GROUP PROJECT REPORT
ON
CHURN DATA PREDICTION IN TELECOM INDUSTRY

Instructor

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Business Analytics

MIS 64036-002

Group-3

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Index

Project Goal

Churn is a challenge for telecom companies considering that it is more difficult to attract new customers than it is to keep onto their present clients. Customer churn modelling has been quite popular recently since there are signs that a significant portion of a company's revenue comes from repeat consumers. Businesses are also very interested in figuring out which consumers are likely to leave, and they commonly use data mining tools to do this. Using the available data, we were able to identify clients who were most likely to abandon this project and provide them with sufficient inducements to do so.

This project's objective is to employ a predictive model to analyse data and spot trends in order to foretell when a regular client would transfer service providers. Our investigation may be carried out using a variety of prediction models, including regression. Here, we'll build our model using a decision tree classifier.

Overview of Data

ABC wireless company has provided the following data from which we can infer:

Demographics

- State
- Account length
- Area code
- International plan
- Voice-mail plan

Calling Behaviour

- Number of messages
- Total day minutes
- Total day calls
- Total day charge
- Total evening minutes
- Total evening calls
- Total evening charges
- Total night minutes
- Total night calls
- Total night charges
- Total International minutes
- Total International calls
- Total International charges
- Number of calls to customer service

Exploratory Analysis

Part 1: Churn Data

Data # Loading the required Libraries that are required for the Project.

```
library(readr)
```

```
## Warning: package 'readr' was built under R version 4.2.2
```

```
library(tidyverse)
```

```
## Warning: package 'tidyverse' was built under R version 4.2.2

## ── Attaching packages ─────────────────────────────────────── tidyverse 1.
3.2 ──

## ✓ ggplot2 3.3.6      ✓ dplyr   1.0.10

## ✓ tibble  3.1.8      ✓ stringr 1.4.1

## ✓ tidyr   1.2.1      ✓ forcats 0.5.2

## ✓ purrr   0.3.5

## ── Conflicts ────────────────────────────────────────── tidyverse_conflict
s() ──

## ✕ dplyr::filter() masks stats::filter()

## ✕ dplyr::lag()    masks stats::lag()
```

```
library(caret)
```

```
## Loading required package: lattice

##

## Attaching package: 'caret'

##

## The following object is masked from 'package:purrr':

##

##     lift
```

```
library(gmodels)
library(rpart)
```

```
## Warning: package 'rpart' was built under R version 4.2.2
```

```
library(pROC)
```

```
## Warning: package 'pROC' was built under R version 4.2.2

## Type 'citation("pROC")' for a citation.

##
```

```
## Attaching package: 'pROC'
##
## The following object is masked from 'package:gmodels':
##
##     ci
##
## The following objects are masked from 'package:stats':
##
##     cov, smooth, var
library(rattle)
## Warning: package 'rattle' was built under R version 4.2.2
## Loading required package: bitops
## Rattle: A free graphical interface for data science with R.
## Version 5.5.1 Copyright (c) 2006-2021 Togaware Pty Ltd.
## Type 'rattle()' to shake, rattle, and roll your data.
```

Importing the Churn Dataset that is given to us.

```
Given_Churn_Datafile= read.csv("C:/Users/girne/Downloads/Churn_Train.csv")
```

Examining the details regarding the data file.

```
# Head Part of the Data file
head(Given_Churn_Datafile)
##   state account_length     area_code international_plan voice_mail_plan
## 1    NV            125 area_code_510                 no              no
## 2    HI            108 area_code_415                 no              no
## 3    DC             82 area_code_415                 no              no
## 4    HI             NA area_code_408                 no             yes
## 5    OH             83 area_code_415                 no              no
## 6    MO             89 area_code_415                 no              no
##   number_vmail_messages total_day_minutes total_day_calls total_day_charge
## 1                     0            2013.4              99            28.66
## 2                     0             291.6              99            49.57
## 3                     0             300.3             109            51.05
## 4                    30             110.3              71            18.75
## 5                     0             337.4             120            57.36
## 6                     0             178.7              81            30.38
##   total_eve_minutes total_eve_calls total_eve_charge total_night_minutes
## 1            1107.6             107            14.93               243.3
## 2             221.1              93            18.79               229.2
## 3             181.0             100            15.39               270.1
## 4             182.4             108            15.50               183.8
## 5             227.4             116            19.33               153.9
## 6                NA              74            19.86               131.9
##   total_night_calls total_night_charge total_intl_minutes total_intl_calls
## 1                92              10.95               10.9                7
## 2               110              10.31               14.0                9
## 3                73              12.15               11.7                4
## 4                88               8.27               11.0                8
## 5               114               6.93               15.8                7
## 6               120               5.94                9.1                4
##   total_intl_charge number_customer_service_calls churn
## 1              2.94                             0    no
## 2              3.78                             2   yes
## 3              3.16                             0   yes
## 4              2.97                             2    no
## 5              4.27                             0   yes
## 6              2.46                             1    no
```

```
#Summary of the Data present in the data file.
summary(Given_Churn_Datafile)
```

```
##     state           account_length     area_code         international_pla
n
##  Length:3333        Min.   :-209.00   Length:3333        Length:3333
##  Class :character   1st Qu.:  72.00   Class :character   Class :character
##  Mode  :character   Median : 100.00   Mode  :character   Mode  :character
##                     Mean   :  97.32
##                     3rd Qu.: 127.00
##                     Max.   : 243.00
##                     NA's   :501
##  voice_mail_plan    number_vmail_messages total_day_minutes total_day_call
s
##  Length:3333        Min.   :-10.000       Min.   :   0.0    Min.   :  0.0
##  Class :character   1st Qu.:  0.000       1st Qu.: 149.3    1st Qu.: 87.0
##  Mode  :character   Median :  0.000       Median : 190.5    Median :101.0
##                     Mean   :  7.333       Mean   : 418.9    Mean   :100.3
##                     3rd Qu.: 16.000       3rd Qu.: 237.8    3rd Qu.:114.0
##                     Max.   : 51.000       Max.   :2185.1    Max.   :165.0
##                     NA's   :200           NA's   :200       NA's   :200
##  total_day_charge total_eve_minutes total_eve_calls total_eve_charge
##  Min.   : 0.00    Min.   :   0.0    Min.   :  0.0   Min.   : 0.00
##  1st Qu.:24.45    1st Qu.: 170.5    1st Qu.: 87.0   1st Qu.:14.14
##  Median :30.65    Median : 209.9    Median :100.0   Median :17.09
##  Mean   :30.63    Mean   : 324.3    Mean   :100.1   Mean   :17.08
##  3rd Qu.:36.84    3rd Qu.: 257.6    3rd Qu.:114.0   3rd Qu.:20.00
##  Max.   :59.64    Max.   :1244.2    Max.   :170.0   Max.   :30.91
##  NA's   :200      NA's   :301       NA's   :200     NA's   :200
##  total_night_minutes total_night_calls total_night_charge total_intl_minut
es
##  Min.   : 23.2       Min.   : 33.0     Min.   : 1.040     Min.   : 0.00
##  1st Qu.:167.3       1st Qu.: 87.0     1st Qu.: 7.530     1st Qu.: 8.50
##  Median :201.4       Median :100.0     Median : 9.060     Median :10.30
##  Mean   :201.2       Mean   :100.1     Mean   : 9.054     Mean   :10.23
##  3rd Qu.:235.3       3rd Qu.:113.0     3rd Qu.:10.590     3rd Qu.:12.10
##  Max.   :395.0       Max.   :175.0     Max.   :17.770     Max.   :20.00
##  NA's   :200                           NA's   :200        NA's   :200
##  total_intl_calls total_intl_charge number_customer_service_calls
##  Min.   : 0.00    Min.   :0.000     Min.   :0.000
##  1st Qu.: 3.00    1st Qu.:2.300     1st Qu.:1.000
##  Median : 4.00    Median :2.780     Median :1.000
##  Mean   : 4.47    Mean   :2.762     Mean   :1.561
##  3rd Qu.: 6.00    3rd Qu.:3.270     3rd Qu.:2.000
##  Max.   :20.00    Max.   :5.400     Max.   :9.000
##  NA's   :301      NA's   :200       NA's   :200
##     churn
##  Length:3333
##  Class :character
##  Mode  :character
##
##
##
##
```

```
#Data Types of Data Columns in the Data file
str(Given_Churn_Datafile)
```

```
## 'data.frame':    3333 obs. of  20 variables:
##  $ state                        : chr  "NV" "HI" "DC" "HI" ...
##  $ account_length               : int  125 108 82 NA 83 89 135 28 86 65 ..
.
##  $ area_code                    : chr  "area_code_510" "area_code_415" "ar
ea_code_415" "area_code_408" ...
##  $ international_plan           : chr  "no" "no" "no" "no" ...
##  $ voice_mail_plan              : chr  "no" "no" "no" "yes" ...
##  $ number_vmail_messages        : int  0 0 0 30 0 0 0 0 0 0 ...
##  $ total_day_minutes            : num  2013 292 300 110 337 ...
##  $ total_day_calls              : int  99 99 109 71 120 81 81 87 115 137 .
..
##  $ total_day_charge             : num  28.7 49.6 51 18.8 57.4 ...
##  $ total_eve_minutes            : num  1108 221 181 182 227 ...
##  $ total_eve_calls              : int  107 93 100 108 116 74 114 92 112 83
...
##  $ total_eve_charge             : num  14.9 18.8 15.4 15.5 19.3 ...
##  $ total_night_minutes          : num  243 229 270 184 154 ...
##  $ total_night_calls            : int  92 110 73 88 114 120 82 112 95 111
...
##  $ total_night_charge           : num  10.95 10.31 12.15 8.27 6.93 ...
##  $ total_intl_minutes           : num  10.9 14 11.7 11 15.8 9.1 10.3 10.1
9.8 12.7 ...
##  $ total_intl_calls             : int  7 9 4 8 7 4 6 3 7 6 ...
##  $ total_intl_charge            : num  2.94 3.78 3.16 2.97 4.27 2.46 2.78
2.73 2.65 3.43 ...
##  $ number_customer_service_calls: int  0 2 0 2 0 1 1 3 2 4 ...
##  $ churn                        : chr  "no" "yes" "yes" "no" ...
```

```
#Glimpse of the Data Given to us

glimpse(Given_Churn_Datafile)
```

```
## Rows: 3,333

## Columns: 20

## $ state                          <chr> "NV", "HI", "DC", "HI", "OH", "MO",
"NC"…

## $ account_length                 <int> 125, 108, 82, NA, 83, 89, 135, 28, 8
6, 6…

## $ area_code                      <chr> "area_code_510", "area_code_415", "a
rea_…

## $ international_plan             <chr> "no", "no", "no", "no", "no", "no",
"no"…

## $ voice_mail_plan                <chr> "no", "no", "no", "yes", "no", "no",
"no…

## $ number_vmail_messages          <int> 0, 0, 0, 30, 0, 0, 0, 0, 0, 0, 0, NA
, 32…

## $ total_day_minutes              <dbl> 2013.4, 291.6, 300.3, 110.3, 337.4,
178.…

## $ total_day_calls                <int> 99, 99, 109, 71, 120, 81, 81, 87, 11
5, 1…

## $ total_day_charge               <dbl> 28.66, 49.57, 51.05, 18.75, 57.36, 3
0.38…

## $ total_eve_minutes              <dbl> 1107.6, 221.1, 181.0, 182.4, 227.4,
NA, …

## $ total_eve_calls                <int> 107, 93, 100, 108, 116, 74, 114, 92,
112…

## $ total_eve_charge               <dbl> 14.93, 18.79, 15.39, 15.50, 19.33, 1
9.86…

## $ total_night_minutes            <dbl> 243.3, 229.2, 270.1, 183.8, 153.9, 1
31.9…

## $ total_night_calls              <int> 92, 110, 73, 88, 114, 120, 82, 112,
95, …

## $ total_night_charge             <dbl> 10.95, 10.31, 12.15, 8.27, 6.93, 5.9
4, 9…

## $ total_intl_minutes             <dbl> 10.9, 14.0, 11.7, 11.0, 15.8, 9.1, 1
0.3,…

## $ total_intl_calls               <int> 7, 9, 4, 8, 7, 4, 6, 3, 7, 6, 7, NA,
4, …

## $ total_intl_charge              <dbl> 2.94, 3.78, 3.16, 2.97, 4.27, 2.46,
2.78…

## $ number_customer_service_calls <int> 0, 2, 0, 2, 0, 1, 1, 3, 2, 4, 1, NA,
3, …
```

```
## $ churn                         <chr> "no", "yes", "yes", "no", "yes", "no
", "…
```

Data Type Conversion.

```
# Converting the Char type data to factors for our convience
Given_Churn_Datafile = Given_Churn_Datafile %>% mutate_if(is.character, as.fa
ctor)
```

Checking where the data conversion is successful or not.

```
str(Given_Churn_Datafile)
```

```
## 'data.frame':    3333 obs. of  20 variables:
##  $ state                        : Factor w/ 51 levels "AK","AL","AR",..: 3
4 12 8 12 36 25 28 39 13 16 ...
##  $ account_length               : int  125 108 82 NA 83 89 135 28 86 65 ..
.
##  $ area_code                    : Factor w/ 3 levels "area_code_408",..: 3
2 2 1 2 2 2 2 1 2 ...
##  $ international_plan           : Factor w/ 2 levels "no","yes": 1 1 1 1 1
1 1 1 1 1 ...
##  $ voice_mail_plan              : Factor w/ 2 levels "no","yes": 1 1 1 2 1
1 1 1 1 1 ...
##  $ number_vmail_messages        : int  0 0 0 30 0 0 0 0 0 0 ...
##  $ total_day_minutes            : num  2013 292 300 110 337 ...
##  $ total_day_calls              : int  99 99 109 71 120 81 81 87 115 137 .
..
##  $ total_day_charge             : num  28.7 49.6 51 18.8 57.4 ...
##  $ total_eve_minutes            : num  1108 221 181 182 227 ...
##  $ total_eve_calls              : int  107 93 100 108 116 74 114 92 112 83
...
##  $ total_eve_charge             : num  14.9 18.8 15.4 15.5 19.3 ...
##  $ total_night_minutes          : num  243 229 270 184 154 ...
##  $ total_night_calls            : int  92 110 73 88 114 120 82 112 95 111
...
##  $ total_night_charge           : num  10.95 10.31 12.15 8.27 6.93 ...
##  $ total_intl_minutes           : num  10.9 14 11.7 11 15.8 9.1 10.3 10.1
9.8 12.7 ...
##  $ total_intl_calls             : int  7 9 4 8 7 4 6 3 7 6 ...
##  $ total_intl_charge            : num  2.94 3.78 3.16 2.97 4.27 2.46 2.78
2.73 2.65 3.43 ...
##  $ number_customer_service_calls: int  0 2 0 2 0 1 1 3 2 4 ...
##  $ churn                        : Factor w/ 2 levels "no","yes": 1 2 2 1 2
1 1 1 1 2 ...
```

Checking for the NA values if they are present in the dataset.

```
colSums(is.na(Given_Churn_Datafile))
```

```
##                         state                account_length
##                             0                           501
##                     area_code            international_plan
##                             0                             0
##               voice_mail_plan         number_vmail_messages
##                             0                           200
##             total_day_minutes               total_day_calls
##                           200                           200
##              total_day_charge             total_eve_minutes
##                           200                           301
##               total_eve_calls              total_eve_charge
##                           200                           200
##           total_night_minutes             total_night_calls
##                           200                             0
##            total_night_charge            total_intl_minutes
##                           200                           200
##              total_intl_calls             total_intl_charge
##                           301                           200
## number_customer_service_calls                         churn
##                           200                             0
```

Checking for the Negative Values if they are present in dataset by columns wise.

```
sapply(Given_Churn_Datafile %>% select_if(is.numeric), function(x) {
                                                                      sum(x <
0, na.rm = TRUE)
```

```
                                                                    })
```

```
##                account_length         number_vmail_messages
##                            51                           201
##             total_day_minutes               total_day_calls
##                             0                             0
##              total_day_charge             total_eve_minutes
##                             0                             0
##               total_eve_calls              total_eve_charge
##                             0                             0
##           total_night_minutes             total_night_calls
##                             0                             0
##            total_night_charge            total_intl_minutes
##                             0                             0
##              total_intl_calls             total_intl_charge
##                             0                             0
## number_customer_service_calls
##                             0
```

```
Given_Churn_Datafile =
  Given_Churn_Datafile %>% mutate_if(is.numeric, function(x) {
                                                                  ifelse(x < 0, abs(x), x)
                                                              })

# We see that account_length and number_vmail_messages have some Negative values and we cannot remove them because they are connected to the final Churn Variable.
```

To deal with NA Values which are present in the data and removing them from the data set.

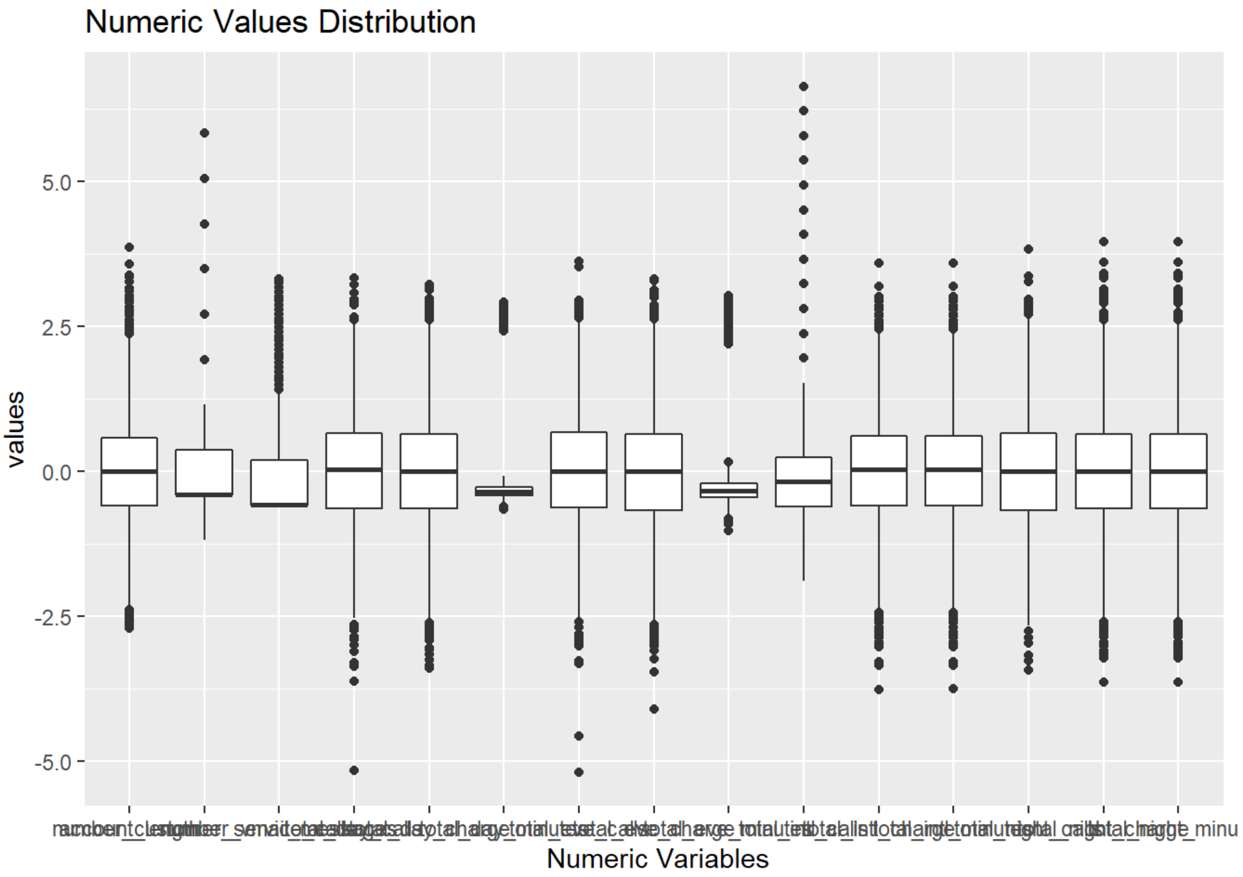
```
# We are following the MedianImpute as a Method to dela with the NA Values in the Dataset

NA_Dealing_Model= preProcess(Given_Churn_Datafile %>% select_if(is.numeric),method = “medianImpute”)

Predict_Data = predict(NA_Dealing_Model, Given_Churn_Datafile %>% select_if(is.numeric))
```

```
Given_Churn_Datafile = Given_Churn_Datafile %>% select(setdiff(names(Given_Ch
urn_Datafile), names(Predict_Data))) %>% cbind(Predict_Data)


# Viewing the Datafile with no NA Values

view(Given_Churn_Datafile)


# Checking Finally wether there are any NA Values Present in the each Column
of the dataset.

colSums(is.na(Given_Churn_Datafile))
```

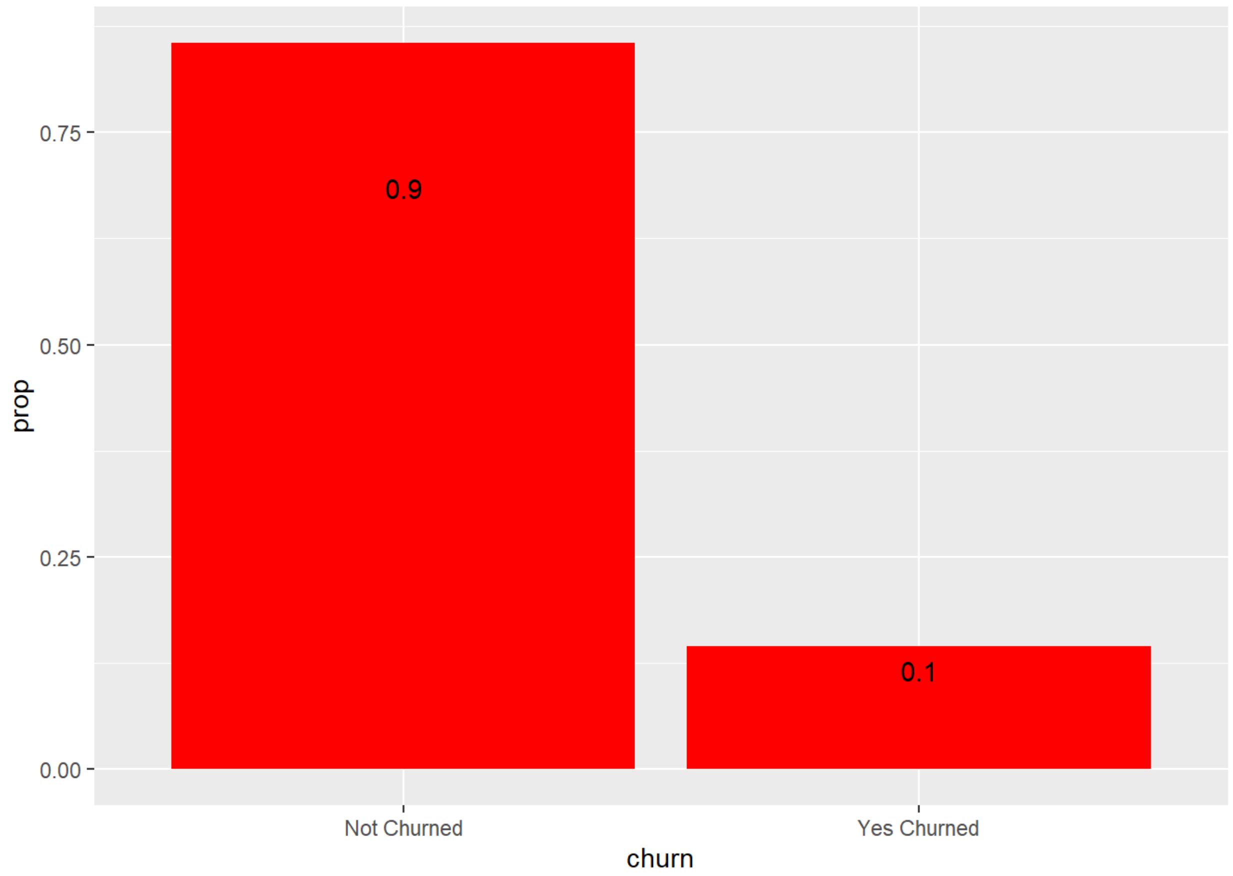
```
##                         state                     area_code
##                             0                             0
##            international_plan               voice_mail_plan
##                             0                             0
##                         churn                account_length
##                             0                             0
##         number_vmail_messages             total_day_minutes
##                             0                             0
##               total_day_calls              total_day_charge
##                             0                             0
##             total_eve_minutes               total_eve_calls
##                             0                             0
##              total_eve_charge           total_night_minutes
##                             0                             0
##             total_night_calls            total_night_charge
##                             0                             0
##            total_intl_minutes              total_intl_calls
##                             0                             0
##             total_intl_charge number_customer_service_calls
##                             0                             0
```

Visualization of the Data present in the Dataset

```
# Numeric Values Distribution Plot

Given_Churn_Datafile %>% select_if(is.numeric) %>% mutate_all(scale) %>% gath
er(“features”,”values”) %>% na.omit() %>%

  ggplot(aes(x = features, y = values)) +
  geom_boxplot(show.legend = FALSE) +
  labs(x = “ Numeric Variables”) +
  ggtitle(label = “Numeric Values Distribution”)
## Warning: attributes are not identical across measure variables;
## they will be dropped
```



```
# Churn Variable Visualization
ggplot(Given_Churn_Datafile, aes(x=churn, y=..prop..,group = 2)) +
geom_bar(fill=”Red”) +
geom_text(aes(label=round(..prop..,1)),stat = “count”,
            position = position_stack(vjust=0.8)) +
  scale_x_discrete(labels = c(“Not Churned”,”Yes Churned”))
```



```
# From the Plot we can see that 90 % hasn’t churned but 10 % churned.
```

Adding the State and Churn Variables to the Updated Churn Dataset for our calculations.

```
Str(Given_Churn_Datafile) # Without Updation
## ‘data.frame’:    3333 obs. Of  20 variables:

##  $ state                      : Factor w/ 51 levels “AK”,”AL”,”AR”,..: 3
4 12 8 12 36 25 28 39 13 16 …

##  $ area_code                  : Factor w/ 3 levels “area_code_408”,..: 3
2 2 1 2 2 2 2 1 2 …

##  $ international_plan         : Factor w/ 2 levels “no”,”yes”: 1 1 1 1 1
1 1 1 1 1 …

##  $ voice_mail_plan            : Factor w/ 2 levels “no”,”yes”: 1 1 1 2 1
1 1 1 1 1 …

##  $ churn                      : Factor w/ 2 levels “no”,”yes”: 1 2 2 1 2
1 1 1 1 2 …

##  $ account_length             : num  125 108 82 101 83 89 135 28 86 65 …
##  $ number_vmail_messages        : num  0 0 0 30 0 0 0 0 0 0 …
##  $ total_day_minutes            : num  2013 292 300 110 337 …
##  $ total_day_calls              : num  99 99 109 71 120 81 81 87 115 137 …
##  $ total_day_charge             : num  28.7 49.6 51 18.8 57.4 …
##  $ total_eve_minutes            : num  1108 221 181 182 227 …
##  $ total_eve_calls              : num  107 93 100 108 116 74 114 92 112 83
…
##  $ total_eve_charge             : num  14.9 18.8 15.4 15.5 19.3 …
##  $ total_night_minutes          : num  243 229 270 184 154 …
##  $ total_night_calls            : int  92 110 73 88 114 120 82 112 95 111
…
##  $ total_night_charge           : num  10.95 10.31 12.15 8.27 6.93 …
##  $ total_intl_minutes           : num  10.9 14 11.7 11 15.8 9.1 10.3 10.1
9.8 12.7 …
##  $ total_intl_calls             : num  7 9 4 8 7 4 6 3 7 6 …
##  $ total_intl_charge            : num  2.94 3.78 3.16 2.97 4.27 2.46 2.78
2.73 2.65 3.43 …
##  $ number_customer_service_calls: num  0 2 0 2 0 1 1 3 2 4 …
```

```
Given_Churn_Datafile = Given_Churn_Datafile %>% select(-state, -churn) %>%
  fastDummies::dummy_cols(., remove_selected_columns = TRUE) %>% mutate(state
= Given_Churn_Datafile$state, churn = Given_Churn_Datafile$churn)
str(Given_Churn_Datafile) # With Updation
```

```
## ‘data.frame’:    3333 obs. Of  24 variables:
##  $ account_length               : num  125 108 82 101 83 89 135 28 86 65 …
##  $ number_vmail_messages        : num  0 0 0 30 0 0 0 0 0 0 …
##  $ total_day_minutes            : num  2013 292 300 110 337 …
##  $ total_day_calls              : num  99 99 109 71 120 81 81 87 115 137 …
##  $ total_day_charge             : num  28.7 49.6 51 18.8 57.4 …
##  $ total_eve_minutes            : num  1108 221 181 182 227 …
##  $ total_eve_calls              : num  107 93 100 108 116 74 114 92 112 83
…
##  $ total_eve_charge             : num  14.9 18.8 15.4 15.5 19.3 …
##  $ total_night_minutes          : num  243 229 270 184 154 …
##  $ total_night_calls            : int  92 110 73 88 114 120 82 112 95 111
…
##  $ total_night_charge           : num  10.95 10.31 12.15 8.27 6.93 …
##  $ total_intl_minutes           : num  10.9 14 11.7 11 15.8 9.1 10.3 10.1
9.8 12.7 …
```

```
##  $ total_intl_calls             : num  7 9 4 8 7 4 6 3 7 6 …
##  $ total_intl_charge            : num  2.94 3.78 3.16 2.97 4.27 2.46 2.78
2.73 2.65 3.43 …
##  $ number_customer_service_calls: num  0 2 0 2 0 1 1 3 2 4 …
##  $ area_code_area_code_408      : int  0 0 0 1 0 0 0 0 1 0 …
##  $ area_code_area_code_415      : int  0 1 1 0 1 1 1 1 0 1 …
##  $ area_code_area_code_510      : int  1 0 0 0 0 0 0 0 0 0 …
##  $ international_plan_no        : int  1 1 1 1 1 1 1 1 1 1 …
##  $ international_plan_yes       : int  0 0 0 0 0 0 0 0 0 0 …
##  $ voice_mail_plan_no           : int  1 1 1 0 1 1 1 1 1 1 …
##  $ voice_mail_plan_yes          : int  0 0 0 1 0 0 0 0 0 0 …
##  $ state                        : Factor w/ 51 levels "AK","AL","AR",..: 3
4 12 8 12 36 25 28 39 13 16 …
##  $ churn                        : Factor w/ 2 levels "no","yes": 1 2 2 1 2
1 1 1 1 2 …
```

Model Strategy

What Technique: we are following the Decision tree as our Model.

Why: We believe that to illustrate the influence of numerous variables and their significance in forecasting the result of the target variable, so we will go with Decision Tree approach.

Preprocessing of Data:

```
# Splitting  the dataset into training set(75%) and validation set(25%).
set.seed(5454)
Data_partition<- createDataPartition(Given_Churn_Datafile$churn, p=0.75, list
=FALSE)
Req_Churn_Data_train = Given_Churn_Datafile[Data_partition,]
Req_Churn_Data_test = Given_Churn_Datafile[-Data_partition,]
```

Scaling the Preprocessed Data

```
PreProcess_Scale <- preProcess(Req_Churn_Data_train %>% select_if(is.numeric)
, method = c("center", "scale"))

Req_Churn_Data_train_norm <- predict(PreProcess_Scale, Req_Churn_Data_train %
>% select_if(is.numeric))

Req_Churn_Data_test_norm <- predict(PreProcess_Scale, Req_Churn_Data_test %>%
select_if(is.numeric))


Req_Churn_Data_train_norm$churn <- Req_Churn_Data_train$churn

Req_Churn_Data_test_norm$churn <- Req_Churn_Data_test$churn
```

Model Construction

```
# Using Rplot

DecisionTree_Model <- rpart(churn ~ ., data = Req_Churn_Data_train_norm, meth
od = "class")

summary(DecisionTree_Model)
```

```
## Call:
## rpart(formula = churn ~ ., data = Req_Churn_Data_train_norm,
##     method = "class")
##   n= 2501
##
##           CP nsplit rel error    xerror       xstd
## 1 0.08402204      0 1.0000000 1.0000000 0.04852815
## 2 0.05922865      2 0.8319559 0.8016529 0.04417526
## 3 0.05234160      4 0.7134986 0.6997245 0.04161548
## 4 0.01652893      8 0.4793388 0.5206612 0.03641341
## 5 0.01239669     10 0.4462810 0.4931129 0.03551356
## 6 0.01101928     12 0.4214876 0.4986226 0.03569602
## 7 0.01000000     14 0.3994490 0.4903581 0.03542184
##
## Variable importance
##                total_day_charge number_customer_service_calls
##                              21                            11
##                total_eve_charge          international_plan_no
##                              8                             7
##        international_plan_yes             total_intl_charge
##                              7                             7
##            total_intl_minutes             total_day_minutes
##                              7                             7
##              total_intl_calls             total_eve_minutes
##                              6                             5
##         number_vmail_messages            voice_mail_plan_no
##                              4                             4
##           voice_mail_plan_yes             total_night_calls
##                              4                             1
##
## Node number 1: 2501 observations,    complexity param=0.08402204
##   predicted class=no   expected loss=0.1451419  P(node) =1
##     class counts:  2138   363
##    probabilities: 0.855 0.145
##   left son=2 (2308 obs) right son=3 (193 obs)
##   Primary splits:
##       number_customer_service_calls < 1.523388     to the left,  improve=6
1.47075, (0 missing)
##       total_day_charge              < 1.621606     to the left,  improve=5
9.79091, (0 missing)
##       international_plan_no         < -1.318779    to the right, improve=4
9.47426, (0 missing)
##       international_plan_yes        < 1.318779     to the left,  improve=4
9.47426, (0 missing)
##       total_day_minutes             < -0.2493636   to the left,  improve=1
8.28591, (0 missing)
##
## Node number 2: 2308 observations,    complexity param=0.05922865
##   predicted class=no   expected loss=0.1130849  P(node) =0.9228309
##     class counts:  2047   261
##    probabilities: 0.887 0.113
##   left son=4 (2078 obs) right son=5 (230 obs)
##   Primary splits:
##       total_day_charge       < 1.247929     to the left,  improve=61.79721
, (0 missing)
```

```
##       international_plan_no  < -1.318779    to the right, improve=49.35911
, (0 missing)
##       international_plan_yes < 1.318779     to the left,  improve=49.35911
, (0 missing)
##       total_day_minutes      < -0.2879089   to the left,  improve=25.10998
, (0 missing)
##       total_eve_charge       < 0.8901874    to the left,  improve= 7.79800
, (0 missing)
##
## Node number 3: 193 observations,    complexity param=0.08402204
##   predicted class=yes  expected loss=0.4715026  P(node) =0.07716913
##     class counts:    91   102
##    probabilities: 0.472 0.528
##   left son=6 (118 obs) right son=7 (75 obs)
##   Primary splits:
##       total_day_charge  < -0.3672269   to the right, improve=35.086420, (0
missing)
##       total_day_minutes < -0.3915621   to the right, improve=31.762260, (0
missing)
##       total_eve_charge  < 0.2318583    to the right, improve= 8.112675, (0
missing)
##       total_eve_minutes < -0.3205428   to the right, improve= 7.129213, (0
missing)
##       total_night_calls < -1.075241    to the right, improve= 4.779043, (0
missing)
##   Surrogate splits:
##       total_day_minutes             < -0.3915621   to the right, agree=0.9
69, adj=0.920, (0 split)
##       total_night_calls             < -1.075241    to the right, agree=0.6
37, adj=0.067, (0 split)
##       total_night_minutes           < -2.275635    to the right, agree=0.6
27, adj=0.040, (0 split)
##       total_night_charge            < -2.276326    to the right, agree=0.6
27, adj=0.040, (0 split)
##       number_customer_service_calls < 3.082464     to the left,  agree=0.6
27, adj=0.040, (0 split)
##
## Node number 4: 2078 observations,    complexity param=0.0523416
##   predicted class=no   expected loss=0.07459095  P(node) =0.8308677
##     class counts:  1923   155
##    probabilities: 0.925 0.075
##   left son=8 (1883 obs) right son=9 (195 obs)
##   Primary splits:
##       international_plan_no  < -1.318779    to the right, improve=42.74661
0, (0 missing)
##       international_plan_yes < 1.318779     to the left,  improve=42.74661
0, (0 missing)
##       total_day_charge       < 0.8109463    to the left,  improve= 4.89700
6, (0 missing)
##       total_intl_minutes     < 1.083145     to the left,  improve= 4.23199
3, (0 missing)
##       total_intl_charge      < 1.081839     to the left,  improve= 4.23199
3, (0 missing)
##   Surrogate splits:
##       international_plan_yes < 1.318779     to the left,  agree=1.000, adj
=1.00, (0 split)
##       total_day_charge       < 1.233363     to the left,  agree=0.907, adj
=0.01, (0 split)
##
## Node number 5: 230 observations,    complexity param=0.05922865
##   predicted class=no   expected loss=0.4608696  P(node) =0.09196321
##     class counts:   124   106
##    probabilities: 0.539 0.461
##   left son=10 (117 obs) right son=11 (113 obs)
##   Primary splits:
##       total_eve_charge      < 0.0717242    to the left,  improve=23.37878,
(0 missing)
##       voice_mail_plan_yes   < 0.5001899    to the right, improve=21.78033,
(0 missing)
##       voice_mail_plan_no    < -0.5001899   to the left,  improve=21.78033,
(0 missing)
##       number_vmail_messages < 0.1466111    to the right, improve=21.11552,
(0 missing)
##       total_eve_minutes     < -0.3578247   to the left,  improve=19.57100,
(0 missing)
##   Surrogate splits:
##       total_eve_minutes  < -0.3471728   to the left,  agree=0.926, adj=0.8
50, (0 split)
##       total_night_calls  < -0.4545841   to the left,  agree=0.565, adj=0.1
15, (0 split)
```

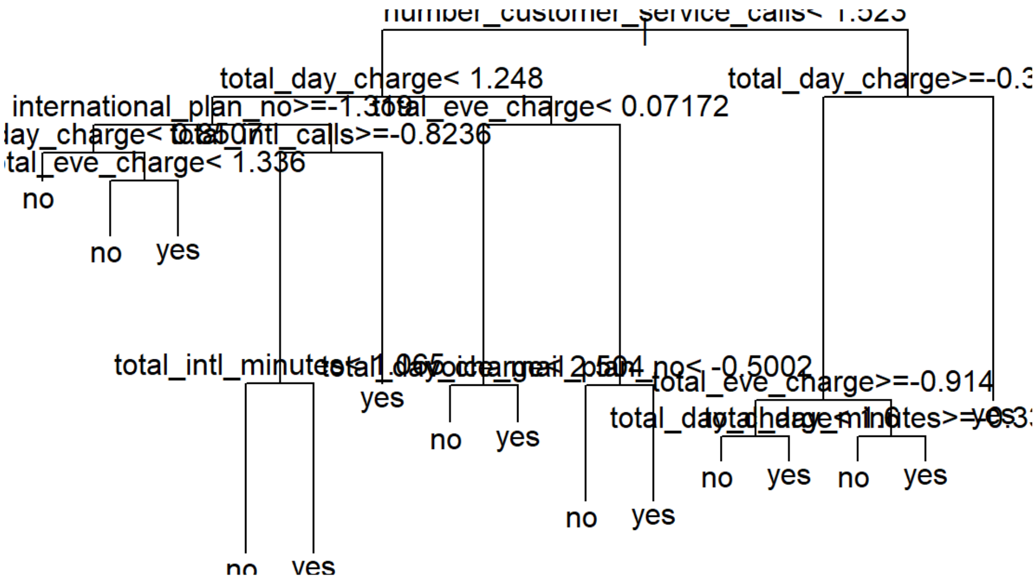
```
##       total_intl_minutes < 0.7323531    to the left,  agree=0.561, adj=0.1
06, (0 split)
##       total_intl_charge  < 0.7331038    to the left,  agree=0.561, adj=0.1
06, (0 split)
##       total_day_calls    < 0.1489096    to the right, agree=0.548, adj=0.0
80, (0 split)
## 
## Node number 6: 118 observations,    complexity param=0.01652893
##   predicted class=no   expected loss=0.2881356  P(node) =0.04718113
##     class counts:    84    34
##    probabilities: 0.712 0.288 
##   left son=12 (96 obs) right son=13 (22 obs)
##   Primary splits:
##       total_eve_charge  < -0.9139902   to the right, improve=6.558295, (0 
missing)
##       total_eve_minutes < -0.5097817   to the right, improve=6.086780, (0 
missing)
##       total_day_charge  < 2.01545      to the left,  improve=4.818620, (0 
missing)
##       total_night_calls < 0.3988196    to the left,  improve=3.859411, (0 
missing)
##       total_day_calls   < -0.1573803   to the left,  improve=1.707479, (0 
missing)
##   Surrogate splits:
##       total_eve_minutes < -0.5097817   to the right, agree=0.966, adj=0.81
8, (0 split)
##       total_night_calls < -1.902784    to the right, agree=0.831, adj=0.09
1, (0 split)
## 
## Node number 7: 75 observations
##   predicted class=yes  expected loss=0.09333333  P(node) =0.029988
##     class counts:     7    68
##    probabilities: 0.093 0.907 
## 
## Node number 8: 1883 observations,    complexity param=0.01239669
##   predicted class=no   expected loss=0.04195433  P(node) =0.7528988
##     class counts:  1804    79
##    probabilities: 0.958 0.042 
##   left son=16 (1714 obs) right son=17 (169 obs)
##   Primary splits:
##       total_day_charge    < 0.8507229    to the left,  improve=4.1702330,
(0 missing)
##       total_eve_charge    < 1.348052     to the left,  improve=2.7665920,
(0 missing)
##       total_day_minutes   < -0.3505868   to the left,  improve=1.5914910,
(0 missing)
##       total_eve_minutes   < -0.3321934   to the left,  improve=1.1171860,
(0 missing)
##       total_night_minutes < -0.7620966   to the left,  improve=0.7805677,
(0 missing)
##
## Node number 9: 195 observations,    complexity param=0.0523416
##   predicted class=no   expected loss=0.3897436  P(node) =0.07796881
##     class counts:   119    76
##    probabilities: 0.610 0.390
##   left son=18 (157 obs) right son=19 (38 obs)
##   Primary splits:
##       total_intl_calls    < -0.8236005   to the right, improve=35.153880,
(0 missing)
##       total_intl_minutes  < 1.064683     to the left,  improve=27.454100,
(0 missing)
##       total_intl_charge   < 1.061325     to the left,  improve=27.454100,
(0 missing)
##       total_night_minutes < 1.419998     to the right, improve= 2.082097,
(0 missing)
##       total_night_charge  < 1.419451     to the right, improve= 2.082097,
(0 missing)
##
## Node number 10: 117 observations,    complexity param=0.01652893
##   predicted class=no   expected loss=0.2393162  P(node) =0.04678129
##     class counts:    89    28
##    probabilities: 0.761 0.239
##   left son=20 (109 obs) right son=21 (8 obs)
##   Primary splits:
##       total_day_charge      < 2.503975     to the left,  improve=6.940034,
(0 missing)
```

```
##       total_day_minutes     < -0.1931379   to the left,  improve=5.792412,
(0 missing)

##       total_night_minutes   < 1.070244     to the left,  improve=5.233092,
(0 missing)

##       total_night_charge    < 1.068673     to the left,  improve=5.233092,
(0 missing)

##       number_vmail_messages < 0.0320373    to the right, improve=3.616295,
(0 missing)

##   Surrogate splits:

##       account_length < 2.534459     to the left,  agree=0.949, adj=0.25, (
0 split)

##

## Node number 11: 113 observations,    complexity param=0.0523416

##   predicted class=yes  expected loss=0.3097345  P(node) =0.04518193

##     class counts:    35    78

##    probabilities: 0.310 0.690

##   left son=22 (25 obs) right son=23 (88 obs)

##   Primary splits:

##       voice_mail_plan_no    < -0.5001899   to the left,  improve=20.879490
, (0 missing)

##       voice_mail_plan_yes   < 0.5001899    to the right, improve=20.879490
, (0 missing)

##       number_vmail_messages < 0.1848024    to the right, improve=18.101190
, (0 missing)

##       total_day_minutes     < -0.2166002   to the left,  improve= 5.371216
, (0 missing)

##       total_day_charge      < 1.621606     to the left,  improve= 4.406838
, (0 missing)

##   Surrogate splits:

##       voice_mail_plan_yes   < 0.5001899    to the right, agree=1.000, adj=
1.00, (0 split)

##       number_vmail_messages < 0.1848024    to the right, agree=0.982, adj=
0.92, (0 split)

##       total_eve_minutes     < 3.001706     to the right, agree=0.788, adj=
0.04, (0 split)

##       total_eve_calls       < 1.902658     to the right, agree=0.788, adj=
0.04, (0 split)

##

## Node number 12: 96 observations,    complexity param=0.01101928

##   predicted class=no   expected loss=0.2083333  P(node) =0.03838465
##     class counts:    76    20
##    probabilities: 0.792 0.208
##   left son=24 (82 obs) right son=25 (14 obs)
##   Primary splits:
##       total_day_charge       < 1.599756     to the left,  improve=6.189315
, (0 missing)
##       total_night_calls      < 0.3988196    to the left,  improve=3.760417
, (0 missing)
##       total_day_minutes      < -0.2185274   to the left,  improve=2.483568
, (0 missing)
##       international_plan_yes < 1.318779     to the left,  improve=1.190476
, (0 missing)
##       international_plan_no  < -1.318779    to the right, improve=1.190476
, (0 missing)
##   Surrogate splits:
##       total_day_minutes < -0.2185274   to the left,  agree=0.885, adj=0.21
4, (0 split)
##
## Node number 13: 22 observations,    complexity param=0.01101928
##   predicted class=yes  expected loss=0.3636364  P(node) =0.008796481
##     class counts:     8    14
##    probabilities: 0.364 0.636
##   left son=26 (12 obs) right son=27 (10 obs)
##   Primary splits:
##       total_day_minutes             < -0.3324035   to the right, improve=4
.848485, (0 missing)
##       total_day_charge              < 0.3050545    to the right, improve=4
.848485, (0 missing)
##       total_intl_calls              < -0.3986753   to the right, improve=2
.715152, (0 missing)
##       total_eve_calls               < 0.1973581    to the right, improve=2
.548485, (0 missing)
##       number_customer_service_calls < 2.302926     to the left,  improve=1
.000866, (0 missing)
##   Surrogate splits:
##       total_day_charge              < 0.3050545    to the right, agree=1.0
00, adj=1.0, (0 split)
##       total_eve_calls               < -0.694645    to the right, agree=0.6
82, adj=0.3, (0 split)
```

```
##       total_night_calls             < 0.7091483    to the left,  agree=0.6
82, adj=0.3, (0 split)

##       total_intl_calls              < -0.8236005   to the right, agree=0.6
82, adj=0.3, (0 split)

##       number_customer_service_calls < 2.302926     to the left,  agree=0.6
82, adj=0.3, (0 split)

##

## Node number 16: 1714 observations

##   predicted class=no   expected loss=0.03150525  P(node) =0.6853259

##     class counts:  1660    54

##    probabilities: 0.968 0.032

##

## Node number 17: 169 observations,    complexity param=0.01239669

##   predicted class=no   expected loss=0.147929  P(node) =0.06757297

##     class counts:   144    25

##    probabilities: 0.852 0.148

##   left son=34 (148 obs) right son=35 (21 obs)

##   Primary splits:

##       total_eve_charge      < 1.336191     to the left,  improve=15.383470
, (0 missing)

##       total_eve_minutes     < -0.1381279   to the left,  improve= 8.862374
, (0 missing)

##       total_day_calls       < 1.323021     to the left,  improve= 2.963844
, (0 missing)

##       number_vmail_messages < -0.006153971 to the right, improve= 2.488166
, (0 missing)

##       voice_mail_plan_yes   < 0.5001899    to the right, improve= 2.244367
, (0 missing)

##   Surrogate splits:

##       total_eve_minutes < -0.1381279   to the left,  agree=0.923, adj=0.38
1, (0 split)

##

## Node number 18: 157 observations,    complexity param=0.0523416

##   predicted class=no   expected loss=0.2420382  P(node) =0.06277489

##     class counts:   119    38

##    probabilities: 0.758 0.242

##   left son=36 (129 obs) right son=37 (28 obs)

##   Primary splits:
```

```
##       total_intl_minutes  < 1.064683     to the left,  improve=39.155480,
(0 missing)
##       total_intl_charge   < 1.061325     to the left,  improve=39.155480,
(0 missing)
##       account_length      < 0.02805502   to the right, improve= 1.923262,
(0 missing)
##       total_night_minutes < 0.2830391    to the right, improve= 1.894086,
(0 missing)
##       total_night_charge  < 0.2822885    to the right, improve= 1.894086,
(0 missing)
##   Surrogate splits:
##       total_intl_charge     < 1.061325     to the left,  agree=1.000, adj=
1.000, (0 split)
##       number_vmail_messages < 2.552661     to the left,  agree=0.834, adj=
0.071, (0 split)
##       total_day_minutes     < -0.5673619   to the right, agree=0.834, adj=
0.071, (0 split)
##       total_day_charge      < -2.419366    to the right, agree=0.834, adj=
0.071, (0 split)
##
## Node number 19: 38 observations
##   predicted class=yes  expected loss=0  P(node) =0.01519392
##     class counts:     0    38
##    probabilities: 0.000 1.000
##
## Node number 20: 109 observations
##   predicted class=no   expected loss=0.1926606  P(node) =0.04358257
##     class counts:    88    21
##    probabilities: 0.807 0.193
##
## Node number 21: 8 observations
##   predicted class=yes  expected loss=0.125  P(node) =0.003198721
##     class counts:     1     7
##    probabilities: 0.125 0.875
##
## Node number 22: 25 observations
##   predicted class=no   expected loss=0.12  P(node) =0.009996002
##     class counts:    22     3
##    probabilities: 0.880 0.120
##
## Node number 23: 88 observations
##   predicted class=yes  expected loss=0.1477273  P(node) =0.03518593
##     class counts:    13    75
##    probabilities: 0.148 0.852
##
## Node number 24: 82 observations
##   predicted class=no   expected loss=0.1341463  P(node) =0.03278689
##     class counts:    71    11
##    probabilities: 0.866 0.134
##
## Node number 25: 14 observations
##   predicted class=yes  expected loss=0.3571429  P(node) =0.005597761
##     class counts:     5     9
##    probabilities: 0.357 0.643
##
## Node number 26: 12 observations
##   predicted class=no   expected loss=0.3333333  P(node) =0.004798081
##     class counts:     8     4
##    probabilities: 0.667 0.333
##
## Node number 27: 10 observations
##   predicted class=yes  expected loss=0  P(node) =0.003998401
##     class counts:     0    10
##    probabilities: 0.000 1.000
##
## Node number 34: 148 observations
##   predicted class=no   expected loss=0.06756757  P(node) =0.05917633
##     class counts:   138    10
##    probabilities: 0.932 0.068
##
## Node number 35: 21 observations
##   predicted class=yes  expected loss=0.2857143  P(node) =0.008396641
##       class counts:     6    15
##      probabilities: 0.286 0.714
##
## Node number 36: 129 observations
##    predicted class=no   expected loss=0.07751938  P(node) =0.05157937
##       class counts:   119    10
##      probabilities: 0.922 0.078
##
## Node number 37: 28 observations
##    predicted class=yes  expected loss=0  P(node) =0.01119552
##       class counts:     0    28
##      probabilities: 0.000 1.000
```

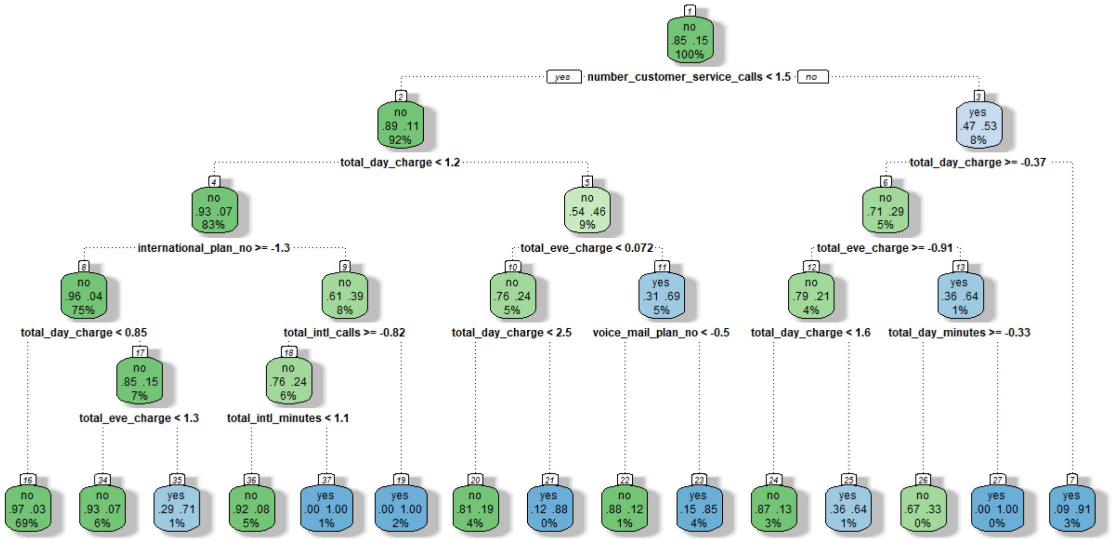
```
plot(DecisionTree_Model)
text(DecisionTree_Model)
```



```
print(DecisionTree_Model)
```

```
## n= 2501
##
## node), split, n, loss, yval, (yprob)
##       * denotes terminal node
##
##  1) root 2501 363 no (0.85485806 0.14514194)
##    2) number_customer_service_calls< 1.523388 2308 261 no (0.88691508 0.11
308492)
##      4) total_day_charge< 1.247929 2078 155 no (0.92540905 0.07459095)
##        8) international_plan_no>=-1.318779 1883  79 no (0.95804567 0.04195
433)
##         16) total_day_charge< 0.8507229 1714  54 no (0.96849475 0.03150525
) *
##         17) total_day_charge>=0.8507229 169  25 no (0.85207101 0.14792899)
##           34) total_eve_charge< 1.336191 148  10 no (0.93243243 0.06756757
) *
##           35) total_eve_charge>=1.336191 21   6 yes (0.28571429 0.71428571
) *
##        9) international_plan_no< -1.318779 195  76 no (0.61025641 0.389743
59)
##         18) total_intl_calls>=-0.8236005 157  38 no (0.75796178 0.24203822
)
##           36) total_intl_minutes< 1.064683 129  10 no (0.92248062 0.077519
38) *
##           37) total_intl_minutes>=1.064683 28   0 yes (0.00000000 1.000000
00) *
##         19) total_intl_calls< -0.8236005 38   0 yes (0.00000000 1.00000000
) *
##      5) total_day_charge>=1.247929 230 106 no (0.53913043 0.46086957)
##       10) total_eve_charge< 0.0717242 117  28 no (0.76068376 0.23931624)
##         20) total_day_charge< 2.503975 109  21 no (0.80733945 0.19266055)
*
##         21) total_day_charge>=2.503975 8   1 yes (0.12500000 0.87500000) *
##       11) total_eve_charge>=0.0717242 113  35 yes (0.30973451 0.69026549)
##         22) voice_mail_plan_no< -0.5001899 25   3 no (0.88000000 0.1200000
0) *
##         23) voice_mail_plan_no>=-0.5001899 88  13 yes (0.14772727 0.852272
73) *
##    3) number_customer_service_calls>=1.523388 193  91 yes (0.47150259 0.52
849741)
```

```
##       6) total_day_charge>=-0.3672269 118  34 no (0.71186441 0.28813559)
##        12) total_eve_charge>=-0.9139902 96  20 no (0.79166667 0.20833333)
##          24) total_day_charge< 1.599756 82  11 no (0.86585366 0.13414634) *
##          25) total_day_charge>=1.599756 14   5 yes (0.35714286 0.64285714)
*
##        13) total_eve_charge< -0.9139902 22   8 yes (0.36363636 0.63636364)
##          26) total_day_minutes>=-0.3324035 12   4 no (0.66666667 0.33333333
) *
##          27) total_day_minutes< -0.3324035 10   0 yes (0.00000000 1.0000000
0) *
##       7) total_day_charge< -0.3672269 75   7 yes (0.09333333 0.90666667) *
# Using fancyRpartPlot
fancyRpartPlot(DecisionTree_Model)
```



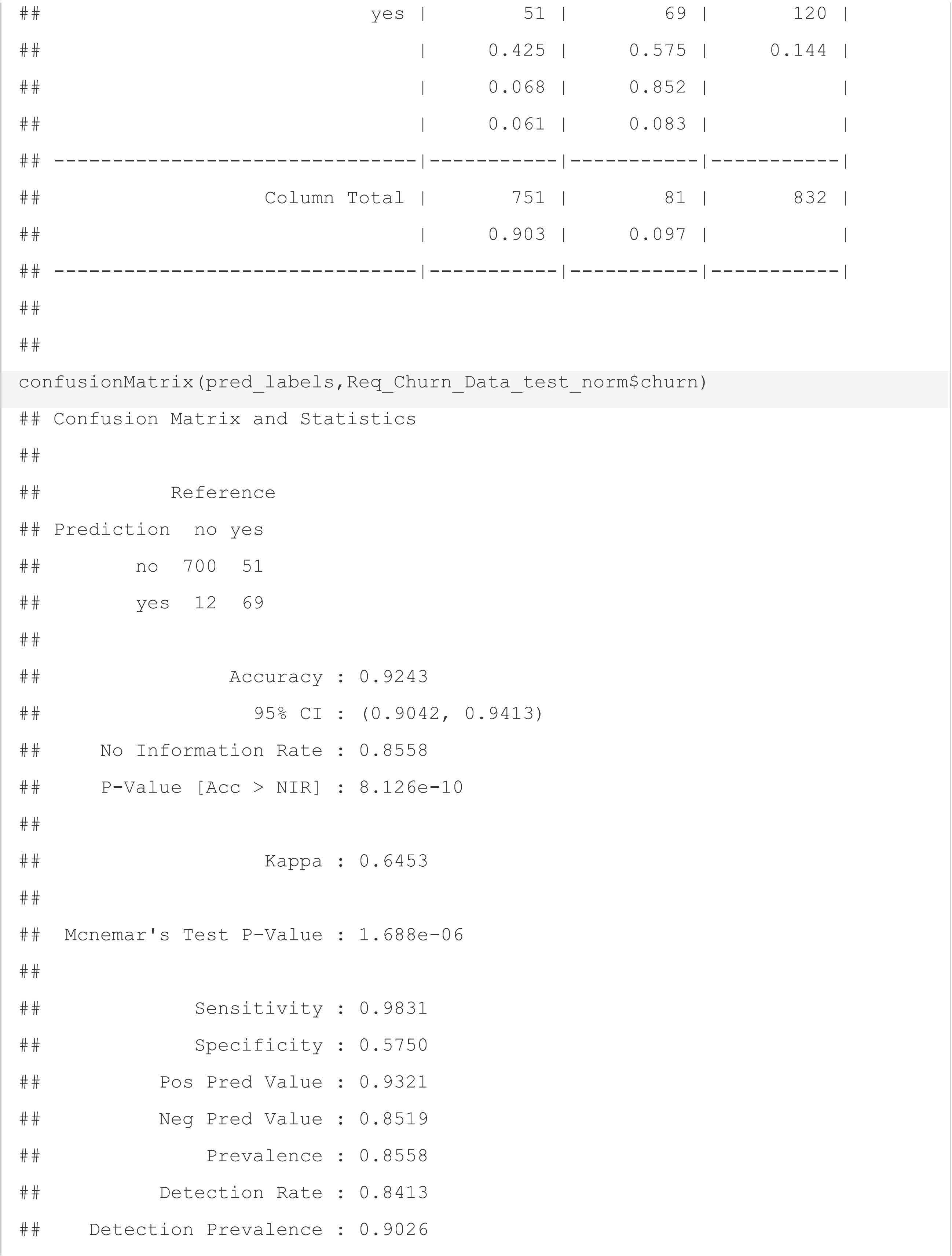
Rattle 2022-Dec-09 00:16:25 girne

Model Performance

Model Building is done and we can interpret the results.

```r
# Predicting values using based on DecisionTree_Model.
pred_labels <- predict(object = DecisionTree_Model,Req_Churn_Data_test_norm, type = "class")
pred_probs <- predict(object = DecisionTree_Model,Req_Churn_Data_test_norm)


# Performance Metrics
# Confusion matrix for the DecisionTree_Model.
CrossTable(x=Req_Churn_Data_test_norm$churn, y = pred_labels, prop.chisq = FALSE)
```

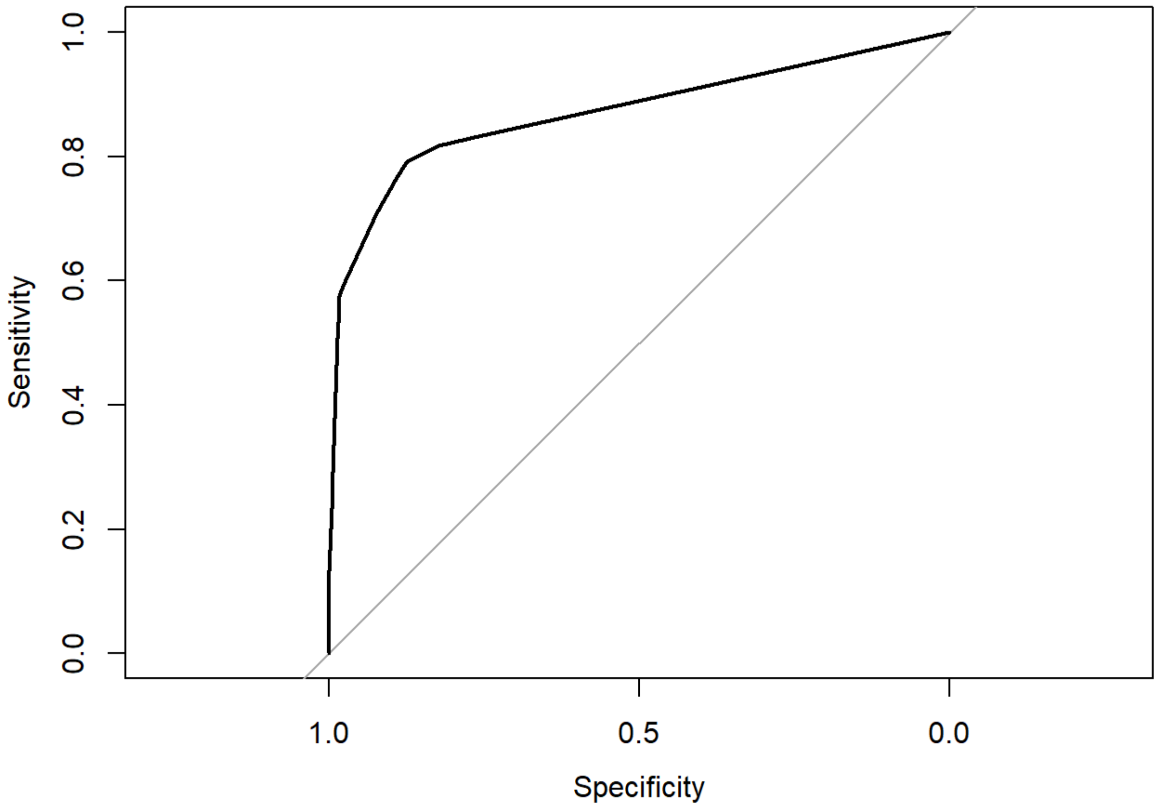
```
## 
## 
##    Cell Contents
## |-------------------------|
## |                       N |
## |           N / Row Total |
## |           N / Col Total |
## |         N / Table Total |
## |-------------------------|
## 
## 
## Total Observations in Table:  832 
## 
## 
##                                | pred_labels 
## Req_Churn_Data_test_norm$churn |        no |       yes | Row Total | 
## -------------------------------|-----------|-----------|-----------|
##                             no |       700 |        12 |       712 | 
##                                |     0.983 |     0.017 |     0.856 | 
##                                |     0.932 |     0.148 |           | 
##                                |     0.841 |     0.014 |           | 
## -------------------------------|-----------|-----------|-----------|
```



```
##                              yes |        51 |        69 |       120 |
##                                  |     0.425 |     0.575 |     0.144 |
##                                  |     0.068 |     0.852 |           |
##                                  |     0.061 |     0.083 |           |
## -------------------------------|-----------|-----------|-----------|
##                     Column Total |       751 |        81 |       832 |
##                                  |     0.903 |     0.097 |           |
## -------------------------------|-----------|-----------|-----------|
##
##
confusionMatrix(pred_labels,Req_Churn_Data_test_norm$churn)
## Confusion Matrix and Statistics
##
##           Reference
## Prediction  no yes
##        no  700  51
##        yes  12  69
##
##                Accuracy : 0.9243
##                  95% CI : (0.9042, 0.9413)
##     No Information Rate : 0.8558
##     P-Value [Acc > NIR] : 8.126e-10
##
##                   Kappa : 0.6453
##
##  Mcnemar's Test P-Value : 1.688e-06
##
##             Sensitivity : 0.9831
##             Specificity : 0.5750
##          Pos Pred Value : 0.9321
##          Neg Pred Value : 0.8519
##              Prevalence : 0.8558
##          Detection Rate : 0.8413
##    Detection Prevalence : 0.9026
##       Balanced Accuracy : 0.7791
##
##        'Positive' Class : no
##
# From the confusion Matrix we can say that

# Accuracy ~ 0.93
# Sensitivity ~ 0.95
# Specificity ~0.6
```

AUC of the Model

```
roc(Req_Churn_Data_test$churn, pred_probs[,2])
## Setting levels: control = no, case = yes
## Setting direction: controls < cases
##
## Call:
## roc.default(response = Req_Churn_Data_test$churn, predictor = pred_probs[,
2])
##
## Data: pred_probs[, 2] in 712 controls (Req_Churn_Data_test$churn no) < 120
cases (Req_Churn_Data_test$churn yes).
## Area under the curve: 0.8702
# As AUC is greater than 0.8 we can say that the model is good.

# Plotting the AUC of the Model
plot.roc(roc(Req_Churn_Data_test$churn, pred_probs[,2]))
## Setting levels: control = no, case = yes
## Setting direction: controls < cases
```



Conclusion:

We used the decision Tree classifier as our model and found out the AUC and Accuracy. As AUC is above 0.8, we can say that our model is Excellent.

Insights:

Part 2: Predicting for Customers_To_Predict

```r
# We need to use load() to read the RData file

load("C:/Users/girne/Downloads/Customers_To_Predict (1).RData")

Customers_To_Predict_data  <- Customers_To_Predict

Customers_To_Predict <- Customers_To_Predict %>% select(-state) %>% fastDummi
es::dummy_cols(., remove_selected_columns = TRUE)

Customers_To_Predict <- as.data.frame(scale(Customers_To_Predict))
```

```r
predict_labels <- predict(object = DecisionTree_Model, Customers_To_Predict,
type = "class")


# Adding the New Predicting column to the Customer_To_Predict Datafile.

Customers_To_Predict <- Customers_To_Predict_data %>% mutate(Churn_Probabilit
y = predict_labels)


# Viewing the Updated Data File

View(Customers_To_Predict)


#Head Part of the Updated Data file

head(Customers_To_Predict)
```

```
## # A tibble: 6 × 20

##   state accoun…¹ area_…² inter…³ voice…⁴ numbe…⁵ total…⁶ total…⁷ total…⁸ tot
al…⁹

##   <chr>    <dbl> <chr>   <chr>   <chr>     <dbl>   <dbl>   <dbl>   <dbl>
<dbl>

## 1 UT          93 area_c… no      no            0    174.     127    29.6
177.

## 2 SD          39 area_c… no      no            0    179       88    30.4
148.

## 3 KY         124 area_c… no      no            0    157.      74    26.7
196.

## 4 MS         162 area_c… yes     no            0    172.     138    29.3
166.

## 5 AK         112 area_c… no      yes          31    143.      92    24.3
234.

## 6 TX         109 area_c… yes     no            0    160.     136    27.1
151

## # … with 10 more variables: total_eve_calls <dbl>, total_eve_charge <dbl>,

## #   total_night_minutes <dbl>, total_night_calls <dbl>,

## #   total_night_charge <dbl>, total_intl_minutes <dbl>, total_intl_calls <
dbl>,

## #   total_intl_charge <dbl>, number_customer_service_calls <dbl>,

## #   Churn_Probability <fct>, and abbreviated variable names ¹account_lengt
h,

## #   ²area_code, ³international_plan, ⁴voice_mail_plan, ⁵number_vmail_messag
es,

## #   ⁶total_day_minutes, ⁷total_day_calls, ⁸total_day_charge, …
```

```
#Printing only the Churn_Probability Column

print(Customers_To_Predict$Churn_Probability)
```

```
##    1    2    3    4    5    6    7    8    9   10   11   12   13   14   15
16

##   no   no   no   no   no  yes   no   no   no   no   no   no   no   no   no
no

##   17   18   19   20   21   22   23   24   25   26   27   28   29   30   31
32

##   no   no   no   no   no   no   no   no   no   no   no   no   no   no  yes
no

##   33   34   35   36   37   38   39   40   41   42   43   44   45   46   47
48

##  yes   no  yes   no   no   no   no   no   no   no   no   no   no   no   no
no

##   49   50   51   52   53   54   55   56   57   58   59   60   61   62   63
64

##   no   no   no   no   no   no   no   no  yes   no  yes   no   no   no   no
no

##   65   66   67   68   69   70   71   72   73   74   75   76   77   78   79
80

##   no   no   no   no  yes   no   no   no   no  yes   no   no   no   no   no
yes

##   81   82   83   84   85   86   87   88   89   90   91   92   93   94   95
96

##   no   no   no   no   no   no   no   no   no   no   no   no   no   no   no
no

##   97   98   99  100  101  102  103  104  105  106  107  108  109  110  111
112

##  yes   no   no  yes   no   no   no   no   no   no   no   no   no  yes   no
no

##  113  114  115  116  117  118  119  120  121  122  123  124  125  126  127
128

##   no   no   no   no   no   no   no   no  yes  yes   no   no   no   no   no
no

##  129  130  131  132  133  134  135  136  137  138  139  140  141  142  143
144

##   no   no  yes   no   no   no  yes   no   no   no   no   no   no  yes   no
no

##  145  146  147  148  149  150  151  152  153  154  155  156  157  158  159
160

##  yes   no  yes   no   no   no   no   no   no   no   no   no   no   no   no
no
```

```
##  161  162  163  164  165  166  167  168  169  170  171  172  173  174  175
176
##   no   no   no   no   no   no   no   no   no   no   no   no  yes   no   no
yes
##  177  178  179  180  181  182  183  184  185  186  187  188  189  190  191
192
##   no   no   no   no   no   no   no   no   no   no   no   no   no   no   no
no
##  193  194  195  196  197  198  199  200  201  202  203  204  205  206  207
208
##   no   no   no   no   no   no   no   no  yes  yes   no   no   no   no   no
no
##  209  210  211  212  213  214  215  216  217  218  219  220  221  222  223
224
##   no   no   no   no   no   no   no   no   no   no   no  yes   no   no   no
no
##  225  226  227  228  229  230  231  232  233  234  235  236  237  238  239
240
##  yes   no   no   no   no   no   no   no   no   no   no   no   no   no   no
no
##  241  242  243  244  245  246  247  248  249  250  251  252  253  254  255
256
##   no   no   no  yes   no   no   no   no   no   no   no   no   no   no   no
no
##  257  258  259  260  261  262  263  264  265  266  267  268  269  270  271
272
##   no   no   no   no   no   no  yes   no   no   no  yes   no   no   no   no
no
##  273  274  275  276  277  278  279  280  281  282  283  284  285  286  287
288
##   no   no   no   no   no   no   no   no   no   no   no   no   no   no   no
no
##  289  290  291  292  293  294  295  296  297  298  299  300  301  302  303
304
##   no   no  yes   no   no   no   no   no   no   no   no   no  yes   no  yes
no
##  305  306  307  308  309  310  311  312  313  314  315  316  317  318  319
320
##   no   no   no   no   no   no   no   no   no   no   no   no   no   no   no
no
##  321  322  323  324  325  326  327  328  329  330  331  332  333  334  335
336
```

```
##   no   no   no   no   no   no   no   no   no   no   no  yes   no   no   no
no
##  337  338  339  340  341  342  343  344  345  346  347  348  349  350  351
352
##   no   no   no   no   no  yes   no   no   no   no   no   no   no   no  yes
no
##  353  354  355  356  357  358  359  360  361  362  363  364  365  366  367
368
##   no   no   no  yes   no   no   no   no   no   no   no   no   no   no   no
no
##  369  370  371  372  373  374  375  376  377  378  379  380  381  382  383
384
##   no   no   no   no   no   no   no   no   no   no   no   no   no   no   no
no
##  385  386  387  388  389  390  391  392  393  394  395  396  397  398  399
400
##   no   no   no   no   no   no   no   no   no   no   no   no   no   no   no
no
##  401  402  403  404  405  406  407  408  409  410  411  412  413  414  415
416
##  yes   no   no  yes   no   no   no   no   no   no   no   no   no   no   no
no
##  417  418  419  420  421  422  423  424  425  426  427  428  429  430  431
432
##   no   no   no   no   no   no   no   no   no   no   no   no   no   no   no
no
##  433  434  435  436  437  438  439  440  441  442  443  444  445  446  447
448
##   no   no   no   no   no   no   no   no   no   no   no   no   no   no   no
no
##  449  450  451  452  453  454  455  456  457  458  459  460  461  462  463
464
##   no   no   no   no   no   no   no   no  yes   no   no   no   no   no   no
no
##  465  466  467  468  469  470  471  472  473  474  475  476  477  478  479
480
##   no   no   no   no   no   no   no   no  yes   no   no   no   no   no   no
no
##  481  482  483  484  485  486  487  488  489  490  491  492  493  494  495
496
##   no   no   no  yes   no   no   no   no   no   no   no   no   no   no   no
no
```

```
##  497  498  499  500  501  502  503  504  505  506  507  508  509  510  511
512
##   no   no   no   no   no   no   no   no   no   no   no   no  yes   no   no
no
##  513  514  515  516  517  518  519  520  521  522  523  524  525  526  527
528
##   no  yes   no   no   no   no   no   no   no   no   no   no   no   no   no
no
##  529  530  531  532  533  534  535  536  537  538  539  540  541  542  543
544
##   no   no   no   no   no   no   no   no   no  yes   no   no   no   no   no
no
##  545  546  547  548  549  550  551  552  553  554  555  556  557  558  559
560
##   no   no   no  yes   no   no   no   no   no   no   no   no   no   no   no
yes
##  561  562  563  564  565  566  567  568  569  570  571  572  573  574  575
576
##   no   no   no   no   no   no   no   no   no   no   no   no   no   no   no
no
##  577  578  579  580  581  582  583  584  585  586  587  588  589  590  591
592
##   no  yes   no   no   no   no   no   no   no   no   no   no   no   no  yes
no
##  593  594  595  596  597  598  599  600  601  602  603  604  605  606  607
608
##   no   no   no   no   no   no  yes   no   no   no  yes   no   no   no   no
no
##  609  610  611  612  613  614  615  616  617  618  619  620  621  622  623
624
##   no   no  yes   no   no   no   no   no   no   no   no   no   no   no   no
yes
##  625  626  627  628  629  630  631  632  633  634  635  636  637  638  639
640
##   no   no   no   no   no   no   no   no  yes   no  yes   no   no   no   no
no
##  641  642  643  644  645  646  647  648  649  650  651  652  653  654  655
656
##   no   no   no   no   no   no   no   no   no   no   no   no   no   no  yes
no
##  657  658  659  660  661  662  663  664  665  666  667  668  669  670  671
672
```

```
##    no   no   no   no   no   no   no   no   no   no   no   no   no   no  yes
no

##   673  674  675  676  677  678  679  680  681  682  683  684  685  686  687
688

##    no   no   no   no   no   no   no   no   no   no   no   no   no  yes   no
no

##   689  690  691  692  693  694  695  696  697  698  699  700  701  702  703
704

##    no   no   no   no   no   no   no   no   no   no   no   no   no   no   no
no

##   705  706  707  708  709  710  711  712  713  714  715  716  717  718  719
720

##    no   no   no   no   no   no   no   no  yes   no   no  yes   no   no   no
no

##   721  722  723  724  725  726  727  728  729  730  731  732  733  734  735
736

##    no   no   no  yes   no   no   no   no   no   no   no   no   no  yes  yes
no

##   737  738  739  740  741  742  743  744  745  746  747  748  749  750  751
752

##    no   no   no  yes   no   no   no   no   no   no   no   no   no   no   no
no

##   753  754  755  756  757  758  759  760  761  762  763  764  765  766  767
768

##   yes   no   no   no   no   no   no   no   no   no   no   no   no   no   no
no

##   769  770  771  772  773  774  775  776  777  778  779  780  781  782  783
784

##    no   no   no   no  yes   no   no   no   no   no   no   no  yes   no   no
no

##   785  786  787  788  789  790  791  792  793  794  795  796  797  798  799
800

##    no   no  yes   no   no   no   no  yes   no   no   no   no   no   no   no
no

##   801  802  803  804  805  806  807  808  809  810  811  812  813  814  815
816

##    no   no   no   no  yes   no   no   no   no   no   no   no   no   no   no
no

##   817  818  819  820  821  822  823  824  825  826  827  828  829  830  831
832

##    no   no   no   no   no   no   no  yes   no   no   no  yes   no   no   no
yes
```

```
##  833  834  835  836  837  838  839  840  841  842  843  844  845  846  847
848

##   no   no   no   no   no  yes   no   no  yes  yes   no   no   no   no   no
no

##  849  850  851  852  853  854  855  856  857  858  859  860  861  862  863
864

##   no   no   no   no   no   no   no   no   no  yes   no   no   no   no   no
no

##  865  866  867  868  869  870  871  872  873  874  875  876  877  878  879
880

##   no   no   no   no   no   no   no   no  yes   no   no   no   no   no  yes
no

##  881  882  883  884  885  886  887  888  889  890  891  892  893  894  895
896

##   no   no   no   no   no   no   no   no   no   no   no   no   no   no   no
no

##  897  898  899  900  901  902  903  904  905  906  907  908  909  910  911
912

##   no   no   no   no  yes   no   no   no   no   no  yes   no   no  yes   no
no

##  913  914  915  916  917  918  919  920  921  922  923  924  925  926  927
928

##   no   no   no   no   no  yes   no   no   no   no   no   no   no   no   no
no

##  929  930  931  932  933  934  935  936  937  938  939  940  941  942  943
944

##   no   no   no   no  yes   no   no   no   no   no   no   no   no   no   no
no

##  945  946  947  948  949  950  951  952  953  954  955  956  957  958  959
960

##   no   no   no  yes   no   no   no   no   no   no   no   no   no   no   no
no

##  961  962  963  964  965  966  967  968  969  970  971  972  973  974  975
976

##   no  yes   no   no   no   no   no   no   no   no   no   no   no   no   no
yes

##  977  978  979  980  981  982  983  984  985  986  987  988  989  990  991
992

##   no   no  yes   no   no  yes   no   no   no   no   no   no   no   no   no
no

##  993  994  995  996  997  998  999 1000 1001 1002 1003 1004 1005 1006 1007
1008
```

```
##   no   no   no   no   no   no   no  yes   no   no   no   no   no  yes   no
yes
## 1009 1010 1011 1012 1013 1014 1015 1016 1017 1018 1019 1020 1021 1022 1023
1024
##   no   no  yes   no   no   no   no   no   no   no   no   no   no   no   no
no
## 1025 1026 1027 1028 1029 1030 1031 1032 1033 1034 1035 1036 1037 1038 1039
1040
##   no   no   no   no   no   no   no   no   no   no   no   no   no   no   no
no
## 1041 1042 1043 1044 1045 1046 1047 1048 1049 1050 1051 1052 1053 1054 1055
1056
##   no   no   no   no   no   no   no   no   no   no   no   no   no   no   no
no
## 1057 1058 1059 1060 1061 1062 1063 1064 1065 1066 1067 1068 1069 1070 1071
1072
##   no   no   no   no   no   no   no   no   no   no   no   no   no   no   no
no
## 1073 1074 1075 1076 1077 1078 1079 1080 1081 1082 1083 1084 1085 1086 1087
1088
##   no   no   no   no   no   no  yes   no   no   no   no   no   no   no   no
no
## 1089 1090 1091 1092 1093 1094 1095 1096 1097 1098 1099 1100 1101 1102 1103
1104
##   no   no  yes   no   no   no   no   no   no   no   no   no   no   no  yes
no
## 1105 1106 1107 1108 1109 1110 1111 1112 1113 1114 1115 1116 1117 1118 1119
1120
##   no   no  yes   no   no   no   no   no   no  yes   no   no   no   no   no
no
## 1121 1122 1123 1124 1125 1126 1127 1128 1129 1130 1131 1132 1133 1134 1135
1136
##   no   no   no   no   no   no   no   no   no   no   no   no   no   no  yes
no
## 1137 1138 1139 1140 1141 1142 1143 1144 1145 1146 1147 1148 1149 1150 1151
1152
##   no   no   no   no   no  yes   no   no   no   no   no   no   no   no   no
no
## 1153 1154 1155 1156 1157 1158 1159 1160 1161 1162 1163 1164 1165 1166 1167
1168
##   no   no   no   no   no   no   no   no   no   no  yes   no   no   no   no
no
```

```
## 1169 1170 1171 1172 1173 1174 1175 1176 1177 1178 1179 1180 1181 1182 1183
1184

##   no   no   no   no  yes   no   no   no   no   no   no   no   no   no   no
no

## 1185 1186 1187 1188 1189 1190 1191 1192 1193 1194 1195 1196 1197 1198 1199
1200

##   no   no   no  yes   no   no   no   no   no  yes   no   no   no   no   no
no

## 1201 1202 1203 1204 1205 1206 1207 1208 1209 1210 1211 1212 1213 1214 1215
1216

##   no  yes   no   no   no  yes   no   no   no   no   no  yes   no   no  yes
no

## 1217 1218 1219 1220 1221 1222 1223 1224 1225 1226 1227 1228 1229 1230 1231
1232

##   no   no   no   no   no   no   no   no   no   no  yes   no   no   no   no
no

## 1233 1234 1235 1236 1237 1238 1239 1240 1241 1242 1243 1244 1245 1246 1247
1248

##   no   no  yes  yes   no   no  yes   no   no   no   no   no   no   no   no
no

## 1249 1250 1251 1252 1253 1254 1255 1256 1257 1258 1259 1260 1261 1262 1263
1264

##   no  yes   no   no   no   no   no   no   no   no   no   no   no   no   no
no

## 1265 1266 1267 1268 1269 1270 1271 1272 1273 1274 1275 1276 1277 1278 1279
1280

##   no   no  yes   no   no   no   no   no   no   no   no   no   no   no   no
no

## 1281 1282 1283 1284 1285 1286 1287 1288 1289 1290 1291 1292 1293 1294 1295
1296

##  yes   no   no   no   no   no  yes   no   no   no   no   no   no  yes   no
no

## 1297 1298 1299 1300 1301 1302 1303 1304 1305 1306 1307 1308 1309 1310 1311
1312

##   no   no  yes   no   no  yes   no   no   no   no   no   no  yes   no   no
no

## 1313 1314 1315 1316 1317 1318 1319 1320 1321 1322 1323 1324 1325 1326 1327
1328

##   no  yes   no   no   no   no   no   no   no   no   no   no   no   no   no
no

## 1329 1330 1331 1332 1333 1334 1335 1336 1337 1338 1339 1340 1341 1342 1343
1344
```

```
##  yes   no   no   no   no   no   no   no   no   no   no   no   no   no   no
no
## 1345 1346 1347 1348 1349 1350 1351 1352 1353 1354 1355 1356 1357 1358 1359
1360
##   no   no   no   no  yes   no   no   no   no   no   no   no   no   no   no
no
## 1361 1362 1363 1364 1365 1366 1367 1368 1369 1370 1371 1372 1373 1374 1375
1376
##   no  yes   no   no   no   no   no   no   no   no   no   no   no   no   no
no
## 1377 1378 1379 1380 1381 1382 1383 1384 1385 1386 1387 1388 1389 1390 1391
1392
##   no   no   no   no   no   no   no   no  yes   no   no   no   no   no  yes
yes
## 1393 1394 1395 1396 1397 1398 1399 1400 1401 1402 1403 1404 1405 1406 1407
1408
##   no   no   no   no   no   no   no   no   no   no   no   no   no   no   no
no
## 1409 1410 1411 1412 1413 1414 1415 1416 1417 1418 1419 1420 1421 1422 1423
1424
##   no   no   no   no  yes  yes   no  yes   no   no   no   no   no   no   no
no
## 1425 1426 1427 1428 1429 1430 1431 1432 1433 1434 1435 1436 1437 1438 1439
1440
##  yes   no   no   no   no   no   no  yes   no   no   no   no   no  yes   no
no
## 1441 1442 1443 1444 1445 1446 1447 1448 1449 1450 1451 1452 1453 1454 1455
1456
##   no   no   no   no  yes  yes   no   no   no   no   no   no   no   no   no
no
## 1457 1458 1459 1460 1461 1462 1463 1464 1465 1466 1467 1468 1469 1470 1471
1472
##   no   no   no   no   no   no   no   no   no   no   no   no   no   no   no
no
## 1473 1474 1475 1476 1477 1478 1479 1480 1481 1482 1483 1484 1485 1486 1487
1488
##   no   no   no   no   no   no   no   no   no   no   no   no   no   no  yes
no
## 1489 1490 1491 1492 1493 1494 1495 1496 1497 1498 1499 1500 1501 1502 1503
1504
##   no   no   no   no  yes   no   no   no   no   no   no   no  yes   no   no
no
```

```
## 1505 1506 1507 1508 1509 1510 1511 1512 1513 1514 1515 1516 1517 1518 1519
1520
##   no  yes   no   no   no  yes   no   no   no   no   no   no   no   no   no
no
## 1521 1522 1523 1524 1525 1526 1527 1528 1529 1530 1531 1532 1533 1534 1535
1536
##   no   no   no   no  yes   no   no   no  yes   no   no   no   no   no   no
no
## 1537 1538 1539 1540 1541 1542 1543 1544 1545 1546 1547 1548 1549 1550 1551
1552
##   no  yes   no   no  yes   no   no   no  yes   no   no   no   no   no   no
no
## 1553 1554 1555 1556 1557 1558 1559 1560 1561 1562 1563 1564 1565 1566 1567
1568
##  yes   no   no   no   no   no   no   no   no   no   no   no   no   no  yes
no
## 1569 1570 1571 1572 1573 1574 1575 1576 1577 1578 1579 1580 1581 1582 1583
1584
##   no   no  yes   no  yes   no   no   no   no   no   no   no   no   no   no
no
## 1585 1586 1587 1588 1589 1590 1591 1592 1593 1594 1595 1596 1597 1598 1599
1600
##   no   no   no   no   no   no   no   no   no   no   no   no   no   no   no
no
## Levels: no yes
```

```
#Displaying the count of Yes/No Present in Churn_Probability Column.
table(Customers_To_Predict$Churn_Probability)
```

```
##
##   no  yes
## 1453  147
```

Interpretation

As we took the 25 % test data, we are having 1600 customers in test data and we can perform the forecast future churn on them.

the results are:

1453 customers are not ready to move out of ABC wireless network.

147 customers moving from ABC wireless to another network.