4630.000    0.0000000         0.0000000           0.00000
## 55    19.50 5774.000   17.2455390         0.6363640           0.00000
## 56    19.75 7544.000  803.0527040         1.0000000          19.75000
## 57    19.88 6869.000  826.6886250         1.0000000          19.88000
## 58    19.90 3161.000  147.8458865         0.6000000           9.95000
## 59    19.91 4107.000  634.7599730         1.0000000           0.00000
## 60    19.96 6713.000  701.0172700         1.0000000          19.96000
## 61    19.98 2064.000 2828.7658220         1.0000000          19.98000
## 62    20.00 4817.333 1199.7706802         0.8232323          16.66667
## 63    20.09  921.000   39.7989930         0.4545450          20.09000
## 64    20.74 7575.000    1.0631140         0.0909090           0.00000
## 65    20.90 5794.500  666.7627825         0.7500000          20.90000
## 66    21.00 3224.000  509.9003170         0.3636360           0.00000
## 67    21.05 4059.000    1.8168140         0.0909090           0.00000
## 68    21.75 3967.000 1033.4987360         1.0000000           0.00000
## 69    21.90 6196.000  556.8574380         1.0000000          21.90000
## 70    21.99 6776.000   12.4233240         0.5454550           0.00000
## 71    22.16 1131.000 6090.5222730         1.0000000          22.16000
## 72    22.48 3406.000   35.2765510         1.0000000          22.48000
## 73    22.50 2241.000 1013.8676360         0.6818180           0.00000
## 74    22.68 2214.000  689.6976440         1.0000000           0.00000
## 75    23.00 2132.500    0.4297235         0.2272725          11.50000
## 76    23.21 1636.000 1621.0353730         1.0000000           0.00000
## 77    23.75 7870.000  183.2858400         1.0000000          23.75000
## 78    23.91 2327.000    1.0594250         0.3636360          23.91000
## 79    24.00  737.000    0.2557100         0.0909090           0.00000
## 80    24.63 5249.000  385.8419970         1.0000000           0.00000
## 81    24.64  587.000    0.3271990         0.4545450          24.64000
## 82    25.00 6273.000 2080.3129910         0.8888890           0.00000
## 83    25.20 3344.000 1396.3858050         1.0000000          25.20000
## 84    25.26 2896.500 1650.7292830         1.0000000          25.26000
## 85    25.50 1167.000    1.0591030         0.1818180          25.50000
## 86    25.69 4795.000    4.1256500         0.3636360          25.69000
## 87    26.09 7364.000  443.5585780         1.0000000          26.09000
## 88    26.12 3183.000 1839.9304600         1.0000000          26.12000
## 89    26.49 4972.000    2.0813570         0.1818180          26.49000
## 90    26.53 8491.000    2.0447450         0.1818180          26.53000
## 91    26.62  919.000    0.8675280         0.2727270           0.00000
## 92    26.80 2992.000  347.5772930         0.8571430          26.80000
## 93    27.00  916.000 1068.4340640         1.0000000           0.00000
## 94    27.05 5123.000  500.2194150         1.0000000           0.00000
## 95    27.16 5033.000 2872.7986140         1.0000000           0.00000
## 96    27.22 8221.000  435.5180680         1.0000000          27.22000
## 97    27.42 4690.000    4.4172730         0.1818180          0.00000
## 98    27.51 3600.000  286.2643560         0.8571430         27.51000
## 99    27.79 8214.000   57.1168110         0.4545450         27.79000
## 100   27.89 4243.000 1868.5237860         1.0000000         27.89000
##     INSTALLMENTS_PURCHASES CASH_ADVANCE PURCHASES_FREQUENCY
## 1               0.04253914   1988.74251        0.0001630788
## 2               0.00000000   2877.42895        0.0852270000
## 3               0.00000000   1700.63459        0.0833330000
## 4               0.00000000      0.00000        0.0833330000
## 5               0.00000000   1922.59360        0.0833330000
## 6               0.00000000    710.16094        0.0833330000
## 7               0.00000000    189.11039        0.1666670000
## 8               0.00000000   5246.29645        0.0833330000
## 9               4.44000000  19862.87844        0.2500000000
## 10              4.80000000      0.00000        0.0833330000
## 11              0.00000000      0.00000        0.0833330000
## 12              0.00000000      0.00000        0.0833330000
## 13              7.26000000    966.74937        0.1666670000
## 14              0.00000000     18.17314        1.0000000000
## 15              9.28000000      0.00000        0.2500000000
## 16              9.68000000      0.00000        0.0833330000
## 17              9.87000000      0.00000        0.0833330000
## 18              9.90000000      0.00000        0.1428570000
## 19             10.79000000      0.00000        0.1666670000
## 20             10.89000000      0.00000        0.0833330000
## 21              0.00000000   1261.34778        0.0833330000
## 22             11.35000000      0.00000        0.0833330000
## 23              0.00000000      0.00000        0.1666670000
## 24              6.00000000     83.08013        0.5416665000
## 25              0.00000000    244.69466        0.0833330000
## 26              0.00000000   1085.48705        0.0833330000
## 27             12.64000000   4516.16260        0.0833330000
## 28             12.65000000      0.00000        0.0833330000
## 29              0.00000000    256.94406        0.0833330000
## 30             13.66000000      0.00000        0.0909090000
## 31             13.69000000      0.00000        0.0833330000
## 32             14.28000000      0.00000        0.4166670000
## 33              0.00000000     79.25217        0.0833330000
## 34             14.95000000   2173.35607        0.0833330000
## 35              0.00000000      0.00000        0.0833330000
## 36              0.00000000    104.51269        0.0871210000
## 37             15.30000000      0.00000        0.0833330000
## 38              0.00000000    182.66132        0.0833330000
## 39             15.80000000      0.00000        0.2500000000
## 40              0.00000000   2183.78246        0.0833330000
## 41              0.00000000      0.00000        0.0833330000
## 42              0.00000000      0.00000        0.0833330000
## 43              0.00000000    171.81466        0.0833330000
## 44              0.00000000   2845.86846        0.0833330000
## 45              0.00000000      0.00000        0.0833330000
## 46              0.00000000      0.00000        0.0833330000
## 47              0.00000000   1214.90989        0.0833330000
## 48             18.00000000   3904.51445        0.0833330000
## 49             18.05000000     19.11884        0.0833330000
## 50             18.35000000  14836.45141        0.4166670000
## 51             18.41000000      0.00000        0.0833330000
## 52             18.77000000      0.00000        0.0833330000
## 53             19.08000000      0.00000        0.1666670000
## 54             19.25000000      0.00000        0.0833330000
## 55             19.50000000      0.00000        0.0833330000
## 56              0.00000000      0.00000        0.0833330000
## 57              0.00000000    869.24620        0.0833330000
## 58              9.95000000     37.62758        0.1416665000
## 59             19.91000000      0.00000        0.0833330000
## 60              0.00000000    153.59777        0.0833330000
## 61              0.00000000      0.00000        0.0833330000
## 62              3.33333333    275.21390        0.1296293333
## 63              0.00000000      0.00000        0.3333330000
## 64             20.74000000      0.00000        0.1666670000
## 65              0.00000000      0.00000        0.1250000000
## 66             21.00000000      0.00000        0.0833330000
## 67             21.05000000      0.00000        0.0833330000
## 68             21.75000000   1238.74695        0.0833330000
## 69              0.00000000      0.00000        0.1666670000
## 70             21.99000000      0.00000        0.0909090000
## 71              0.00000000      0.00000        0.0833330000
## 72              0.00000000      0.00000        0.0833330000
## 73             22.50000000      0.00000        0.2500000000
## 74             22.68000000      0.00000        0.0833330000
## 75             11.50000000      0.00000        0.0833330000
## 76             23.21000000      0.00000        0.3333330000
## 77              0.00000000     64.00625        0.0833330000
## 78              0.00000000      0.00000        0.3333330000
## 79             24.00000000      0.00000        0.1666670000
## 80             24.63000000      0.00000        0.4166670000
## 81              0.00000000      0.00000        0.0833330000
## 82             25.00000000   2422.88959        0.1111110000
## 83              0.00000000   1920.24988        0.0833330000
## 84              0.00000000    226.40183        0.1250000000
## 85              0.00000000      0.00000        0.0833330000
## 86              0.00000000      0.00000        0.0833330000
## 87              0.00000000    646.93268        0.0833330000
## 88              0.00000000    158.97124        0.0833330000
## 89              0.00000000      0.00000        0.0833330000
## 90              0.00000000      0.00000        0.0833330000
## 91             26.62000000      0.00000        0.3333330000
## 92              0.00000000    470.84647        0.1428570000
## 93             27.00000000      0.00000        0.0833330000
## 94             27.05000000      0.00000        0.0833330000
## 95             27.16000000   2692.77704        0.0833330000
## 96              0.00000000      0.00000        0.0833330000
## 97             27.42000000      0.00000        0.0833330000
## 98              0.00000000    871.19926        0.1428570000
## 99              0.00000000    381.17115        0.0833330000
## 100             0.00000000     47.99887        0.0833330000
##     ONEOFF_PURCHASES_FREQUENCY PURCHASES_INSTALLMENTS_FREQUENCY
## 1                   0.00000000                      0.000285388
## 2                   0.08522700                      0.000000000
## 3                  0.08333300                  0.000000000
## 4                  0.08333300                  0.000000000
## 5                  0.08333300                  0.000000000
## 6                  0.08333300                  0.000000000
## 7                  0.16666700                  0.000000000
## 8                  0.08333300                  0.000000000
## 9                  0.00000000                  0.166667000
## 10                 0.00000000                  0.083333000
## 11                 0.08333300                  0.000000000
## 12                 0.08333300                  0.000000000
## 13                 0.00000000                  0.166667000
## 14                 1.00000000                  0.000000000
## 15                 0.00000000                  0.250000000
## 16                 0.00000000                  0.083333000
## 17                 0.00000000                  0.083333000
## 18                 0.00000000                  0.142857000
## 19                 0.00000000                  0.166667000
## 20                 0.00000000                  0.083333000
## 21                 0.08333300                  0.000000000
## 22                 0.00000000                  0.083333000
## 23                 0.16666700                  0.000000000
## 24                 0.04166650                  0.458333500
## 25                 0.08333300                  0.000000000
## 26                 0.08333300                  0.000000000
## 27                 0.00000000                  0.083333000
## 28                 0.00000000                  0.083333000
## 29                 0.08333300                  0.000000000
## 30                 0.00000000                  0.090909000
## 31                 0.00000000                  0.083333000
## 32                 0.00000000                  0.416667000
## 33                 0.08333300                  0.000000000
## 34                 0.00000000                  0.083333000
## 35                 0.08333300                  0.000000000
## 36                 0.08712100                  0.000000000
## 37                 0.00000000                  0.083333000
## 38                 0.08333300                  0.000000000
## 39                 0.00000000                  0.250000000
## 40                 0.08333300                  0.000000000
## 41                 0.08333300                  0.000000000
## 42                 0.08333300                  0.000000000
## 43                 0.08333300                  0.000000000
## 44                 0.08333300                  0.000000000
## 45                 0.08333300                  0.000000000
## 46                 0.08333300                  0.000000000
## 47                 0.08333300                  0.000000000
## 48                 0.00000000                  0.083333000
## 49                 0.00000000                  0.083333000
## 50                 0.00000000                  0.416667000
## 51                 0.00000000                  0.083333000
## 52                 0.00000000                  0.083333000
## 53                 0.00000000                  0.083333000
## 54                 0.00000000                  0.083333000
## 55                 0.00000000                  0.083333000
## 56                 0.08333300                  0.000000000
## 57                  0.08333300                      0.000000000
## 58                  0.04166650                      0.050000000
## 59                  0.00000000                      0.083333000
## 60                  0.08333300                      0.000000000
## 61                  0.08333300                      0.000000000
## 62                  0.07407383                      0.055555500
## 63                  0.33333300                      0.000000000
## 64                  0.00000000                      0.166667000
## 65                  0.12500000                      0.000000000
## 66                  0.00000000                      0.083333000
## 67                  0.00000000                      0.083333000
## 68                  0.00000000                      0.083333000
## 69                  0.16666700                      0.000000000
## 70                  0.00000000                      0.090909000
## 71                  0.08333300                      0.000000000
## 72                  0.08333300                      0.000000000
## 73                  0.00000000                      0.250000000
## 74                  0.00000000                      0.083333000
## 75                  0.04166650                      0.041666500
## 76                  0.00000000                      0.333333000
## 77                  0.08333300                      0.000000000
## 78                  0.33333300                      0.000000000
## 79                  0.00000000                      0.166667000
## 80                  0.00000000                      0.416667000
## 81                  0.08333300                      0.000000000
## 82                  0.00000000                      0.111111000
## 83                  0.08333300                      0.000000000
## 84                  0.12500000                      0.000000000
## 85                  0.08333300                      0.000000000
## 86                  0.08333300                      0.000000000
## 87                  0.08333300                      0.000000000
## 88                  0.08333300                      0.000000000
## 89                  0.08333300                      0.000000000
## 90                  0.08333300                      0.000000000
## 91                  0.00000000                      0.333333000
## 92                  0.14285700                      0.000000000
## 93                  0.00000000                      0.083333000
## 94                  0.00000000                      0.083333000
## 95                  0.00000000                      0.083333000
## 96                  0.08333300                      0.000000000
## 97                  0.00000000                      0.083333000
## 98                  0.14285700                      0.000000000
## 99                  0.08333300                      0.000000000
## 100                 0.08333300                      0.000000000
##     CASH_ADVANCE_FREQUENCY CASH_ADVANCE_TRX PURCHASES_TRX CREDIT_LIMIT
## 1               0.27259049        6.2964775   0.001956947     4029.727
## 2               0.10984850        4.2500000   1.000000000     6375.000
## 3               0.33333300        7.0000000   1.000000000     1000.000
## 4               0.00000000        0.0000000   0.000000000     3000.000
## 5               0.16666700        3.0000000   1.000000000     3500.000
## 6               0.12500000        2.0000000   1.000000000     4100.000
## 7               0.08333300        1.0000000   2.000000000     4500.000
## 8               0.25000000        6.0000000   1.000000000     2500.000
## 9               0.41666700       11.0000000   3.000000000    16500.000
## 10              0.00000000        0.0000000   1.000000000     2200.000
## 11              0.00000000        0.0000000   1.000000000     2500.000
## 12              0.00000000        0.0000000   1.000000000     8500.000
## 13              0.16666700        1.0000000   1.000000000     1500.000
## 14              0.02777767        0.6666667  12.000000000     6400.000
## 15              0.00000000        0.0000000   3.000000000     5000.000
## 16              0.00000000        0.0000000   1.000000000     8000.000
## 17              0.00000000        0.0000000   1.000000000     5000.000
## 18              0.00000000        0.0000000   1.000000000     1900.000
## 19              0.00000000        0.0000000   1.000000000     1200.000
## 20              0.00000000        0.0000000   1.000000000     4000.000
## 21              0.08333300        1.0000000   1.000000000     4000.000
## 22              0.00000000        0.0000000   1.000000000     1200.000
## 23              0.00000000        0.0000000   2.000000000    10000.000
## 24              0.04166650        1.5000000   6.500000000     1400.000
## 25              0.16666700        2.0000000   1.000000000     3000.000
## 26              0.16666700        6.0000000   1.000000000     2500.000
## 27              0.41666700       13.0000000   1.000000000    10000.000
## 28              0.00000000        0.0000000   1.000000000     5000.000
## 29              0.25000000        5.0000000   1.000000000     1500.000
## 30              0.00000000        0.0000000   1.000000000     7000.000
## 31              0.00000000        0.0000000   1.000000000     2900.000
## 32              0.00000000        0.0000000   5.000000000    10500.000
## 33              0.25000000        3.0000000   1.000000000     1200.000
## 34              0.41666700       11.0000000   1.000000000     5700.000
## 35              0.00000000        0.0000000   1.000000000     1700.000
## 36              0.04545450        0.5000000   1.000000000     4500.000
## 37              0.00000000        0.0000000   1.000000000     5000.000
## 38              0.33333300        6.0000000   1.000000000      200.000
## 39              0.00000000        0.0000000   3.000000000     7000.000
## 40              0.33333300        9.0000000   1.000000000     5500.000
## 41              0.00000000        0.0000000   1.000000000     3350.000
## 42              0.00000000        0.0000000   1.000000000     6000.000
## 43              0.33333300        4.0000000   1.000000000      600.000
## 44              0.25000000        6.0000000   1.000000000     8954.545
## 45              0.00000000        0.0000000   1.000000000     4000.000
## 46              0.00000000        0.0000000   1.000000000     1500.000
## 47              0.12500000        1.5000000   1.000000000     2500.000
## 48              0.41666700       23.0000000   1.000000000     6000.000
## 49              0.08333300        1.0000000   1.000000000     1000.000
## 50              0.08333300        1.0000000   5.000000000    18000.000
## 51              0.00000000        0.0000000   1.000000000     1000.000
## 52              0.00000000        0.0000000   1.000000000     5000.000
## 53              0.00000000        0.0000000   2.000000000     7000.000
## 54              0.00000000        0.0000000   1.000000000     4000.000
## 55              0.00000000        0.0000000   1.000000000     1500.000
## 56              0.00000000        0.0000000   1.000000000     2000.000
## 57              0.33333300       20.0000000   2.000000000      900.000
## 58              0.08333350        1.0000000   1.500000000     3750.000
## 59              0.00000000        0.0000000   1.000000000     6000.000
## 60              0.25000000        3.0000000   1.000000000     3500.000
## 61              0.00000000        0.0000000   2.000000000     5500.000
## 62              0.15277767        2.1666667   1.500000000     3000.000
## 63              0.00000000        0.0000000   5.000000000     3200.000
## 64              0.00000000        0.0000000   2.000000000     1500.000
## 65              0.00000000        0.0000000   1.000000000     1000.000
## 66              0.00000000        0.0000000   1.000000000    11500.000
## 67              0.00000000        0.0000000   1.000000000     2900.000
## 68              0.33333300        5.0000000   1.000000000     3000.000
## 69              0.00000000        0.0000000   2.000000000      600.000
## 70              0.00000000        0.0000000   1.000000000     4000.000
## 71              0.00000000        0.0000000   1.000000000     9000.000
## 72              0.00000000        0.0000000   1.000000000     7500.000
## 73              0.00000000        0.0000000   3.000000000     6500.000
## 74              0.00000000        0.0000000   1.000000000    11500.000
## 75              0.00000000        0.0000000   1.000000000     4000.000
## 76              0.00000000        0.0000000   4.000000000     2000.000
## 77              0.08333300        2.0000000   1.000000000      500.000
## 78              0.00000000        0.0000000   4.000000000    15500.000
## 79              0.00000000        0.0000000   2.000000000     1500.000
## 80              0.00000000        0.0000000   5.000000000     4500.000
## 81              0.00000000        0.0000000   1.000000000     1800.000
## 82              0.33333300        6.0000000   1.000000000     2500.000
## 83              0.58333300       19.0000000   1.000000000     2500.000
## 84              0.12500000        1.5000000   1.500000000     3050.000
## 85              0.00000000        0.0000000   1.000000000     5500.000
## 86              0.00000000        0.0000000   1.000000000     4500.000
## 87              0.50000000       16.0000000   4.000000000     1200.000
## 88              0.08333300        1.0000000   1.000000000     1950.000
## 89              0.00000000        0.0000000   1.000000000     7500.000
## 90              0.00000000        0.0000000   1.000000000     2500.000
## 91              0.00000000        0.0000000   4.000000000     4500.000
## 92              0.42857100       11.0000000   1.000000000      500.000
## 93              0.00000000        0.0000000   1.000000000     1200.000
## 94              0.00000000        0.0000000   1.000000000     1200.000
## 95              0.41666700       15.0000000   1.000000000     5000.000
## 96              0.00000000        0.0000000   1.000000000      500.000
## 97              0.00000000        0.0000000   1.000000000     1800.000
## 98              0.42857100        3.0000000   1.000000000      500.000
## 99              0.08333300        1.0000000   1.000000000     4500.000
## 100             0.08333300        1.0000000   2.000000000     2000.000
##         PAYMENTS MINIMUM_PAYMENTS PRC_FULL_PAYMENT   TENURE
## 1    1653.130103       968.694784       0.04432393 11.31849
## 2    1273.540476       629.643771       0.03125000 11.75000
## 3    1084.281127       367.409536       0.00000000 12.00000
## 4     150.381107        53.294711       0.00000000 12.00000
## 5       0.000000         0.000000       0.00000000 12.00000
## 6     848.476405       604.791575       0.00000000 12.00000
## 7       0.000000         0.000000       0.00000000 12.00000
## 8    4678.254753       464.860442       0.08333300 12.00000
## 9   21440.298660      1350.823356       0.10000000 12.00000
## 10     70.517745       246.213204       0.00000000 12.00000
## 11   1127.028432       223.627537       0.08333300 12.00000
## 12      4.523555         4.763689       0.00000000 12.00000
## 13    431.732367        92.246251       0.00000000  6.00000
## 14    769.002348      1076.353714       0.00000000 12.00000
## 15      0.000000         0.000000       0.00000000 12.00000
## 16     72.282497        17.530337       0.00000000 12.00000
## 17    151.732627        98.617471        0.50000000 12.00000
## 18    186.923852      7243.733403        0.00000000  7.00000
## 19    918.160924       166.281511        0.00000000 12.00000
## 20      0.000000         0.000000        0.00000000 12.00000
## 21    745.984976      1243.564770        0.00000000 12.00000
## 22    421.348577       206.637191        0.00000000 12.00000
## 23   7280.584479      1013.780486        0.08333300 12.00000
## 24     79.733163        65.870176        0.00000000 12.00000
## 25    628.314620      1288.695715        0.00000000 12.00000
## 26    481.589626       238.636185        0.08333300 12.00000
## 27  10813.829330      1661.518089        0.08333300 12.00000
## 28      0.000000         0.000000        0.00000000 12.00000
## 29    396.056561       308.356999        0.00000000 12.00000
## 30   1703.339459       208.367436        0.00000000 11.00000
## 31   2165.403988       219.961065        0.00000000 12.00000
## 32   1263.292815      1486.059666        0.08333300 12.00000
## 33    347.568201       463.992512        0.00000000 12.00000
## 34   1289.284068      1172.289863        0.00000000 12.00000
## 35    607.535166        43.582049        0.00000000 12.00000
## 36    352.719365       261.538020        0.00000000 11.50000
## 37    190.254352       117.892476        0.00000000 12.00000
## 38    255.103798       198.933162        0.00000000 12.00000
## 39   1542.583506       375.127536        0.00000000 12.00000
## 40   1032.183632      1129.747227        0.00000000 12.00000
## 41    667.190047       182.614350        0.50000000 12.00000
## 42     57.595083        67.192500        0.00000000 12.00000
## 43    243.905711       291.892373        0.00000000 12.00000
## 44  10226.601760      1024.126428        0.10000000 12.00000
## 45    589.674674       472.763536        0.00000000 12.00000
## 46     18.825023        10.074393        0.00000000 12.00000
## 47   5253.799504       411.220052        0.50000000 12.00000
## 48    483.729934       720.971058        0.00000000 12.00000
## 49    233.886707       230.806229        0.00000000 12.00000
## 50  22281.700460      1592.560164        0.09090900 12.00000
## 51   1407.291593       424.623595        0.00000000 12.00000
## 52      0.000000         0.000000        0.00000000 12.00000
## 53    170.180973       161.234787        0.00000000 12.00000
## 54      0.000000         0.000000        0.00000000 12.00000
## 55     95.789433       119.880198        0.00000000 12.00000
## 56    402.155365       322.394919        0.00000000 12.00000
## 57   1072.638864       373.912056        0.08333300 12.00000
## 58    132.130910       111.680274        0.25000000 11.00000
## 59    610.491342       246.804668        0.00000000 12.00000
## 60    218.851473       332.899226        0.00000000 12.00000
## 61    593.220384      1159.310924        0.00000000 12.00000
## 62    711.253366       388.624279        0.00000000 11.50000
## 63      0.000000         0.000000        0.00000000 12.00000
## 64    168.489938        98.859855        0.00000000 12.00000
## 65    173.167499       263.360908        0.00000000  9.00000
## 66  23150.571840      1863.225391        0.33333300 12.00000
## 67    243.137299       112.019269        0.00000000 12.00000
## 68    255.779858       489.808320        0.00000000 12.00000
## 69    162.272808       271.112945        0.00000000 12.00000
## 70      0.000000         0.000000        0.00000000 11.00000
## 71    568.781100     30528.432400       0.00000000 12.00000
## 72     68.205028       200.034390       0.00000000 12.00000
## 73   1441.188109       248.194890       0.00000000 12.00000
## 74    906.092735       224.709183       0.00000000 12.00000
## 75      0.000000         0.000000       0.00000000 12.00000
## 76    500.515114       475.627205       0.00000000 12.00000
## 77    584.679478       139.651483       0.08333300 12.00000
## 78     31.845894        22.081988       0.11111100 12.00000
## 79      9.533313         8.842600       0.00000000 12.00000
## 80   1349.938041       203.987924       0.00000000 12.00000
## 81     45.640106        26.849523       0.00000000 12.00000
## 82    540.687217       570.576789       0.00000000  9.00000
## 83    410.617369       503.627101       0.00000000 12.00000
## 84    819.279904       526.338710       0.00000000 12.00000
## 85    563.748018        83.648417       0.50000000 12.00000
## 86    163.352538       128.336305       0.00000000 12.00000
## 87   1218.866837       200.752923       0.08333300 12.00000
## 88    525.947589       627.660656       0.00000000 12.00000
## 89     78.573329        42.095280       0.00000000 12.00000
## 90    155.972776        82.345774       0.00000000 12.00000
## 91     18.336805         8.745383       0.09090900 12.00000
## 92     28.654864       256.522546       0.00000000  7.00000
## 93    219.692369       310.328990       0.00000000 12.00000
## 94    104.687781       300.921255       0.00000000 12.00000
## 95    507.240956      1102.034141       0.00000000 12.00000
## 96    160.536841       220.943631       0.00000000 12.00000
## 97    228.417814       175.836378       1.00000000 12.00000
## 98    733.901545       122.835190       0.25000000  7.00000
## 99   1215.965938        99.950697       1.00000000 12.00000
## 100   440.707307       517.115912       0.00000000 12.00000
```

Compute Distance Matrix

```
# distance between observations
dist(rbind(c(1,2,3), c(2,3,2)))
```

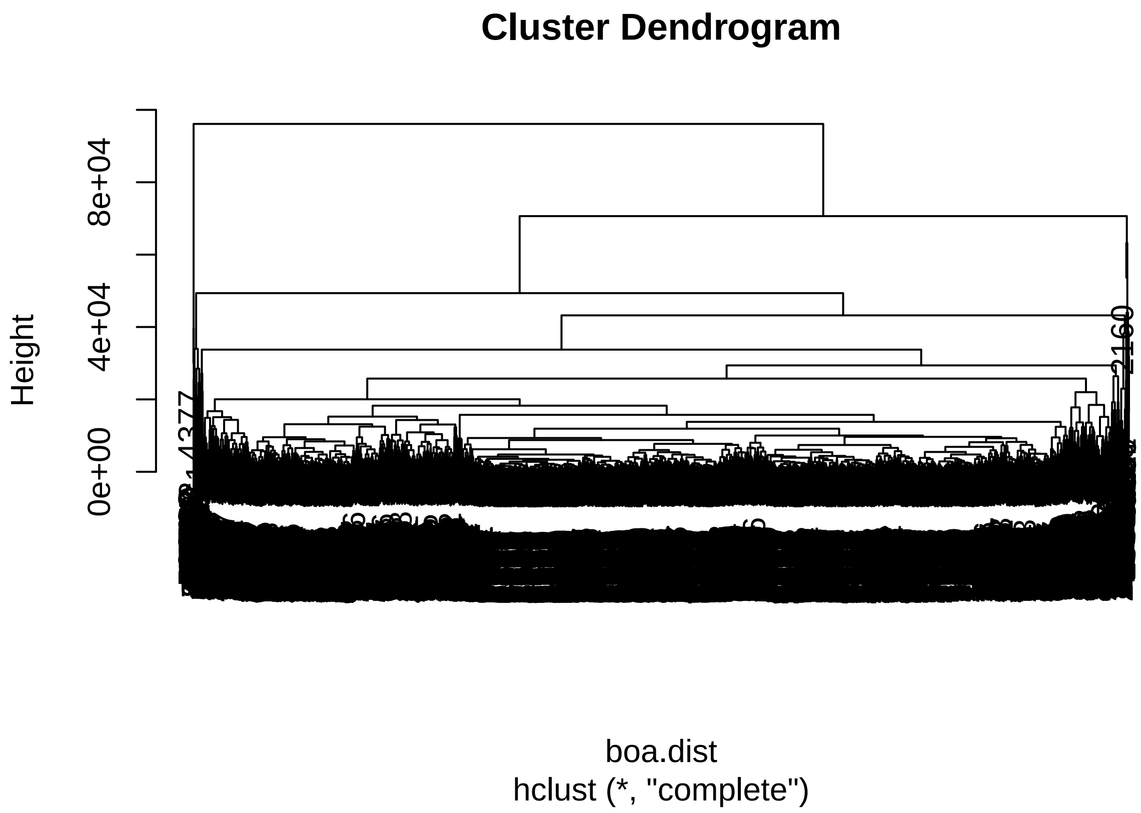
```
##          1
## 2 1.732051
```

```
# get the distance between data types using daisy which combines all datatypes
library(cluster)
boa.dist<-daisy(boa.df.new)
as.matrix(boa.dist)[1:4,1:4]
```

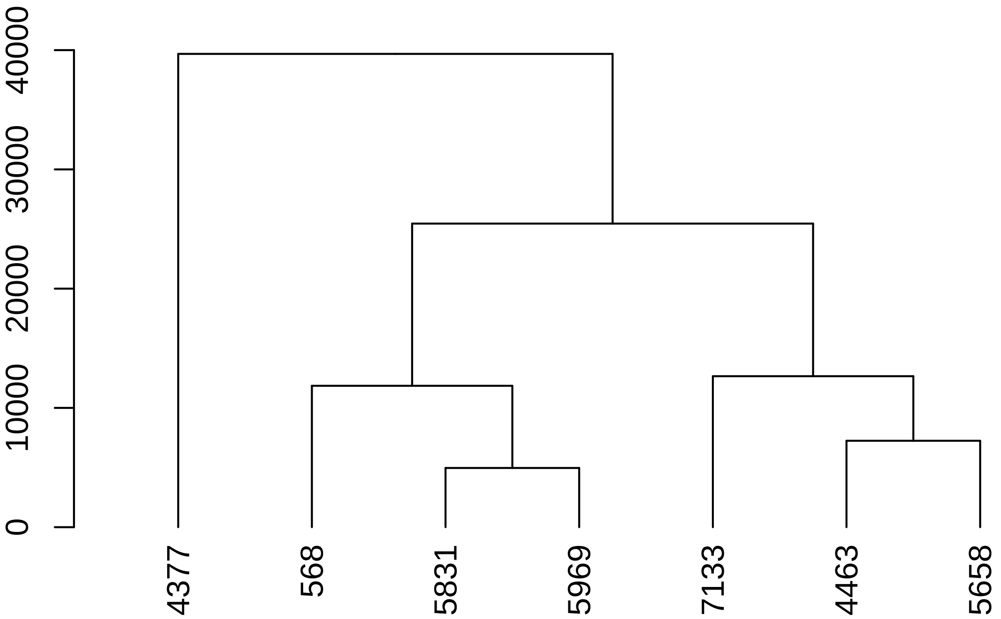
```
##           1         2        3        4
## 1     0.000 10178.701 7021.031 6873.993
## 2 10178.701     0.000 7427.988 7857.647
## 3  7021.031  7427.988    0.000 1426.931
## 4  6873.993  7857.647 1426.931    0.000
```

H Clust

```
# combine closest neighbors into larger groups for hierarchical clustering
boa.hc<-hclust(boa.dist,method="complete")
plot(boa.hc)
```



```
# cut the tree for better visualization
plot(cut(as.dendrogram(boa.hc),h=4e+04)$lower[[1]])
```



```
# comparing observations in branches
boa.df[c(5831,5969),] # similar
```

```
##         X CUST_ID  BALANCE BALANCE_FREQUENCY PURCHASES ONEOFF_PURCHASES
## 5831 5831  C15993 8038.893                 1         0                0
## 5969 5969  C16134 6022.224                 1         0                0
##      INSTALLMENTS_PURCHASES CASH_ADVANCE PURCHASES_FREQUENCY
## 5831                      0     197.9156                   0
## 5969                      0    4111.4656                   0
##      ONEOFF_PURCHASES_FREQUENCY PURCHASES_INSTALLMENTS_FREQUENCY
## 5831                          0                                0
## 5969                          0                                0
##      CASH_ADVANCE_FREQUENCY CASH_ADVANCE_TRX PURCHASES_TRX CREDIT_LIMIT
## 5831               0.166667                8             0         9000
## 5969               0.166667                6             0         7000
##      PAYMENTS MINIMUM_PAYMENTS PRC_FULL_PAYMENT TENURE
## 5831 3569.183         43132.73                0     12
## 5969 4560.776         42629.55                0     12
```

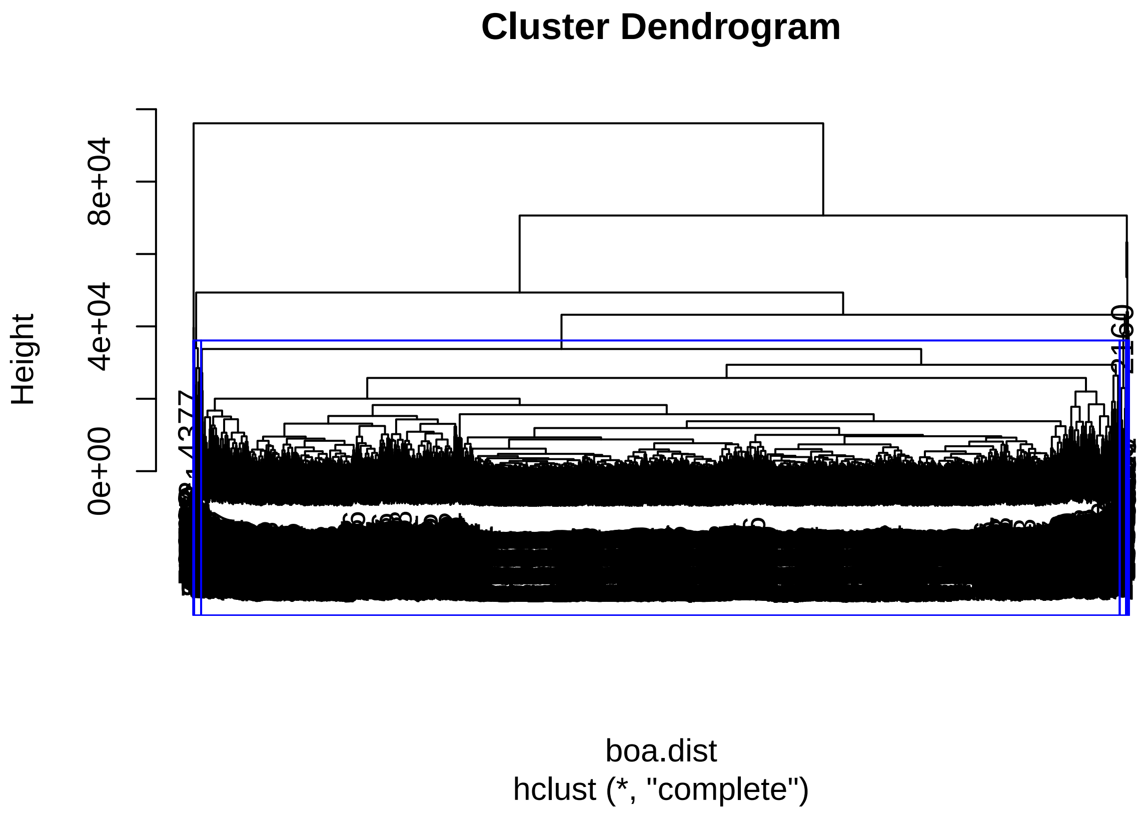
```
boa.df[c(568,7133),] # not similar differ in the last 4 variables
```

```
##         X CUST_ID  BALANCE BALANCE_FREQUENCY PURCHASES ONEOFF_PURCHASES
## 568   568  C10591 3457.086                 1    2448.6                0
## 7133 7133  C17325 9024.812                 1       0.0                0
##      INSTALLMENTS_PURCHASES CASH_ADVANCE PURCHASES_FREQUENCY
## 568                  2448.6        0.000                   1
## 7133                    0.0     2750.442                   0
##      ONEOFF_PURCHASES_FREQUENCY PURCHASES_INSTALLMENTS_FREQUENCY
## 568                           0                                1
## 7133                          0                                0
##      CASH_ADVANCE_FREQUENCY CASH_ADVANCE_TRX PURCHASES_TRX CREDIT_LIMIT
## 568                0.000000                0            12         1700
## 7133               0.083333                2             0         9000
##      PAYMENTS MINIMUM_PAYMENTS PRC_FULL_PAYMENT TENURE
## 568  227.5145         38512.12                0     12
## 7133 302.4842         61031.62                0     12
```

```
# check how well clustering model reflects distance matrix
cor(cophenetic(boa.hc),boa.dist)
```

```
## [1] 0.8598062
```

```
plot(boa.hc)
# At 85% the hierarchical tree represents the distance between the trees well.

# getting k groups from tree
rect.hclust(boa.hc,k=10,border = "blue")
```



```
# getting purchase membership from hclust
boa.hc.purchases<-cutree(boa.hc,k=10)
table(boa.hc.purchases)
```

```
## boa.hc.purchases
##    1    2    3    4    5    6    7    8    9   10
## 8787   61   67    2   15    5    6    5    1    1
```

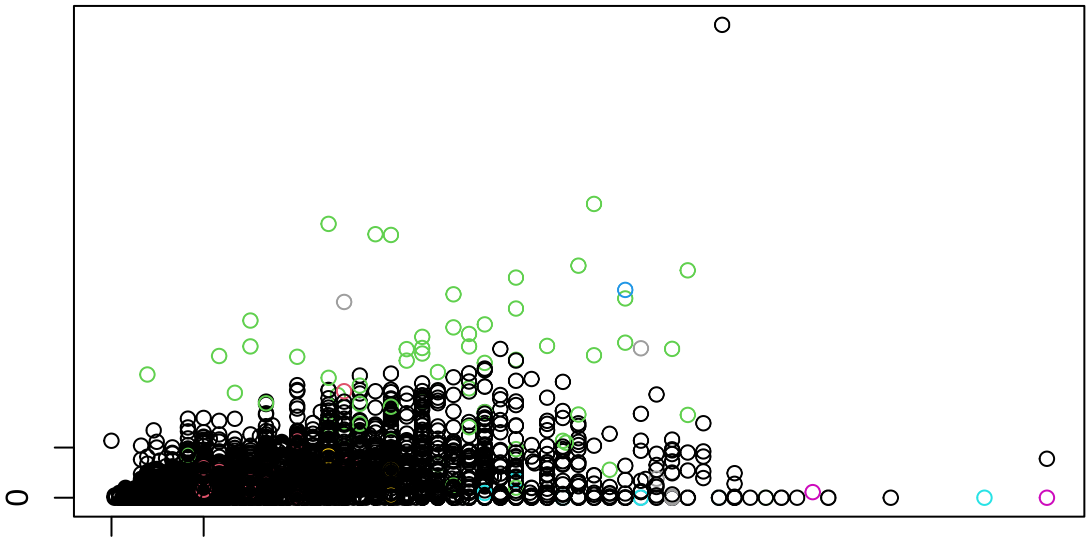
```
# comparing segments
boa.summ(boa.df.new, boa.hc.purchases)
```

```
##    Group.1        X   BALANCE BALANCE_FREQUENCY ONEOFF_PURCHASES
## 1        1 4493.627  1512.198         0.8765615         533.8092
## 2        2 4131.869  3172.547         0.9832754         148.9170
## 3        3 3314.060  4438.527         0.8247157        1005.3907
## 4        4 1973.000 16571.695         1.0000000        6426.0900
## 5        5 1771.600  4281.864         0.9933333       19257.4787
## 6        6 2728.600  6879.309         0.9636364       35158.2400
## 7        7 4937.000  6024.526         1.0000000           0.0000
## 8        8 3162.600  6814.389         0.8545454       11529.8200
## 9        9 2160.000 10905.054         1.0000000         133.5000
## 10      10 4377.000 10571.411         1.0000000           0.0000
##    INSTALLMENTS_PURCHASES CASH_ADVANCE PURCHASES_FREQUENCY
## 1                392.5290     893.1400           0.4901471
## 2                384.4325     965.0994           0.4176602
## 3                868.9455   11043.2705           0.4005621
## 4               7076.7700   10356.3350           1.0000000
## 5               6683.5627     149.3933           0.9933333
## 6               3023.4520     111.6334           0.8833332
## 7                710.3350    1176.6373           0.5000000
## 8               1281.8620    7279.2503           0.7000000
## 9                298.4300   47137.2118           0.5833330
## 10              7739.4800       0.0000           1.0000000
##    ONEOFF_PURCHASES_FREQUENCY PURCHASES_INSTALLMENTS_FREQUENCY
## 1                  0.20161626                        0.3633034
## 2                  0.04284644                        0.3831347
## 3                  0.23229630                        0.3263068
## 4                  0.87500000                        0.6666665
## 5                  0.94222227                        0.8033333
## 6                  0.83333340                        0.6500000
## 7                  0.00000000                        0.5000000
## 8                  0.38333340                        0.6000000
## 9                  0.25000000                        0.5000000
## 10                 0.00000000                        1.0000000
##    CASH_ADVANCE_FREQUENCY CASH_ADVANCE_TRX PURCHASES_TRX CREDIT_LIMIT  PAYMENTS
## 1              0.13309075        3.1159668      14.30044     4413.722  1532.039
## 2              0.11421585        3.2786885      12.50820     3468.033  1054.004
## 3              0.43564643       18.7910448      26.37313    10859.701 17546.531
## 4              0.41666650       18.0000000     125.00000    17250.000 21718.454
## 5              0.01111107        0.3333333     124.00000    15066.667 23169.875
## 6              0.01666660        0.2000000     166.00000    19900.000 35553.331
## 7              0.06944450        2.6666667      32.50000     6200.000  2083.188
## 8              0.28333340       11.4000000      53.00000    15600.000 37341.715
## 9              1.00000000      123.0000000      21.00000    19600.000 39048.598
## 10             0.00000000        0.0000000      44.00000     8000.000  2688.447
##    MINIMUM_PAYMENTS PRC_FULL_PAYMENT   TENURE
## 1          666.1803      0.153682508 11.51269
## 2        16785.8559      0.004098344 11.85246
## 3         1610.8447      0.187596597 11.59701
## 4        19928.0393      0.000000000 12.00000
## 5         1212.7009      0.584595933 11.86667
## 6         6445.0784      0.566666600 12.00000
## 7        48656.1372      0.000000000 12.00000
## 8         2910.4627      0.183333400 12.00000
## 9         5394.1737      0.000000000 12.00000
## 10       76406.2075      0.000000000 12.00000
```

```
head(boa.summ(boa.df.new, boa.df$PURCHASES), 100)
```

```
##     Group.1        X      BALANCE BALANCE_FREQUENCY ONEOFF_PURCHASES
## 1      0.00 4569.760 2151.2029350         0.8825000          0.00000
## 2      0.01 2817.000 1692.2194260         0.6590910          0.01000
## 3      0.05  329.000  850.6301140         1.0000000          0.05000
## 4      0.24 3591.000    1.8694350         0.4545450          0.24000
## 5      0.70 5814.000  212.3061480         0.1818180          0.70000
## 6      1.00 4832.500 2321.6780220         1.0000000          1.00000
## 7      1.40 7002.000   46.7957010         0.2727270          1.40000
## 8      2.00 2045.000 1709.6939560         1.0000000          2.00000
## 9      4.44 3556.000 6744.8456860         1.0000000          0.00000
## 10     4.80 6233.000    7.4569660         0.2727270          0.00000
## 11     4.99 3163.000  793.0052270         1.0000000          4.99000
## 12     6.90 8195.000    0.4372850         0.1818180          6.90000
## 13     7.26 6518.000  644.9339110         0.8333330          0.00000
## 14     8.40 3708.667 2901.6828830         1.0000000          8.40000
## 15     9.28 5929.000    0.0000000         0.0000000          0.00000
## 16     9.68 5260.000    2.6411010         1.0000000          0.00000
## 17     9.87 7640.000    1.6952940         0.0909090          0.00000
## 18     9.90 6643.000 1083.3791710         1.0000000          0.00000
## 19    10.79 7849.000  411.3629690         1.0000000          0.00000
## 20    10.89 7920.000    0.0000000         0.0000000          0.00000
## 21    11.06  615.000 3419.6616760         1.0000000         11.06000
## 22    11.35 4851.000 1074.2584870         1.0000000          0.00000
## 23    11.41 2339.000 3860.2380720         1.0000000         11.41000
## 24    12.00 2794.500   34.2897165         0.6363640          6.00000
## 25    12.22 3932.000 2944.1569960         1.0000000         12.22000
## 26    12.40 6180.000  933.0725190         1.0000000         12.40000
## 27    12.64 2743.000 6784.2582760         1.0000000          0.00000
## 28    12.65 1132.000    0.0000000         0.0000000          0.00000
## 29    13.00 8666.000 1112.9156570         1.0000000         13.00000
## 30    13.66 4756.000  207.2095970         1.0000000          0.00000
## 31    13.69 5911.000   56.0603270         0.1818180          0.00000
## 32    14.28 2593.000  339.4062590         1.0000000          0.00000
## 33    14.72 5553.000 1175.9226280         1.0000000         14.72000
## 34    14.95  321.000 4732.3735400         1.0000000          0.00000
## 35    14.98 3273.000  124.1178380         0.3636360         14.98000
## 36    15.00 7854.500  647.5574050         0.7272725         15.00000
## 37    15.30 7396.000    1.9413280         0.1818180          0.00000
## 38    15.40 1956.000  107.1300200         1.0000000          15.40000
## 39    15.80 5105.000  900.5417510         1.0000000           0.00000
## 40    15.92 5721.000 3881.6795820         1.0000000          15.92000
## 41    16.00 1984.000  410.4281480         0.5909090          16.00000
## 42    16.50  384.000    1.8380840         0.2727270          16.50000
## 43    17.00 6253.000  492.0402230         1.0000000          17.00000
## 44    17.30 6173.000 4198.6180900         0.7272730          17.30000
## 45    17.60 7294.000 1242.8862660         1.0000000          17.60000
## 46    17.70 3169.000    0.6839390         0.1818180          17.70000
## 47    17.80 2589.500  225.7873070         0.4090905          17.80000
## 48    18.00 5487.000 2893.8974870         1.0000000           0.00000
## 49    18.05  859.000  910.0725140         1.0000000           0.00000
## 50    18.35 3909.000 6928.7213770         1.0000000           0.00000
## 51    18.41  600.000  917.7328460         1.0000000           0.00000
## 52    18.77 4402.000    0.0000000         0.0000000           0.00000
## 53    19.08 1582.000    1.3432070         0.1818180           0.00000
## 54    19.25 4630.000    0.0000000         0.0000000           0.00000
## 55    19.50 5774.000   17.2455390         0.6363640           0.00000
## 56    19.75 7544.000  803.0527040         1.0000000          19.75000
## 57    19.88 6869.000  826.6886250         1.0000000          19.88000
## 58    19.90 3161.000  147.8458865         0.6000000           9.95000
## 59    19.91 4107.000  634.7599730         1.0000000           0.00000
## 60    19.96 6713.000  701.0172700         1.0000000          19.96000
## 61    19.98 2064.000 2828.7658220         1.0000000          19.98000
## 62    20.00 4817.333 1199.7706802         0.8232323          16.66667
## 63    20.09  921.000   39.7989930         0.4545450          20.09000
## 64    20.74 7575.000    1.0631140         0.0909090           0.00000
## 65    20.90 5794.500  666.7627825         0.7500000          20.90000
## 66    21.00 3224.000  509.9003170         0.3636360           0.00000
## 67    21.05 4059.000    1.8168140         0.0909090           0.00000
## 68    21.75 3967.000 1033.4987360         1.0000000           0.00000
## 69    21.90 6196.000  556.8574380         1.0000000          21.90000
## 70    21.99 6776.000   12.4233240         0.5454550           0.00000
## 71    22.16 1131.000 6090.5222730         1.0000000          22.16000
## 72    22.48 3406.000   35.2765510         1.0000000          22.48000
## 73    22.50 2241.000 1013.8676360         0.6818180           0.00000
## 74    22.68 2214.000  689.6976440         1.0000000           0.00000
## 75    23.00 2132.500    0.4297235         0.2272725          11.50000
## 76    23.21 1636.000 1621.0353730         1.0000000           0.00000
## 77    23.75 7870.000  183.2858400         1.0000000          23.75000
## 78    23.91 2327.000    1.0594250         0.3636360          23.91000
## 79    24.00  737.000    0.2557100         0.0909090           0.00000
## 80    24.63 5249.000  385.8419970         1.0000000           0.00000
## 81    24.64  587.000    0.3271990         0.4545450          24.64000
## 82    25.00 6273.000 2080.3129910         0.8888890           0.00000
## 83    25.20 3344.000 1396.3858050         1.0000000          25.20000
## 84    25.26 2896.500 1650.7292830         1.0000000          25.26000
## 85    25.50 1167.000    1.0591030         0.1818180          25.50000
## 86    25.69 4795.000    4.1256500         0.3636360          25.69000
## 87    26.09 7364.000  443.5585780         1.0000000          26.09000
## 88    26.12 3183.000 1839.9304600         1.0000000          26.12000
## 89    26.49 4972.000    2.0813570         0.1818180          26.49000
## 90    26.53 8491.000    2.0447450         0.1818180          26.53000
## 91    26.62  919.000    0.8675280         0.2727270           0.00000
## 92    26.80 2992.000  347.5772930         0.8571430         26.80000
## 93    27.00  916.000 1068.4340640         1.0000000          0.00000
## 94    27.05 5123.000  500.2194150         1.0000000          0.00000
## 95    27.16 5033.000 2872.7986140         1.0000000          0.00000
## 96    27.22 8221.000  435.5180680         1.0000000         27.22000
## 97    27.42 4690.000    4.4172730         0.1818180          0.00000
## 98    27.51 3600.000  286.2643560         0.8571430         27.51000
## 99    27.79 8214.000   57.1168110         0.4545450         27.79000
## 100   27.89 4243.000 1868.5237860         1.0000000         27.89000
##     INSTALLMENTS_PURCHASES CASH_ADVANCE PURCHASES_FREQUENCY
## 1               0.04253914   1988.74251        0.0001630788
## 2               0.00000000   2877.42895        0.0852270000
## 3               0.00000000   1700.63459        0.0833330000
## 4               0.00000000      0.00000        0.0833330000
## 5               0.00000000   1922.59360        0.0833330000
## 6               0.00000000    710.16094        0.0833330000
## 7               0.00000000    189.11039        0.1666670000
## 8               0.00000000   5246.29645        0.0833330000
## 9               4.44000000  19862.87844        0.2500000000
## 10              4.80000000      0.00000        0.0833330000
## 11              0.00000000      0.00000        0.0833330000
## 12              0.00000000      0.00000        0.0833330000
## 13              7.26000000    966.74937        0.1666670000
## 14              0.00000000     18.17314        1.0000000000
## 15              9.28000000      0.00000        0.2500000000
## 16              9.68000000      0.00000        0.0833330000
## 17              9.87000000      0.00000        0.0833330000
## 18              9.90000000      0.00000        0.1428570000
## 19             10.79000000      0.00000        0.1666670000
## 20             10.89000000      0.00000        0.0833330000
## 21              0.00000000   1261.34778        0.0833330000
## 22             11.35000000      0.00000        0.0833330000
## 23              0.00000000      0.00000        0.1666670000
## 24              6.00000000     83.08013        0.5416665000
## 25              0.00000000    244.69466        0.0833330000
## 26              0.00000000   1085.48705        0.0833330000
## 27             12.64000000   4516.16260        0.0833330000
## 28             12.65000000      0.00000        0.0833330000
## 29              0.00000000    256.94406        0.0833330000
## 30             13.66000000      0.00000        0.0909090000
## 31             13.69000000      0.00000        0.0833330000
## 32             14.28000000      0.00000        0.4166670000
## 33              0.00000000     79.25217        0.0833330000
## 34             14.95000000   2173.35607        0.0833330000
## 35              0.00000000      0.00000        0.0833330000
## 36              0.00000000    104.51269        0.0871210000
## 37             15.30000000      0.00000        0.0833330000
## 38              0.00000000    182.66132        0.0833330000
## 39             15.80000000      0.00000        0.2500000000
## 40              0.00000000   2183.78246        0.0833330000
## 41              0.00000000      0.00000        0.0833330000
## 42              0.00000000      0.00000        0.0833330000
## 43              0.00000000    171.81466        0.0833330000
## 44              0.00000000   2845.86846        0.0833330000
## 45              0.00000000      0.00000        0.0833330000
## 46              0.00000000      0.00000        0.0833330000
## 47              0.00000000   1214.90989        0.0833330000
## 48             18.00000000   3904.51445        0.0833330000
## 49             18.05000000     19.11884        0.0833330000
## 50             18.35000000  14836.45141        0.4166670000
## 51             18.41000000      0.00000        0.0833330000
## 52             18.77000000      0.00000        0.0833330000
## 53             19.08000000      0.00000        0.1666670000
## 54             19.25000000      0.00000        0.0833330000
## 55             19.50000000      0.00000        0.0833330000
## 56              0.00000000      0.00000        0.0833330000
## 57              0.00000000    869.24620        0.0833330000
## 58              9.95000000     37.62758        0.1416665000
## 59             19.91000000      0.00000        0.0833330000
## 60              0.00000000    153.59777        0.0833330000
## 61              0.00000000      0.00000        0.0833330000
## 62              3.33333333    275.21390        0.1296293333
## 63              0.00000000      0.00000        0.3333330000
## 64             20.74000000      0.00000        0.1666670000
## 65              0.00000000      0.00000        0.1250000000
## 66             21.00000000      0.00000        0.0833330000
## 67             21.05000000      0.00000        0.0833330000
## 68             21.75000000   1238.74695        0.0833330000
## 69              0.00000000      0.00000        0.1666670000
## 70             21.99000000      0.00000        0.0909090000
## 71              0.00000000      0.00000        0.0833330000
## 72              0.00000000      0.00000        0.0833330000
## 73             22.50000000      0.00000        0.2500000000
## 74             22.68000000      0.00000        0.0833330000
## 75             11.50000000      0.00000        0.0833330000
## 76             23.21000000      0.00000        0.3333330000
## 77              0.00000000     64.00625        0.0833330000
## 78              0.00000000      0.00000        0.3333330000
## 79             24.00000000      0.00000        0.1666670000
## 80             24.63000000      0.00000        0.4166670000
## 81              0.00000000      0.00000        0.0833330000
## 82             25.00000000   2422.88959        0.1111110000
## 83              0.00000000   1920.24988        0.0833330000
## 84              0.00000000    226.40183        0.1250000000
## 85              0.00000000      0.00000        0.0833330000
## 86              0.00000000      0.00000        0.0833330000
## 87              0.00000000    646.93268        0.0833330000
## 88              0.00000000    158.97124        0.0833330000
## 89              0.00000000      0.00000        0.0833330000
## 90              0.00000000      0.00000        0.0833330000
## 91             26.62000000      0.00000        0.3333330000
## 92              0.00000000    470.84647        0.1428570000
## 93             27.00000000      0.00000        0.0833330000
## 94             27.05000000      0.00000        0.0833330000
## 95             27.16000000   2692.77704        0.0833330000
## 96              0.00000000      0.00000        0.0833330000
## 97             27.42000000      0.00000        0.0833330000
## 98              0.00000000    871.19926        0.1428570000
## 99              0.00000000    381.17115        0.0833330000
## 100             0.00000000     47.99887        0.0833330000
##     ONEOFF_PURCHASES_FREQUENCY PURCHASES_INSTALLMENTS_FREQUENCY
## 1                   0.00000000                      0.000285388
## 2                   0.08522700                      0.000000000
## 3                   0.08333300                      0.000000000
## 4                   0.08333300                      0.000000000
## 5                   0.08333300                      0.000000000
## 6                   0.08333300                      0.000000000
## 7                   0.16666700                      0.000000000
## 8                   0.08333300                      0.000000000
## 9                   0.00000000                      0.166667000
## 10                  0.00000000                      0.083333000
## 11                  0.08333300                      0.000000000
## 12                  0.08333300                      0.000000000
## 13                  0.00000000                      0.166667000
## 14                  1.00000000                      0.000000000
## 15                  0.00000000                      0.250000000
## 16                  0.00000000                      0.083333000
## 17                  0.00000000                      0.083333000
## 18                  0.00000000                      0.142857000
## 19                  0.00000000                      0.166667000
## 20                  0.00000000                      0.083333000
## 21                  0.08333300                      0.000000000
## 22                  0.00000000                      0.083333000
## 23                  0.16666700                      0.000000000
## 24                  0.04166650                      0.458333500
## 25                  0.08333300                      0.000000000
## 26                  0.08333300                      0.000000000
## 27                  0.00000000                      0.083333000
## 28                  0.00000000                      0.083333000
## 29                  0.08333300                      0.000000000
## 30                  0.00000000                      0.090909000
## 31                  0.00000000                      0.083333000
## 32                  0.00000000                      0.416667000
## 33                  0.08333300                      0.000000000
## 34                  0.00000000                      0.083333000
## 35                  0.08333300                      0.000000000
## 36                  0.08712100                      0.000000000
## 37                  0.00000000                      0.083333000
## 38                  0.08333300                      0.000000000
## 39                  0.00000000                      0.250000000
## 40                  0.08333300                      0.000000000
## 41                  0.08333300                      0.000000000
## 42                  0.08333300                      0.000000000
## 43                  0.08333300                      0.000000000
## 44                  0.08333300                      0.000000000
## 45                  0.08333300                      0.000000000
## 46                  0.08333300                      0.000000000
## 47                  0.08333300                      0.000000000
## 48                  0.00000000                      0.083333000
## 49                  0.00000000                      0.083333000
## 50                  0.00000000                      0.416667000
## 51                  0.00000000                      0.083333000
## 52                  0.00000000                      0.083333000
## 53                  0.00000000                      0.083333000
## 54                  0.00000000                      0.083333000
## 55                  0.00000000                      0.083333000
## 56                  0.08333300                      0.000000000
## 57                  0.08333300                      0.000000000
## 58                  0.04166650                      0.050000000
## 59                  0.00000000                      0.083333000
## 60                  0.08333300                      0.000000000
## 61                  0.08333300                      0.000000000
## 62                  0.07407383                      0.055555500
## 63                  0.33333300                      0.000000000
## 64                  0.00000000                      0.166667000
## 65                  0.12500000                      0.000000000
## 66                  0.00000000                      0.083333000
## 67                  0.00000000                      0.083333000
## 68                  0.00000000                      0.083333000
## 69                  0.16666700                      0.000000000
## 70                  0.00000000                      0.090909000
## 71                  0.08333300                      0.000000000
## 72                  0.08333300                      0.000000000
## 73                  0.00000000                      0.250000000
## 74                  0.00000000                      0.083333000
## 75                  0.04166650                      0.041666500
## 76                  0.00000000                      0.333333000
## 77                  0.08333300                      0.000000000
## 78                  0.33333300                      0.000000000
## 79                  0.00000000                      0.166667000
## 80                  0.00000000                      0.416667000
## 81                  0.08333300                      0.000000000
## 82                  0.00000000                      0.111111000
## 83                  0.08333300                      0.000000000
## 84                  0.12500000                      0.000000000
## 85                  0.08333300                      0.000000000
## 86                  0.08333300                      0.000000000
## 87                  0.08333300                      0.000000000
## 88                  0.08333300                      0.000000000
## 89                  0.08333300                      0.000000000
## 90                  0.08333300                      0.000000000
## 91                  0.00000000                      0.333333000
## 92                  0.14285700                      0.000000000
## 93                  0.00000000                      0.083333000
## 94                  0.00000000                      0.083333000
## 95                  0.00000000                      0.083333000
## 96                  0.08333300                      0.000000000
## 97                  0.00000000                      0.083333000
## 98                  0.14285700                      0.000000000
## 99                  0.08333300                      0.000000000
## 100                 0.08333300                      0.000000000
##     CASH_ADVANCE_FREQUENCY CASH_ADVANCE_TRX PURCHASES_TRX CREDIT_LIMIT
## 1               0.27259049        6.2964775   0.001956947     4029.727
## 2               0.10984850        4.2500000   1.000000000     6375.000
## 3               0.33333300        7.0000000   1.000000000     1000.000
## 4               0.00000000        0.0000000   0.000000000     3000.000
## 5               0.16666700        3.0000000   1.000000000     3500.000
## 6               0.12500000        2.0000000   1.000000000     4100.000
## 7               0.08333300        1.0000000   2.000000000     4500.000
## 8               0.25000000        6.0000000   1.000000000     2500.000
## 9               0.41666700       11.0000000   3.000000000    16500.000
## 10              0.00000000        0.0000000   1.000000000     2200.000
## 11              0.00000000        0.0000000   1.000000000     2500.000
## 12              0.00000000        0.0000000   1.000000000     8500.000
## 13              0.16666700        1.0000000   1.000000000     1500.000
## 14              0.02777767        0.6666667  12.000000000     6400.000
## 15              0.00000000        0.0000000   3.000000000     5000.000
## 16              0.00000000        0.0000000   1.000000000     8000.000
## 17              0.00000000        0.0000000   1.000000000     5000.000
## 18              0.00000000        0.0000000   1.000000000     1900.000
## 19              0.00000000        0.0000000   1.000000000     1200.000
## 20              0.00000000        0.0000000   1.000000000     4000.000
## 21              0.08333300        1.0000000   1.000000000     4000.000
## 22              0.00000000        0.0000000   1.000000000     1200.000
## 23              0.00000000        0.0000000   2.000000000    10000.000
## 24              0.04166650        1.5000000   6.500000000     1400.000
## 25              0.16666700        2.0000000   1.000000000     3000.000
## 26              0.16666700        6.0000000   1.000000000     2500.000
## 27              0.41666700       13.0000000   1.000000000    10000.000
## 28              0.00000000        0.0000000   1.000000000     5000.000
## 29              0.25000000        5.0000000   1.000000000     1500.000
## 30              0.00000000        0.0000000   1.000000000     7000.000
## 31              0.00000000        0.0000000   1.000000000     2900.000
## 32              0.00000000        0.0000000   5.000000000    10500.000
## 33              0.25000000        3.0000000   1.000000000     1200.000
## 34              0.41666700       11.0000000   1.000000000     5700.000
## 35              0.00000000        0.0000000   1.000000000     1700.000
## 36              0.04545450        0.5000000   1.000000000     4500.000
## 37              0.00000000        0.0000000   1.000000000     5000.000
## 38              0.33333300        6.0000000   1.000000000      200.000
## 39              0.00000000        0.0000000   3.000000000     7000.000
## 40              0.33333300        9.0000000   1.000000000     5500.000
## 41              0.00000000        0.0000000   1.000000000     3350.000
## 42              0.00000000        0.0000000   1.000000000     6000.000
## 43              0.33333300        4.0000000   1.000000000      600.000
## 44              0.25000000        6.0000000   1.000000000     8954.545
## 45              0.00000000        0.0000000   1.000000000     4000.000
## 46              0.00000000        0.0000000   1.000000000     1500.000
## 47              0.12500000        1.5000000   1.000000000     2500.000
## 48              0.41666700       23.0000000   1.000000000     6000.000
## 49              0.08333300        1.0000000   1.000000000     1000.000
## 50              0.08333300        1.0000000   5.000000000    18000.000
## 51              0.00000000        0.0000000   1.000000000     1000.000
## 52              0.00000000        0.0000000   1.000000000     5000.000
## 53              0.00000000        0.0000000   2.000000000     7000.000
## 54              0.00000000        0.0000000   1.000000000     4000.000
## 55              0.00000000        0.0000000   1.000000000     1500.000
## 56              0.00000000        0.0000000   1.000000000     2000.000
## 57              0.33333300       20.0000000   2.000000000      900.000
## 58              0.08333350        1.0000000   1.500000000     3750.000
## 59              0.00000000        0.0000000   1.000000000     6000.000
## 60              0.25000000        3.0000000   1.000000000     3500.000
## 61              0.00000000        0.0000000   2.000000000     5500.000
## 62              0.15277767        2.1666667   1.500000000     3000.000
## 63              0.00000000        0.0000000   5.000000000     3200.000
## 64              0.00000000        0.0000000   2.000000000     1500.000
## 65              0.00000000        0.0000000   1.000000000     1000.000
## 66              0.00000000        0.0000000   1.000000000    11500.000
## 67              0.00000000        0.0000000   1.000000000     2900.000
## 68              0.33333300        5.0000000   1.000000000     3000.000
## 69              0.00000000        0.0000000   2.000000000      600.000
## 70              0.00000000        0.0000000   1.000000000     4000.000
## 71              0.00000000        0.0000000   1.000000000     9000.000
## 72              0.00000000        0.0000000   1.000000000     7500.000
## 73              0.00000000        0.0000000   3.000000000     6500.000
## 74              0.00000000        0.0000000   1.000000000    11500.000
## 75              0.00000000        0.0000000   1.000000000     4000.000
## 76              0.00000000        0.0000000   4.000000000     2000.000
## 77              0.08333300        2.0000000   1.000000000      500.000
## 78              0.00000000        0.0000000   4.000000000    15500.000
## 79              0.00000000        0.0000000   2.000000000     1500.000
## 80              0.00000000        0.0000000   5.000000000     4500.000
## 81              0.00000000        0.0000000   1.000000000     1800.000
## 82              0.33333300        6.0000000   1.000000000     2500.000
## 83              0.58333300       19.0000000   1.000000000     2500.000
## 84              0.12500000        1.5000000   1.500000000     3050.000
## 85              0.00000000        0.0000000   1.000000000     5500.000
## 86              0.00000000        0.0000000   1.000000000     4500.000
## 87              0.50000000       16.0000000   4.000000000     1200.000
## 88              0.08333300        1.0000000   1.000000000     1950.000
## 89              0.00000000        0.0000000   1.000000000     7500.000
## 90              0.00000000        0.0000000   1.000000000     2500.000
## 91              0.00000000        0.0000000   4.000000000     4500.000
## 92              0.42857100       11.0000000   1.000000000      500.000
## 93              0.00000000        0.0000000   1.000000000     1200.000
## 94              0.00000000        0.0000000   1.000000000     1200.000
## 95              0.41666700       15.0000000   1.000000000     5000.000
## 96              0.00000000        0.0000000   1.000000000      500.000
## 97              0.00000000        0.0000000   1.000000000     1800.000
## 98              0.42857100        3.0000000   1.000000000      500.000
## 99              0.08333300        1.0000000   1.000000000     4500.000
## 100             0.08333300        1.0000000   2.000000000     2000.000
##         PAYMENTS MINIMUM_PAYMENTS PRC_FULL_PAYMENT   TENURE
## 1    1653.130103       968.694784       0.04432393 11.31849
## 2    1273.540476       629.643771       0.03125000 11.75000
## 3    1084.281127       367.409536       0.00000000 12.00000
## 4     150.381107        53.294711       0.00000000 12.00000
## 5       0.000000         0.000000       0.00000000 12.00000
## 6     848.476405       604.791575       0.00000000 12.00000
## 7       0.000000         0.000000       0.00000000 12.00000
## 8    4678.254753       464.860442       0.08333300 12.00000
## 9   21440.298660      1350.823356       0.10000000 12.00000
## 10     70.517745       246.213204       0.00000000 12.00000
## 11   1127.028432       223.627537       0.08333300 12.00000
## 12      4.523555         4.763689       0.00000000 12.00000
## 13    431.732367        92.246251       0.00000000  6.00000
## 14    769.002348      1076.353714       0.00000000 12.00000
## 15      0.000000         0.000000       0.00000000 12.00000
## 16     72.282497        17.530337       0.00000000 12.00000
## 17    151.732627        98.617471       0.50000000 12.00000
## 18    186.923852      7243.733403       0.00000000  7.00000
## 19    918.160924       166.281511       0.00000000 12.00000
## 20      0.000000         0.000000       0.00000000 12.00000
## 21    745.984976      1243.564770       0.00000000 12.00000
## 22    421.348577       206.637191       0.00000000 12.00000
## 23   7280.584479      1013.780486       0.08333300 12.00000
## 24     79.733163        65.870176       0.00000000 12.00000
## 25    628.314620      1288.695715       0.00000000 12.00000
## 26    481.589626       238.636185       0.08333300 12.00000
## 27  10813.829330      1661.518089       0.08333300 12.00000
## 28      0.000000         0.000000       0.00000000 12.00000
## 29    396.056561       308.356999       0.00000000 12.00000
## 30   1703.339459       208.367436       0.00000000 11.00000
## 31   2165.403988       219.961065       0.00000000 12.00000
## 32   1263.292815      1486.059666       0.08333300 12.00000
## 33    347.568201       463.992512       0.00000000 12.00000
## 34   1289.284068      1172.289863       0.00000000 12.00000
## 35    607.535166        43.582049       0.00000000 12.00000
## 36    352.719365       261.538020       0.00000000 11.50000
## 37    190.254352       117.892476       0.00000000 12.00000
## 38    255.103798       198.933162       0.00000000 12.00000
## 39   1542.583506       375.127536       0.00000000 12.00000
## 40   1032.183632      1129.747227       0.00000000 12.00000
## 41    667.190047       182.614350       0.50000000 12.00000
## 42     57.595083        67.192500       0.00000000 12.00000
## 43    243.905711       291.892373       0.00000000 12.00000
## 44  10226.601760      1024.126428       0.10000000 12.00000
## 45    589.674674       472.763536       0.00000000 12.00000
## 46     18.825023        10.074393       0.00000000 12.00000
## 47   5253.799504       411.220052       0.50000000 12.00000
## 48    483.729934       720.971058       0.00000000 12.00000
## 49    233.886707       230.806229       0.00000000 12.00000
## 50  22281.700460      1592.560164       0.09090900 12.00000
## 51   1407.291593       424.623595       0.00000000 12.00000
## 52      0.000000         0.000000       0.00000000 12.00000
## 53    170.180973       161.234787       0.00000000 12.00000
## 54      0.000000         0.000000       0.00000000 12.00000
## 55     95.789433       119.880198       0.00000000 12.00000
## 56    402.155365       322.394919       0.00000000 12.00000
## 57   1072.638864       373.912056       0.08333300 12.00000
## 58    132.130910       111.680274       0.25000000 11.00000
## 59    610.491342       246.804668       0.00000000 12.00000
## 60    218.851473       332.899226       0.00000000 12.00000
## 61    593.220384      1159.310924       0.00000000 12.00000
## 62    711.253366       388.624279       0.00000000 11.50000
## 63      0.000000         0.000000       0.00000000 12.00000
## 64    168.489938        98.859855       0.00000000 12.00000
## 65    173.167499       263.360908       0.00000000  9.00000
## 66  23150.571840      1863.225391       0.33333300 12.00000
## 67    243.137299       112.019269       0.00000000 12.00000
## 68    255.779858       489.808320       0.00000000 12.00000
## 69    162.272808       271.112945       0.00000000 12.00000
## 70      0.000000         0.000000       0.00000000 11.00000
## 71    568.781100     30528.432400       0.00000000 12.00000
## 72     68.205028       200.034390       0.00000000 12.00000
## 73   1441.188109       248.194890       0.00000000 12.00000
## 74    906.092735       224.709183       0.00000000 12.00000
## 75      0.000000         0.000000       0.00000000 12.00000
## 76    500.515114       475.627205       0.00000000 12.00000
## 77    584.679478       139.651483       0.08333300 12.00000
## 78     31.845894        22.081988       0.11111100 12.00000
## 79      9.533313         8.842600       0.00000000 12.00000
## 80   1349.938041       203.987924       0.00000000 12.00000
## 81     45.640106        26.849523       0.00000000 12.00000
## 82    540.687217       570.576789       0.00000000  9.00000
## 83    410.617369       503.627101       0.00000000 12.00000
## 84    819.279904       526.338710       0.00000000 12.00000
## 85    563.748018        83.648417       0.50000000 12.00000
## 86    163.352538       128.336305       0.00000000 12.00000
## 87   1218.866837       200.752923       0.08333300 12.00000
## 88    525.947589       627.660656       0.00000000 12.00000
## 89     78.573329        42.095280       0.00000000 12.00000
## 90    155.972776        82.345774       0.00000000 12.00000
## 91     18.336805         8.745383       0.09090900 12.00000
## 92     28.654864       256.522546       0.00000000  7.00000
## 93    219.692369       310.328990       0.00000000 12.00000
## 94    104.687781       300.921255       0.00000000 12.00000
## 95    507.240956      1102.034141       0.00000000 12.00000
## 96    160.536841       220.943631       0.00000000 12.00000
## 97    228.417814       175.836378       1.00000000 12.00000
## 98    733.901545       122.835190       0.25000000  7.00000
## 99   1215.965938        99.950697       1.00000000 12.00000
## 100   440.707307       517.115912       0.00000000 12.00000
```

```
# emerging group 5 & 6
plot(jitter(as.numeric(boa.df.new$CASH_ADVANCE)) ~
       jitter(as.numeric(boa.df.new$CREDIT_LIMIT)),
     col=boa.hc.purchases,
     yaxt="n",
     xaxt="n",
     ylab="",
     xlab="")
axis(1, at=c(50, 3000), labels=c("Min credit limit: 50", "Max credit limit: 3000"))
axis(2, at=c(0, 5000), labels=levels(boa.df.new$CASH_ADVANCE))
```



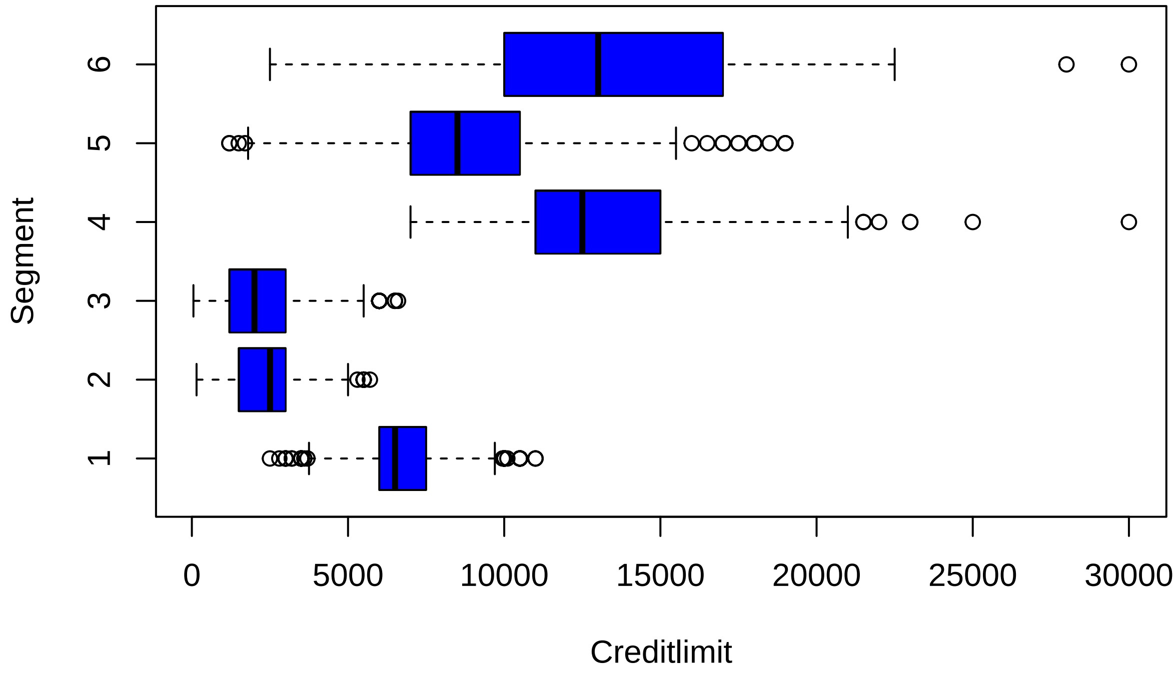
Min credit limit: 50

K Means

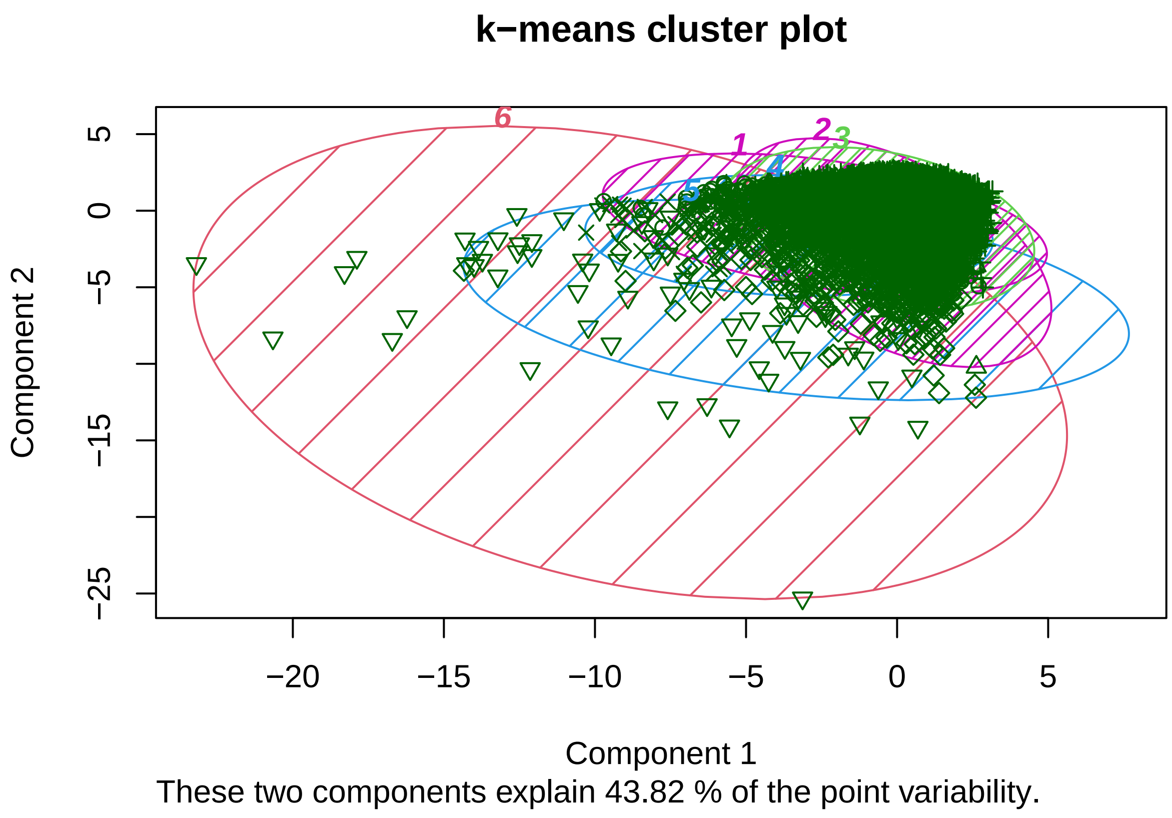
```r
boa.df.num <- boa.df.new
set.seed(12345)

boa.k<-kmeans(boa.df.num,centers = 6)
boa.summ(boa.df.new,boa.k$cluster)
```

```
##   Group.1        X  BALANCE BALANCE_FREQUENCY ONEOFF_PURCHASES
## 1       1 3473.192 1666.250         0.9066200         876.0499
## 2       2 2383.478 1033.415         0.8789913         318.9521
## 3       3 7032.866  699.745         0.8353757         242.3384
## 4       4 2528.185 2890.655         0.9091980        2042.4956
## 5       5 3414.552 6100.887         0.9765424         476.2747
## 6       6 2505.634 5043.583         0.8593260        7289.1705
##   INSTALLMENTS_PURCHASES CASH_ADVANCE PURCHASES_FREQUENCY
## 1               527.9718     786.3986           0.5690613
## 2               257.2039     509.2856           0.4292796
## 3               284.8894     514.0729           0.4751120
## 4              1031.9138     564.0622           0.7049679
## 5               453.9301    4984.7457           0.3654152
## 6              2768.6097    7546.1825           0.6296676
##   ONEOFF_PURCHASES_FREQUENCY PURCHASES_INSTALLMENTS_FREQUENCY
## 1                  0.3235480                        0.3949300
## 2                  0.1546873                        0.3115449
## 3                  0.1246642                        0.3757905
## 4                  0.4798681                         0.5005175
## 5                  0.1574601                         0.2772320
## 6                  0.4841991                         0.5139087
##   CASH_ADVANCE_FREQUENCY CASH_ADVANCE_TRX PURCHASES_TRX CREDIT_LIMIT  PAYMENTS
## 1             0.11583796         2.555057     20.183857     6801.164  1991.591
## 2             0.10876211         2.191609     10.001298     2454.562  1009.112
## 3             0.11333867         2.503684      9.976717     2219.845   886.118
## 4             0.07900764         1.497942     36.674897    13110.905  3347.170
## 5             0.41935725        12.966616     15.556904     8741.130  3863.819
## 6             0.28261880        11.978495     65.526882    13292.473 21525.445
##   MINIMUM_PAYMENTS PRC_FULL_PAYMENT   TENURE
## 1         600.2507       0.19050166 11.80219
## 2         612.3474       0.11460082 11.59299
## 3         476.9178       0.16859332 11.23224
## 4         855.5973       0.23079449 11.84156
## 5        3916.8317       0.02294102 11.57511
## 6        2457.0669       0.31323406 11.78495
```

```
boxplot(boa.df.num$CREDIT_LIMIT~boa.k$cluster,
        col="blue",
        xlab="Creditlimit",
        ylab="Segment",
        horizontal = TRUE)
```



```
# visualizing the overall clusters
library(cluster)
clusplot(boa.df.new,boa.k$cluster,
         color="TRUE",
         shade="TRUE",
         labels= 4,
         main="k-means cluster plot")
```



We can focus on Group 2,4,because 5,6 are overlapping

M Clust

```
library(mclust)
boa.mc<-Mclust(boa.df.num)
summary(boa.mc)
```

```
## ----------------------------------------------------
## Gaussian finite mixture model fitted by EM algorithm
## ----------------------------------------------------
##
## Mclust VEV (ellipsoidal, equal shape) model with 4 components:
##
##  log-likelihood    n  df       BIC       ICL
##         -604665 8950 635 -1215108 -1215387
##
## Clustering table:
```

```
##    1    2    3    4
## 2292 1367 4002 1289
```

```
boa.mc4<-Mclust(boa.df.num, G=8)
summary(boa.mc4)
```

```
## ----------------------------------------------------
## Gaussian finite mixture model fitted by EM algorithm
## ----------------------------------------------------
##
## Mclust EEV (ellipsoidal, equal volume and shape) model with 8 components:
##
##  log-likelihood    n   df      BIC      ICL
##       -605311.5 8950 1248 -1221979 -1223711
##
## Clustering table:
##    1    2    3    4    5    6    7    8
##  285  239  629 1665 2024 1382 2593  133
```

We will use the 1 model because it has a lower log likelihood.

Comparing the Different Models with BIC

```
BIC(boa.mc,boa.mc4)
```

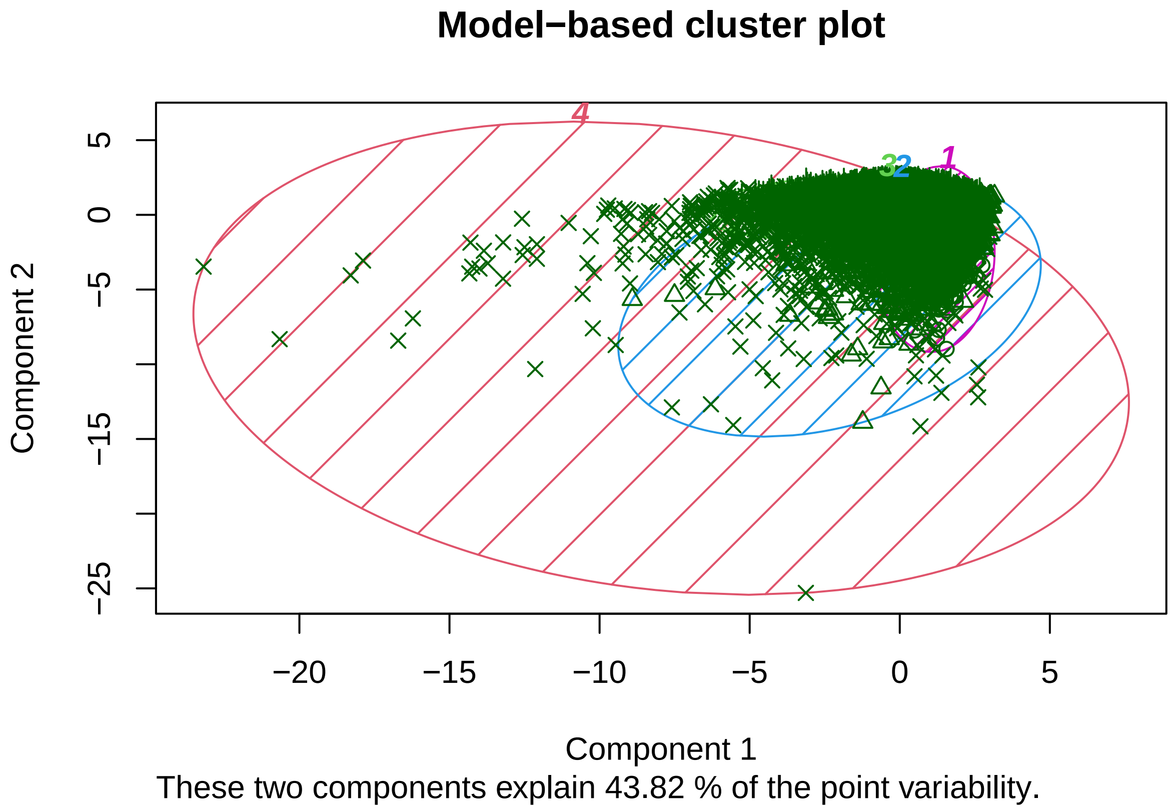
```
##           df     BIC
## boa.mc   635 1215108
## boa.mc4 1248 1221979
```

The 1st model has a lower BIC meaning it is group better that the first model.

```
# check the summary
boa.summ(boa.df.new,boa.mc$class)
```

```
##   Group.1        X   BALANCE BALANCE_FREQUENCY ONEOFF_PURCHASES
## 1       1 4418.907 2012.5306         0.9239582         63.03483
## 2       2 4521.628 2236.8750         0.8571661        464.04798
## 3       3 4653.367  561.6782         0.8217121        554.93689
## 4       4 3974.980 3168.1034         0.9880706       1786.36743
##   INSTALLMENTS_PURCHASES CASH_ADVANCE PURCHASES_FREQUENCY
## 1               2.405345  1433.551849          0.04999687
## 2             184.925099  2214.636661          0.41279185
## 3             457.894718     1.007874          0.67792812
## 4            1232.160667  1895.852435          0.77322715
##   ONEOFF_PURCHASES_FREQUENCY PURCHASES_INSTALLMENTS_FREQUENCY
## 1                 0.04559752                      0.004399357
## 2                 0.16354572                      0.253374064
## 3                 0.24510078                      0.515989632
## 4                 0.39024551                      0.651883651
##   CASH_ADVANCE_FREQUENCY CASH_ADVANCE_TRX PURCHASES_TRX CREDIT_LIMIT PAYMENTS
## 1           0.2417214939      5.452006981     0.7966841     3694.815 1125.984
## 2           0.2358160680      5.029992685     7.9378200     5039.927 2775.862
## 3           0.0005849343      0.006996502    15.9882559     4222.633 1064.733
## 4           0.2566434888      7.507370054    42.6617533     6181.730 3782.168
##   MINIMUM_PAYMENTS PRC_FULL_PAYMENT   TENURE
## 1         678.4855       0.01970663 11.87347
## 2         885.0488       0.09316473 10.65838
## 3         275.9230       0.26566551 11.58646
## 4        2788.9509       0.10863381 11.58029
```

```
library(cluster)
clusplot(boa.df.new, boa.mc$class, color=TRUE, shade=TRUE,
         labels=5, lines=0, main="Model-based cluster plot")
```



```
# summarizing clusters
boa.summ(boa.df.new, boa.k$cluster)
```

```
##   Group.1        X  BALANCE BALANCE_FREQUENCY ONEOFF_PURCHASES
## 1       1 3473.192 1666.250         0.9066200         876.0499
## 2       2 2383.478 1033.415         0.8789913         318.9521
## 3       3 7032.866  699.745         0.8353757         242.3384
## 4       4 2528.185 2890.655         0.9091980        2042.4956
## 5       5 3414.552 6100.887         0.9765424         476.2747
## 6       6 2505.634 5043.583         0.8593260        7289.1705
##   INSTALLMENTS_PURCHASES CASH_ADVANCE PURCHASES_FREQUENCY
## 1               527.9718     786.3986           0.5690613
## 2               257.2039     509.2856           0.4292796
## 3               284.8894     514.0729           0.4751120
## 4              1031.9138     564.0622           0.7049679
## 5               453.9301    4984.7457           0.3654152
## 6              2768.6097    7546.1825           0.6296676
##   ONEOFF_PURCHASES_FREQUENCY PURCHASES_INSTALLMENTS_FREQUENCY
## 1                  0.3235480                        0.3949300
## 2                  0.1546873                        0.3115449
## 3                  0.1246642                        0.3757905
## 4                  0.4798681                        0.5005175
## 5                  0.1574601                        0.2772320
## 6                  0.4841991                        0.5139087
##   CASH_ADVANCE_FREQUENCY CASH_ADVANCE_TRX PURCHASES_TRX CREDIT_LIMIT  PAYMENTS
## 1             0.11583796         2.555057     20.183857     6801.164  1991.591
## 2             0.10876211         2.191609     10.001298     2454.562  1009.112
## 3             0.11333867         2.503684      9.976717     2219.845   886.118
## 4             0.07900764         1.497942     36.674897    13110.905  3347.170
## 5             0.41935725        12.966616     15.556904     8741.130  3863.819
## 6             0.28261880        11.978495     65.526882    13292.473 21525.445
##   MINIMUM_PAYMENTS PRC_FULL_PAYMENT   TENURE
## 1         600.2507       0.19050166 11.80219
## 2         612.3474       0.11460082 11.59299
## 3         476.9178       0.16859332 11.23224
## 4         855.5973       0.23079449 11.84156
## 5        3916.8317       0.02294102 11.57511
## 6        2457.0669       0.31323406 11.78495
```

REPORT Our business goal was to see which variables would emerge when we remove purchases from the variables so we can better see what to focus on in order to generate and maintain customers. We removed purchases because we believe this is a dominant variable in determining the clusters so we wanted to explore other variables that would drive insight. Purchases was believed to be dominant as this is the purpose of the credit card and is the outcome that Bank of America wants their customers to do. After exploring the emerging variables, we can develop a business strategy to leverage these factors. After modeling these variables in clusters, we found that balance (how much is left in their account to make purchases), cash advance (cash in advance given by the user), and credit limit (limit of credit card for user) were most significant. With these variables in mind, we created six customer segments. We identified the characteristics of these customers, and created a plan to appeal to them.

The first customer segment we identified are those that have low balance, low cash advance, and high full payment. We propose to increase their credit limit with low interest rate and discounts on purchases. This will appeal to them since they save money with low rates and discounts, but have the advantage of a higher credit limit which isn't a big risk for Bank of America as this segment pays in full.

Customer segment 2 are those that have low balance and low frequency of purchase. For these customers, we would provide incentives like reward programs with attractive benefits such as increase free air miles in order to encourage them to purchase more frequently.

Customer segment 3 are those that have low balance, low cash advance, low purchase frequency, low credit limit, low minimum payment, and a considerably high full payment. We would propose promotions for when they make a certain amount of payments in a month. This would encourage them to not only spend more but spend more often. Because they have a low credit limit and pay in full, it isn't a high risk for the customer to spend more than they have.

Customer segment 4 are those that have low balance, high one off purchases (maximum purchase amount done in one go), high cash advance frequency, high minimum, and full payment. Since these customers are typically bigger spenders, we would propose to increase their credit limit with cash backs for purchases. This would benefit them a lot since they are spending large amounts, they'll get a significant amount with cash back rewards.

Customer segment 5 are those that have a high balance, high one off purchases, high cash advance, high minimum payments, but low full payments. Since these customers aren't able to pay in full we can offer educational programs and materials for them to plan better, but also increase credit limit with a certain percent since this helps with ROI. Since this customer has a higher balance, raising the credit limit would be appealing for them.

Lastly, customer segment 6 are those that have a high balance, high cash advance, and high frequency of purchase. We can offer them a higher credit limit, cash back benefits, and reward programs to show them that they are a valued customer and to maintain their purchasing habits.

After determining which variables were dominant when taking out purchases, we were able to identify core customer profiles and propose this marketing strategy to generate more purchase amounts and frequencies to get customers to use credit cards more.