Assn2_Part3_OMalley.R

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Wed Apr 1 08:01:12 2015

```
# Sean O'Malley
# Assn 2 : Part 3
# Churn Business Problem

Churn_Calls<-read.csv("/Users/SeanOMalley1/Desktop/Week\ 2\ ADM/Churn_Calls.csv")
library(caret)
```

```
## Loading required package: lattice
## Loading required package: ggplot2
```

```
library(C50)
```

```
## Warning: package 'C50' was built under R version 3.1.3
```

```
library(car)
```

```
## Warning: package 'car' was built under R version 3.1.3
```

```
library(datasets)
library(ggplot2)
library(gmodels)
library(graphics)
library(grDevices)
library(grid)
library(knitr)
library(lattice)
library(MASS)
library(methods)
library(modeltools)
```

```
## Loading required package: stats4
```

```
library(mvtnorm)
library(party)
```

```
## Loading required package: strucchange
## Loading required package: zoo
```

```
## Warning: package 'zoo' was built under R version 3.1.3
```

```
##
## Attaching package: 'zoo'
##
## The following objects are masked from 'package:base':
##
##     as.Date, as.Date.numeric
##
## Loading required package: sandwich
```

```
library(pscl)
```

```
## Classes and Methods for R developed in the
##
## Political Science Computational Laboratory
##
## Department of Political Science
##
## Stanford University
##
## Simon Jackman
##
## hurdle and zeroinfl functions by Achim Zeileis
```

```
library(psych)
```

```
##
## Attaching package: 'psych'
##
## The following object is masked from 'package:car':
##
##     logit
##
## The following object is masked from 'package:ggplot2':
##
##     %+%
```

```
library(raster)
```

```
## Warning: package 'raster' was built under R version 3.1.3
```

```
## Loading required package: sp
##
## Attaching package: 'raster'
##
## The following objects are masked from 'package:MASS':
##
##     area, select
```

```
library(rattle)
```

```
## Rattle: A free graphical interface for data mining with R.
## Version 3.4.1 Copyright (c) 2006-2014 Togaware Pty Ltd.
## Type 'rattle()' to shake, rattle, and roll your data.
```

```
library(rpart)
library(rpart.plot)
library(sandwich)
library(sp)
library(stats)
library(stats4)
library(strucchange)
library(texreg)
```

```
## Version:  1.34
## Date:     2014-10-31
## Author:   Philip Leifeld (University of Konstanz)
##
## Please cite the JSS article in your publications -- see citation("texreg").
##
## Attaching package: 'texreg'
##
## The following object is masked from 'package:raster':
##
##     extract
```

```
library(utils)
library(zoo)




# EDA
#View(Churn_Calls)
str(Churn_Calls) # 5 factors, 7 integers, 8 numeric
```

```
## 'data.frame':    5000 obs. of  20 variables:
##  $ state                         : Factor w/ 51 levels "AK","AL","AR",..: 1 1 1 1 1
1 1 1 1 1 ...
##  $ account_length                : int  1 36 36 41 42 48 50 51 52 52 ...
##  $ area_code                     : Factor w/ 3 levels "area_code_408",..: 1 1 2 2 2
2 1 3 1 2 ...
##  $ international_plan            : Factor w/ 2 levels "no","yes": 1 1 2 1 1 1 1 2 1
1 ...
##  $ voice_mail_plan               : Factor w/ 2 levels "no","yes": 1 2 2 1 1 2 1 2 1
2 ...
##  $ number_vmail_messages         : int  0 30 19 0 0 37 0 12 0 24 ...
##  $ total_day_minutes             : num  175 146 172 159 171 ...
##  $ total_day_calls               : int  74 128 96 66 129 115 107 60 104 71 ...
##  $ total_day_charge              : num  29.8 24.9 29.2 27.1 29.1 ...
##  $ total_eve_minutes             : num  152 162 198 126 184 ...
##  $ total_eve_calls               : int  79 80 111 75 96 84 118 134 83 80 ...
##  $ total_eve_charge              : num  12.9 13.8 16.9 10.7 15.6 ...
##  $ total_night_minutes           : num  230 129 322 262 130 ...
##  $ total_night_calls             : int  109 109 76 76 90 80 99 98 109 124 ...
##  $ total_night_charge            : num  10.37 5.82 14.48 11.79 5.86 ...
##  $ total_intl_minutes            : num  5.3 14.5 10.5 11.1 4.6 12.2 8.7 12.3 11.8 4
.1 ...
##  $ total_intl_calls              : int  3 6 1 5 6 1 3 7 4 5 ...
##  $ total_intl_charge             : num  1.43 3.92 2.84 3 1.24 3.29 2.35 3.32 3.19 1
.11 ...
##  $ number_customer_service_calls: int  1 0 1 1 0 1 1 2 2 2 ...
##  $ churn                         : Factor w/ 2 levels "no","yes": 1 1 2 1 1 1 1 1 1
1 ...
```

```
dim(Churn_Calls) # 5000 observations and 20 variables
```

```
## [1] 5000   20
```

```
summary(Churn_Calls) # 4,293 did not churn, 707 did churn
```

```
##      state      account_length          area_code    international_plan
##  WV     : 158   Min.   :  1.0   area_code_408:1259   no :4527
##  MN     : 125   1st Qu.: 73.0   area_code_415:2495   yes: 473
##  AL     : 124   Median :100.0   area_code_510:1246
##  ID     : 119   Mean   :100.3
##  VA     : 118   3rd Qu.:127.0
##  OH     : 116   Max.   :243.0
##  (Other):4240
##  voice_mail_plan number_vmail_messages total_day_minutes total_day_calls
```

```
##  no :3677        Min.   : 0.000        Min.   :  0.0     Min.   :  0
##  yes:1323        1st Qu.: 0.000        1st Qu.:143.7     1st Qu.: 87
##                  Median : 0.000        Median :180.1     Median :100
##                  Mean   : 7.755        Mean   :180.3     Mean   :100
##                  3rd Qu.:17.000        3rd Qu.:216.2     3rd Qu.:113
##                  Max.   :52.000        Max.   :351.5     Max.   :165
##
##  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.:24.43    1st Qu.:166.4     1st Qu.: 87.0   1st Qu.:14.14
##  Median :30.62    Median :201.0     Median :100.0   Median :17.09
##  Mean   :30.65    Mean   :200.6     Mean   :100.2   Mean   :17.05
##  3rd Qu.:36.75    3rd Qu.:234.1     3rd Qu.:114.0   3rd Qu.:19.90
##  Max.   :59.76    Max.   :363.7     Max.   :170.0   Max.   :30.91
##
##  total_night_minutes total_night_calls total_night_charge
##  Min.   :  0.0       Min.   :  0.00    Min.   : 0.000
##  1st Qu.:166.9       1st Qu.: 87.00    1st Qu.: 7.510
##  Median :200.4       Median :100.00    Median : 9.020
##  Mean   :200.4       Mean   : 99.92    Mean   : 9.018
##  3rd Qu.:234.7       3rd Qu.:113.00    3rd Qu.:10.560
##  Max.   :395.0       Max.   :175.00    Max.   :17.770
##
##  total_intl_minutes total_intl_calls total_intl_charge
##  Min.   : 0.00      Min.   : 0.000   Min.   :0.000
##  1st Qu.: 8.50      1st Qu.: 3.000   1st Qu.:2.300
##  Median :10.30      Median : 4.000   Median :2.780
##  Mean   :10.26      Mean   : 4.435   Mean   :2.771
##  3rd Qu.:12.00      3rd Qu.: 6.000   3rd Qu.:3.240
##  Max.   :20.00      Max.   :20.000   Max.   :5.400
##
##  number_customer_service_calls churn
##  Min.   :0.00                  no :4293
##  1st Qu.:1.00                  yes: 707
##  Median :1.00
##  Mean   :1.57
##  3rd Qu.:2.00
##  Max.   :9.00
##
```

```
# Randomize Data
set.seed(12345)
Churn_Calls_Rand<-Churn_Calls[order(runif(5000)),]

# Confirm Randomized Data
summary(Churn_Calls)
```

```
##      state      account_length          area_code    international_plan
##  WV     : 158   Min.   :  1.0   area_code_408:1259   no :4527
##  MN     : 125   1st Qu.: 73.0   area_code_415:2495   yes: 473
##  AL     : 124   Median :100.0   area_code_510:1246
##  ID     : 119   Mean   :100.3
##  VA     : 118   3rd Qu.:127.0
##  OH     : 116   Max.   :243.0
##  (Other):4240
##  voice_mail_plan number_vmail_messages total_day_minutes total_day_calls
##  no :3677        Min.   : 0.000        Min.   :  0.0     Min.   :  0
##  yes:1323        1st Qu.: 0.000        1st Qu.:143.7     1st Qu.: 87
##                  Median : 0.000        Median :180.1     Median :100
##                  Mean   : 7.755        Mean   :180.3     Mean   :100
##                  3rd Qu.:17.000        3rd Qu.:216.2     3rd Qu.:113
##                  Max.   :52.000        Max.   :351.5     Max.   :165
##
##  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.:24.43    1st Qu.:166.4     1st Qu.: 87.0   1st Qu.:14.14
##  Median :30.62    Median :201.0     Median :100.0   Median :17.09
##  Mean   :30.65    Mean   :200.6     Mean   :100.2   Mean   :17.05
##  3rd Qu.:36.75    3rd Qu.:234.1     3rd Qu.:114.0   3rd Qu.:19.90
##  Max.   :59.76    Max.   :363.7     Max.   :170.0   Max.   :30.91
##
##  total_night_minutes total_night_calls total_night_charge
##  Min.   :  0.0       Min.   :  0.00    Min.   : 0.000
##  1st Qu.:166.9       1st Qu.: 87.00    1st Qu.: 7.510
##  Median :200.4       Median :100.00    Median : 9.020
##  Mean   :200.4       Mean   : 99.92    Mean   : 9.018
##  3rd Qu.:234.7       3rd Qu.:113.00    3rd Qu.:10.560
##  Max.   :395.0       Max.   :175.00    Max.   :17.770
##
##  total_intl_minutes total_intl_calls total_intl_charge
##  Min.   : 0.00      Min.   : 0.000   Min.   :0.000
##  1st Qu.: 8.50      1st Qu.: 3.000   1st Qu.:2.300
##  Median :10.30      Median : 4.000   Median :2.780
##  Mean   :10.26      Mean   : 4.435   Mean   :2.771
##  3rd Qu.:12.00      3rd Qu.: 6.000   3rd Qu.:3.240
##  Max.   :20.00      Max.   :20.000   Max.   :5.400
##
##  number_customer_service_calls churn
##  Min.   :0.00                  no :4293
##  1st Qu.:1.00                  yes: 707
##  Median :1.00
##  Mean   :1.57
##  3rd Qu.:2.00
##  Max.   :9.00
```

```
##
```

```
summary(Churn_Calls_Rand)
```

```
##      state      account_length          area_code    international_plan
##  WV     : 158   Min.   :  1.0   area_code_408:1259   no :4527
##  MN     : 125   1st Qu.: 73.0   area_code_415:2495   yes: 473
##  AL     : 124   Median :100.0   area_code_510:1246
##  ID     : 119   Mean   :100.3
##  VA     : 118   3rd Qu.:127.0
##  OH     : 116   Max.   :243.0
##  (Other):4240
##  voice_mail_plan number_vmail_messages total_day_minutes total_day_calls
##  no :3677        Min.   : 0.000        Min.   :  0.0     Min.   :  0
##  yes:1323        1st Qu.: 0.000        1st Qu.:143.7     1st Qu.: 87
##                  Median : 0.000        Median :180.1     Median :100
##                  Mean   : 7.755        Mean   :180.3     Mean   :100
##                  3rd Qu.:17.000        3rd Qu.:216.2     3rd Qu.:113
##                  Max.   :52.000        Max.   :351.5     Max.   :165
##
##  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.:24.43    1st Qu.:166.4     1st Qu.: 87.0   1st Qu.:14.14
##  Median :30.62    Median :201.0     Median :100.0   Median :17.09
##  Mean   :30.65    Mean   :200.6     Mean   :100.2   Mean   :17.05
##  3rd Qu.:36.75    3rd Qu.:234.1     3rd Qu.:114.0   3rd Qu.:19.90
##  Max.   :59.76    Max.   :363.7     Max.   :170.0   Max.   :30.91
##
##  total_night_minutes total_night_calls total_night_charge
##  Min.   :  0.0       Min.   :  0.00    Min.   : 0.000
##  1st Qu.:166.9       1st Qu.: 87.00    1st Qu.: 7.510
##  Median :200.4       Median :100.00    Median : 9.020
##  Mean   :200.4       Mean   : 99.92    Mean   : 9.018
##  3rd Qu.:234.7       3rd Qu.:113.00    3rd Qu.:10.560
##  Max.   :395.0       Max.   :175.00    Max.   :17.770
##
##  total_intl_minutes total_intl_calls total_intl_charge
##  Min.   : 0.00      Min.   : 0.000   Min.   :0.000
##  1st Qu.: 8.50      1st Qu.: 3.000   1st Qu.:2.300
##  Median :10.30      Median : 4.000   Median :2.780
##  Mean   :10.26      Mean   : 4.435   Mean   :2.771
##  3rd Qu.:12.00      3rd Qu.: 6.000   3rd Qu.:3.240
##  Max.   :20.00      Max.   :20.000   Max.   :5.400
##
##  number_customer_service_calls churn
##  Min.   :0.00                  no :4293
```

```
##  1st Qu.:1.00                  yes: 707
##  Median :1.00
##  Mean   :1.57
##  3rd Qu.:2.00
##  Max.   :9.00
##
```

```
    # same statistics
head(Churn_Calls)
```

```
##   state account_length     area_code international_plan voice_mail_plan
## 1    AK              1 area_code_408                 no              no
## 2    AK             36 area_code_408                 no             yes
## 3    AK             36 area_code_415                yes             yes
## 4    AK             41 area_code_415                 no              no
## 5    AK             42 area_code_415                 no              no
## 6    AK             48 area_code_415                 no             yes
##   number_vmail_messages total_day_minutes total_day_calls total_day_charge
## 1                     0             175.2              74            29.78
## 2                    30             146.3             128            24.87
## 3                    19             171.9              96            29.22
## 4                     0             159.3              66            27.08
## 5                     0             171.0             129            29.07
## 6                    37             211.7             115            35.99
##   total_eve_minutes total_eve_calls total_eve_charge total_night_minutes
## 1             151.7              79            12.89               230.5
## 2             162.5              80            13.81               129.3
## 3             198.4             111            16.86               321.7
## 4             125.9              75            10.70               261.9
## 5             183.9              96            15.63               130.2
## 6             159.9              84            13.59               144.1
##   total_night_calls total_night_charge total_intl_minutes total_intl_calls
## 1               109              10.37                5.3                3
## 2               109               5.82               14.5                6
## 3                76              14.48               10.5                1
## 4                76              11.79               11.1                5
## 5                90               5.86                4.6                6
## 6                80               6.48               12.2                1
##   total_intl_charge number_customer_service_calls churn
## 1              1.43                             1    no
## 2              3.92                             0    no
## 3              2.84                             1   yes
## 4              3.00                             1    no
## 5              1.24                             0    no
## 6              3.29                             1    no
```

```
head(Churn_Calls_Rand)
```

```
##      state account_length     area_code international_plan voice_mail_plan
## 2723    ND            182 area_code_415                 no              no
## 1100    IA             88 area_code_415                 no              no
## 4479    VT            107 area_code_510                 no              no
## 3599    OR            129 area_code_408                 no              no
## 2446    MS            190 area_code_415                yes              no
## 3763    RI            106 area_code_415                 no              no
##      number_vmail_messages total_day_minutes total_day_calls
## 2723                     0             104.9             111
## 1100                     0             113.7              67
## 4479                     0             189.7              76
## 3599                     0              98.0              99
## 2446                     0             111.9              55
## 3763                     0             155.9              90
##      total_day_charge total_eve_minutes total_eve_calls total_eve_charge
## 2723            17.83             198.5             120            16.87
## 1100            19.33             165.1             127            14.03
## 4479            32.25             156.1              65            13.27
## 3599            16.66             240.7              62            20.46
## 2446            19.02             223.0             124            18.96
## 3763            26.50             198.0             101            16.83
##      total_night_minutes total_night_calls total_night_charge
## 2723               258.2                91              11.62
## 1100               141.5               142               6.37
## 4479               244.0                91              10.98
## 3599               254.8               123              11.47
## 2446               243.2                81              10.94
## 3763               189.1                95               8.51
##      total_intl_minutes total_intl_calls total_intl_charge
## 2723                8.0                5              2.16
## 1100               10.8                3              2.92
## 4479                8.3                3              2.24
## 3599               10.5                4              2.84
## 2446               10.0                7              2.70
## 3763                8.0                2              2.16
##      number_customer_service_calls churn
## 2723                             2    no
## 1100                             1    no
## 4479                             5    no
## 3599                             0    no
## 2446                             3    no
## 3763                             2    no
```

```
# Establish Training and Testing Datasets
churn_training<-Churn_Calls_Rand[1:3000,] # training dataset of 60%
churn_testing<-Churn_Calls_Rand[3001:5000,]# testing dataset of 40%

# Confirm overall statistics
prop.table(table(Churn_Calls$churn)) # prop table allows us to test percentages of fa
ctors
```

```
##
##     no    yes
## 0.8586 0.1414
```

```
prop.table(table(Churn_Calls_Rand$churn)) # they match!!
```

```
##
##     no    yes
## 0.8586 0.1414
```

```
## Decision Tree Using rpart
library(rpart)
ChurnTree<- rpart(churn~.,method="class", data=churn_training) # churn tree involving
all variables
summary(ChurnTree)
```

```
## Call:
## rpart(formula = churn ~ ., data = churn_training, method = "class")
##   n= 3000
##
##           CP nsplit rel error    xerror       xstd
## 1 0.07298851      0 1.0000000 1.0000000 0.04433415
## 2 0.05287356      4 0.7080460 0.7149425 0.03838183
## 3 0.03218391      8 0.4574713 0.4758621 0.03191323
## 4 0.01839080      9 0.4252874 0.4758621 0.03191323
## 5 0.01494253     12 0.3701149 0.4643678 0.03155365
## 6 0.01379310     14 0.3402299 0.4482759 0.03104087
## 7 0.01000000     15 0.3264368 0.4505747 0.03111481
##
## Variable importance
##             total_day_minutes              total_day_charge
##                            17                            17
## number_customer_service_calls                         state
##                             9                             8
##              total_eve_charge             total_eve_minutes
```

```
##                             7                             7
##             total_intl_charge            total_intl_minutes
##                             7                             7
##              total_intl_calls            international_plan
##                             6                             6
##         number_vmail_messages               voice_mail_plan
##                             3                             3
##
## Node number 1: 3000 observations,    complexity param=0.07298851
##   predicted class=no   expected loss=0.145  P(node) =1
##     class counts:  2565   435
##    probabilities: 0.855 0.145
##   left son=2 (2752 obs) right son=3 (248 obs)
##   Primary splits:
##       total_day_minutes             < 254.45 to the left,  improve=82.78520, (0 mi
ssing)
##       total_day_charge              < 43.255 to the left,  improve=82.78520, (0 mi
ssing)
##       number_customer_service_calls < 3.5    to the left,  improve=70.07219, (0 mi
ssing)
##       international_plan            splits as  LR, improve=57.71958, (0 missing)
##       state                         splits as  LLLLRLLLRRRLLLLRRLLRRRRRLRRRRLLRLRR
RRRLLLLRRRLLRLRL, improve=12.45077, (0 missing)
##   Surrogate splits:
##       total_day_charge < 43.255 to the left,  agree=1, adj=1, (0 split)
##
## Node number 2: 2752 observations,    complexity param=0.07298851
##   predicted class=no   expected loss=0.1097384  P(node) =0.9173333
##     class counts:  2450   302
##    probabilities: 0.890 0.110
##   left son=4 (2525 obs) right son=5 (227 obs)
##   Primary splits:
##       number_customer_service_calls < 3.5    to the left,  improve=76.215470, (0 m
issing)
##       international_plan            splits as  LR, improve=54.317860, (0 missing)
##       state                         splits as  LLRLRLLRRLRLLLLLRLLLRRRRLRRRRLLRLRR
RLLLLLLRRLLLRLRL, improve= 8.644776, (0 missing)
##       total_intl_minutes            < 13.35  to the left,  improve= 7.896989, (0 m
issing)
##       total_intl_charge             < 3.605  to the left,  improve= 7.896989, (0 m
issing)
##
## Node number 3: 248 observations,    complexity param=0.07298851
##   predicted class=yes  expected loss=0.4637097  P(node) =0.08266667
##     class counts:   115   133
##    probabilities: 0.464 0.536
##   left son=6 (54 obs) right son=7 (194 obs)
```

```
##   Primary splits:
##       voice_mail_plan       splits as  RL, improve=27.17992, (0 missing)
##       number_vmail_messages < 7      to the right, improve=27.17992, (0 missing)
##       total_eve_minutes     < 184.65 to the left,  improve=20.53918, (0 missing)
##       total_eve_charge      < 15.695 to the left,  improve=20.53918, (0 missing)
##       state                 splits as  LRLLLRL-RRRLRLLRRLLRRRLLRLRLLLRRLRLRRRRRLLL
RLLRRLLL, improve=15.38143, (0 missing)
##   Surrogate splits:
##       number_vmail_messages < 7      to the right, agree=1.000, adj=1.000, (0 spli
t)
##       state                 splits as  RLLRRRR-RRRRRRRRRRRRRLLRRRRRRRRRRRRRRRRRR
RRRRRRRR, agree=0.802, adj=0.093, (0 split)
##       total_night_calls     < 50     to the left,  agree=0.786, adj=0.019, (0 spli
t)
##       total_intl_calls      < 11     to the right, agree=0.786, adj=0.019, (0 spli
t)
##
## Node number 4: 2525 observations,    complexity param=0.05287356
##   predicted class=no   expected loss=0.07445545  P(node) =0.8416667
##     class counts:  2337   188
##    probabilities: 0.926 0.074
##   left son=8 (2292 obs) right son=9 (233 obs)
##   Primary splits:
##       international_plan splits as  LR,         improve=49.913100, (0 missing)
##       total_day_minutes  < 220.15 to the left,  improve=11.368260, (0 missing)
##       total_day_charge   < 37.425 to the left,  improve=11.368260, (0 missing)
##       total_intl_minutes < 13.35  to the left,  improve= 8.583436, (0 missing)
##       total_intl_charge  < 3.605  to the left,  improve= 8.583436, (0 missing)
##
## Node number 5: 227 observations,    complexity param=0.07298851
##   predicted class=yes  expected loss=0.4977974  P(node) =0.07566667
##     class counts:   113   114
##    probabilities: 0.498 0.502
##   left son=10 (144 obs) right son=11 (83 obs)
##   Primary splits:
##       total_day_minutes < 160    to the right, improve=39.671830, (0 missing)
##       total_day_charge  < 27.2   to the right, improve=39.671830, (0 missing)
##       state             splits as  RRRRRLLLLRRLLRRLRLRRRRRLRRL-LRRRRRLLR-LRRLRRLL
RLLL, improve=15.526980, (0 missing)
##       total_eve_minutes < 171.1  to the right, improve= 9.260099, (0 missing)
##       total_eve_charge  < 14.545 to the right, improve= 9.260099, (0 missing)
##   Surrogate splits:
##       total_day_charge      < 27.2   to the right, agree=1.000, adj=1.000, (0 spli
t)
##       state                 splits as  LRRLLLLLLRLLRLLLLLRLLRRLLRRL-LLLLLLLLL-LRRL
LLLLLRLL, agree=0.731, adj=0.265, (0 split)
##       total_eve_minutes     < 114.5  to the right, agree=0.656, adj=0.060, (0 spli
```

```
t)
##       total_eve_charge      < 9.735  to the right, agree=0.656, adj=0.060, (0 spli
t)
##       number_vmail_messages < 40.5   to the left,  agree=0.648, adj=0.036, (0 spli
t)
##
## Node number 6: 54 observations
##   predicted class=no   expected loss=0.09259259  P(node) =0.018
##     class counts:    49     5
##    probabilities: 0.907 0.093
##
## Node number 7: 194 observations,    complexity param=0.05287356
##   predicted class=yes  expected loss=0.3402062  P(node) =0.06466667
##     class counts:    66   128
##    probabilities: 0.340 0.660
##   left son=14 (93 obs) right son=15 (101 obs)
##   Primary splits:
##       total_eve_minutes < 200.4  to the left,  improve=28.70420, (0 missing)
##       total_eve_charge  < 17.035 to the left,  improve=28.70420, (0 missing)
##       state             splits as  LR-LRRL-RRRLRLLRLLLRRRRRRLRLLLRRLRLRRRRRRRRRLLR
RLLR, improve=11.47816, (0 missing)
##       total_day_minutes < 286.85 to the left,  improve=11.06617, (0 missing)
##       total_day_charge  < 48.765 to the left,  improve=11.06617, (0 missing)
##   Surrogate splits:
##       total_eve_charge    < 17.035 to the left,  agree=1.000, adj=1.000, (0 split)
##       state               splits as  LR-RRRR-RRRLRLLRLLLRLRRLRLRLRRLRRRLRRRLLRLRRL
LRRLLR, agree=0.701, adj=0.376, (0 split)
##       total_intl_calls    < 4.5    to the right, agree=0.572, adj=0.108, (0 split)
##       total_night_minutes < 166.9  to the left,  agree=0.557, adj=0.075, (0 split)
##       total_night_charge  < 7.515  to the left,  agree=0.557, adj=0.075, (0 split)
##
## Node number 8: 2292 observations,    complexity param=0.0183908
##   predicted class=no   expected loss=0.04275742  P(node) =0.764
##     class counts:  2194    98
##    probabilities: 0.957 0.043
##   left son=16 (1968 obs) right son=17 (324 obs)
##   Primary splits:
##       total_day_minutes < 221.95 to the left,  improve=8.880575, (0 missing)
##       total_day_charge  < 37.73  to the left,  improve=8.880575, (0 missing)
##       total_eve_minutes < 242.3  to the left,  improve=5.162783, (0 missing)
##       total_eve_charge  < 20.595 to the left,  improve=5.162783, (0 missing)
##       state             splits as  LLLRRLRRRLLLLRLRRLLLLLRRRRRLRRLRRLRRLRLLLRRRRLL
RLRL, improve=2.618379, (0 missing)
##   Surrogate splits:
##       total_day_charge < 37.73  to the left,  agree=1, adj=1, (0 split)
##
## Node number 9: 233 observations,    complexity param=0.05287356
```

```
##   predicted class=no   expected loss=0.3862661  P(node) =0.07766667
##     class counts:   143    90
##    probabilities: 0.614 0.386
##   left son=18 (187 obs) right son=19 (46 obs)
##   Primary splits:
##       total_intl_calls   < 2.5    to the right, improve=43.177990, (0 missing)
##       total_intl_minutes < 13.1   to the left,  improve=40.863640, (0 missing)
##       total_intl_charge  < 3.535  to the left,  improve=40.863640, (0 missing)
##       state              splits as  LLRLRLLLRLLLRLRRRRLRRRRRLLLRLLLRRRRRRRLLLRRRLL
LRLRL, improve=19.242490, (0 missing)
##       total_day_calls    < 67.5   to the left,  improve= 2.793532, (0 missing)
##   Surrogate splits:
##       state          splits as  LLLLRLLLLLLLRLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLLL
L, agree=0.820, adj=0.087, (0 split)
##       account_length < 195    to the left,  agree=0.811, adj=0.043, (0 split)
##
## Node number 10: 144 observations,    complexity param=0.01494253
##   predicted class=no   expected loss=0.2777778  P(node) =0.048
##     class counts:   104    40
##    probabilities: 0.722 0.278
##   left son=20 (81 obs) right son=21 (63 obs)
##   Primary splits:
##       state             splits as  RLLLLLRLLLRLRRRLRL-LLLRRLRRR-LRRLRRLLL-LL-LRRLL
RLLL, improve=10.285710, (0 missing)
##       total_eve_minutes < 155.55 to the right, improve= 6.281979, (0 missing)
##       total_eve_charge  < 13.225 to the right, improve= 6.281979, (0 missing)
##       total_night_calls < 114.5  to the left,  improve= 3.309329, (0 missing)
##       total_day_minutes < 200.1  to the right, improve= 3.233874, (0 missing)
##   Surrogate splits:
##       number_customer_service_calls < 4.5    to the left,  agree=0.632, adj=0.159,
(0 split)
##       total_eve_minutes             < 189.95 to the right, agree=0.618, adj=0.127,
(0 split)
##       total_eve_charge              < 16.145 to the right, agree=0.618, adj=0.127,
(0 split)
##       account_length                < 106.5  to the left,  agree=0.604, adj=0.095,
(0 split)
##       total_eve_calls               < 97.5   to the right, agree=0.597, adj=0.079,
(0 split)
##
## Node number 11: 83 observations,    complexity param=0.0137931
##   predicted class=yes  expected loss=0.1084337  P(node) =0.02766667
##     class counts:     9    74
##    probabilities: 0.108 0.892
##   left son=22 (10 obs) right son=23 (73 obs)
##   Primary splits:
##       state             splits as  RRRRRRRRRRR-LR--LRRRRRRRRRR---RRRRRL-R--RRRRRLR
```

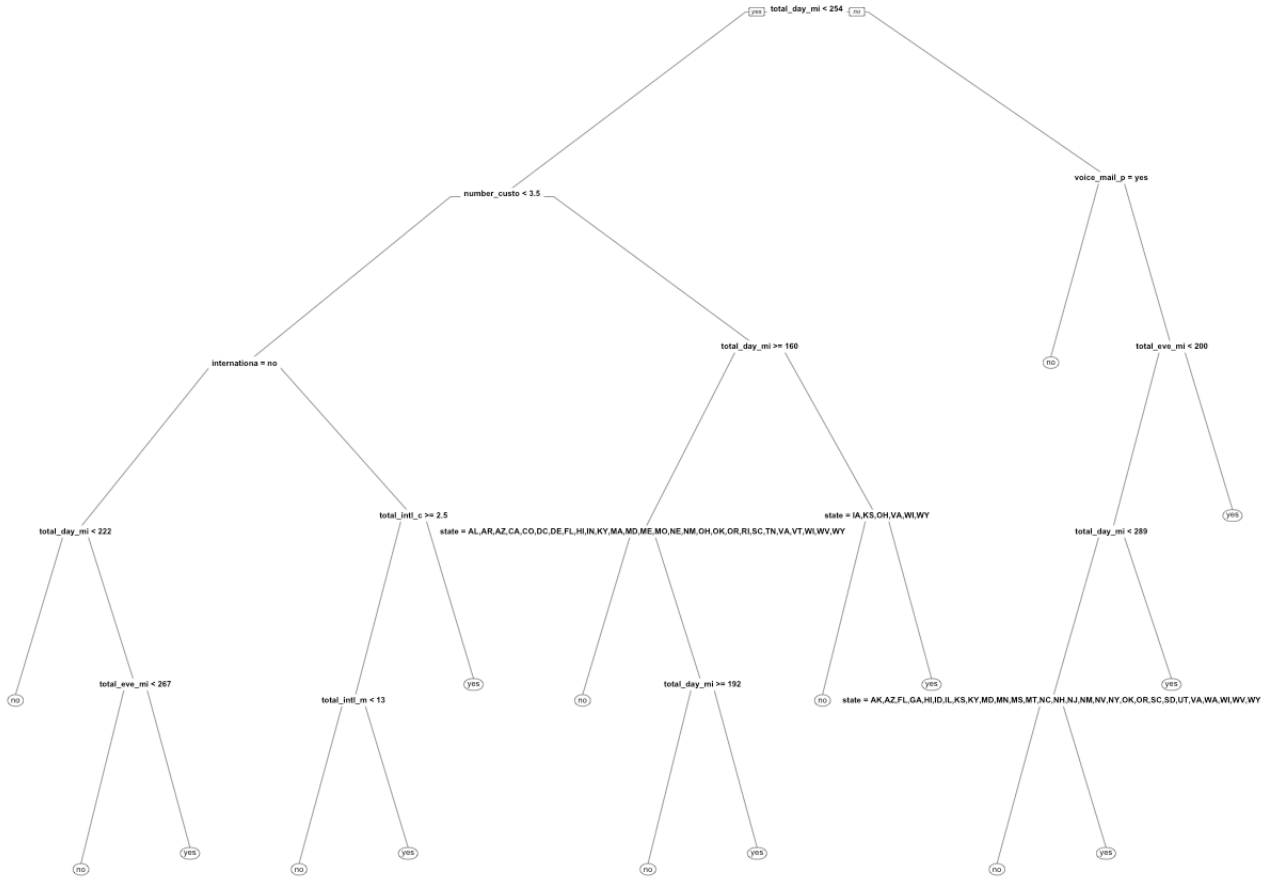
```
RLRL, improve=10.875590, (0 missing)
##       total_eve_minutes < 233.6  to the right, improve= 6.574509, (0 missing)
##       total_eve_charge  < 19.855 to the right, improve= 6.574509, (0 missing)
##       total_day_minutes < 134.65 to the right, improve= 1.551130, (0 missing)
##       total_day_charge  < 22.89  to the right, improve= 1.551130, (0 missing)
##   Surrogate splits:
##       total_eve_minutes < 258.2  to the right, agree=0.916, adj=0.3, (0 split)
##       total_eve_charge  < 21.95  to the right, agree=0.916, adj=0.3, (0 split)
##
## Node number 14: 93 observations,    complexity param=0.03218391
##   predicted class=no   expected loss=0.3763441  P(node) =0.031
##     class counts:    58    35
##    probabilities: 0.624 0.376
##   left son=28 (71 obs) right son=29 (22 obs)
##   Primary splits:
##       total_day_minutes   < 288.7  to the left,  improve=11.251300, (0 missing)
##       total_day_charge    < 49.08  to the left,  improve=11.251300, (0 missing)
##       state               splits as  L--L--L--RLR-LLRRRLRRR-R-RLLLRRLLLLRRLRRLRRRR
LRRRLL, improve= 9.043011, (0 missing)
##       total_night_minutes < 209.25 to the left,  improve= 8.679499, (0 missing)
##       total_night_charge  < 9.415  to the left,  improve= 8.679499, (0 missing)
##   Surrogate splits:
##       total_day_charge < 49.08  to the left,  agree=1.000, adj=1.000, (0 split)
##       state            splits as  L--L--R--LLL-LLRLLRLLL-L-LLLRLLLLLLLLLLLLLLLLLL
LLL, agree=0.806, adj=0.182, (0 split)
##       total_day_calls  < 65.5   to the right, agree=0.774, adj=0.045, (0 split)
##
## Node number 15: 101 observations
##   predicted class=yes  expected loss=0.07920792  P(node) =0.03366667
##     class counts:     8    93
##    probabilities: 0.079 0.921
##
## Node number 16: 1968 observations
##   predicted class=no   expected loss=0.02489837  P(node) =0.656
##     class counts:  1919    49
##    probabilities: 0.975 0.025
##
## Node number 17: 324 observations,    complexity param=0.0183908
##   predicted class=no   expected loss=0.1512346  P(node) =0.108
##     class counts:   275    49
##    probabilities: 0.849 0.151
##   left son=34 (296 obs) right son=35 (28 obs)
##   Primary splits:
##       total_eve_minutes   < 267.35 to the left,  improve=24.676120, (0 missing)
##       total_eve_charge    < 22.725 to the left,  improve=24.676120, (0 missing)
##       state               splits as  LLRRRLRLRRLLLRLRRLLLLLLRLRRLRLLRRLLLLRLLLLLRL
LLLLRL, improve=11.394020, (0 missing)
```

```
##       total_night_minutes < 191.7  to the left,  improve= 4.296437, (0 missing)
##       total_night_charge  < 8.625  to the left,  improve= 4.296437, (0 missing)
##   Surrogate splits:
##       total_eve_charge < 22.725 to the left,  agree=1, adj=1, (0 split)
##
## Node number 18: 187 observations,    complexity param=0.05287356
##   predicted class=no   expected loss=0.2352941  P(node) =0.06233333
##     class counts:   143    44
##    probabilities: 0.765 0.235
##   left son=36 (147 obs) right son=37 (40 obs)
##   Primary splits:
##       total_intl_minutes < 13.1   to the left,  improve=59.511800, (0 missing)
##       total_intl_charge  < 3.535  to the left,  improve=59.511800, (0 missing)
##       state              splits as  LRRL-LLLRRLL-LRRRLLRRRRLLLLRLLLRRRRRRLLLLRRLR
LRLRL, improve=11.980990, (0 missing)
##       total_intl_calls   < 9.5    to the left,  improve= 3.518837, (0 missing)
##       account_length     < 81.5   to the right, improve= 3.487649, (0 missing)
##   Surrogate splits:
##       total_intl_charge < 3.535  to the left,  agree=1.000, adj=1.000, (0 split)
##       state             splits as  LLLL-LLLLLLL-LLRLLLLLLLLLLLLLLLLLLLRLLLLLLLLLL
LLRL, agree=0.813, adj=0.125, (0 split)
##       total_intl_calls  < 9.5    to the left,  agree=0.802, adj=0.075, (0 split)
##       total_day_calls   < 146.5  to the left,  agree=0.797, adj=0.050, (0 split)
##       total_day_minutes < 58.55  to the right, agree=0.791, adj=0.025, (0 split)
##
## Node number 19: 46 observations
##   predicted class=yes  expected loss=0  P(node) =0.01533333
##     class counts:     0    46
##    probabilities: 0.000 1.000
##
## Node number 20: 81 observations
##   predicted class=no   expected loss=0.1111111  P(node) =0.027
##     class counts:    72     9
##    probabilities: 0.889 0.111
##
## Node number 21: 63 observations,    complexity param=0.01494253
##   predicted class=no   expected loss=0.4920635  P(node) =0.021
##     class counts:    32    31
##    probabilities: 0.508 0.492
##   left son=42 (34 obs) right son=43 (29 obs)
##   Primary splits:
##       total_day_minutes < 191.7  to the right, improve=5.788210, (0 missing)
##       total_day_charge  < 32.585 to the right, improve=5.788210, (0 missing)
##       total_night_calls < 119.5  to the left,  improve=3.104308, (0 missing)
##       total_eve_calls   < 92.5   to the right, improve=2.927853, (0 missing)
##       total_day_calls   < 105.5  to the left,  improve=2.886003, (0 missing)
##   Surrogate splits:
```

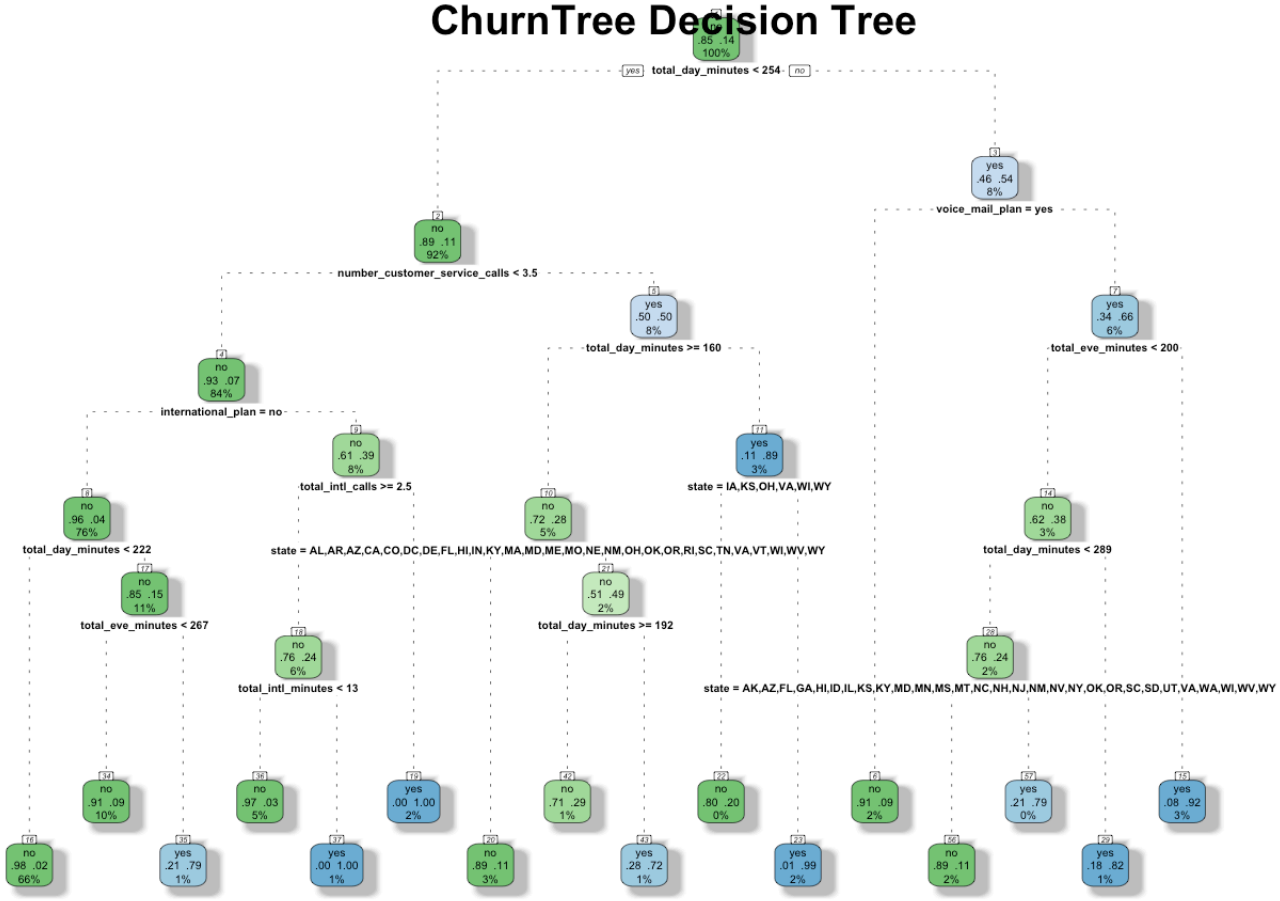
```
##       total_day_charge  < 32.585 to the right, agree=1.000, adj=1.000, (0 split)
##       state             splits as  R-----L---L-LLL-L-----RL-RRL--LR-LR--------RL--
L---, agree=0.762, adj=0.483, (0 split)
##       account_length    < 91     to the right, agree=0.635, adj=0.207, (0 split)
##       total_eve_minutes < 219    to the right, agree=0.635, adj=0.207, (0 split)
##       total_eve_charge  < 18.615 to the right, agree=0.635, adj=0.207, (0 split)
##
## Node number 22: 10 observations
##   predicted class=no   expected loss=0.2  P(node) =0.003333333
##     class counts:     8     2
##    probabilities: 0.800 0.200
##
## Node number 23: 73 observations
##   predicted class=yes  expected loss=0.01369863  P(node) =0.02433333
##     class counts:     1    72
##    probabilities: 0.014 0.986
##
## Node number 28: 71 observations,    complexity param=0.0183908
##   predicted class=no   expected loss=0.2394366  P(node) =0.02366667
##     class counts:    54    17
##    probabilities: 0.761 0.239
##   left son=56 (57 obs) right son=57 (14 obs)
##   Primary splits:
##       state              splits as  L--L-----LLL-LL-LL-RLR-L-LLL-RLLLLLRLLRRLLRRL
LRLLLL, improve=10.408030, (0 missing)
##       total_night_minutes < 209.5  to the left,  improve= 8.974602, (0 missing)
##       total_night_charge  < 9.425  to the left,  improve= 8.974602, (0 missing)
##       total_eve_minutes   < 155.45 to the left,  improve= 3.367219, (0 missing)
##       total_eve_charge    < 13.21  to the left,  improve= 3.367219, (0 missing)
##   Surrogate splits:
##       total_night_minutes < 280.65 to the left,  agree=0.831, adj=0.143, (0 split)
##       total_night_charge  < 12.63  to the left,  agree=0.831, adj=0.143, (0 split)
##       total_day_minutes   < 284.95 to the left,  agree=0.817, adj=0.071, (0 split)
##       total_day_charge    < 48.44  to the left,  agree=0.817, adj=0.071, (0 split)
##
## Node number 29: 22 observations
##   predicted class=yes  expected loss=0.1818182  P(node) =0.007333333
##     class counts:     4    18
##    probabilities: 0.182 0.818
##
## Node number 34: 296 observations
##   predicted class=no   expected loss=0.09121622  P(node) =0.09866667
##     class counts:   269    27
##    probabilities: 0.909 0.091
##
## Node number 35: 28 observations
##   predicted class=yes  expected loss=0.2142857  P(node) =0.009333333
```

```
##     class counts:     6    22
##    probabilities: 0.214 0.786
##
## Node number 36: 147 observations
##   predicted class=no   expected loss=0.02721088  P(node) =0.049
##     class counts:   143     4
##    probabilities: 0.973 0.027
##
## Node number 37: 40 observations
##   predicted class=yes  expected loss=0  P(node) =0.01333333
##     class counts:     0    40
##    probabilities: 0.000 1.000
##
## Node number 42: 34 observations
##   predicted class=no   expected loss=0.2941176  P(node) =0.01133333
##     class counts:    24    10
##    probabilities: 0.706 0.294
##
## Node number 43: 29 observations
##   predicted class=yes  expected loss=0.2758621  P(node) =0.009666667
##     class counts:     8    21
##    probabilities: 0.276 0.724
##
## Node number 56: 57 observations
##   predicted class=no   expected loss=0.1052632  P(node) =0.019
##     class counts:    51     6
##    probabilities: 0.895 0.105
##
## Node number 57: 14 observations
##   predicted class=yes  expected loss=0.2142857  P(node) =0.004666667
##     class counts:     3    11
##    probabilities: 0.214 0.786
```

```
    # this tells us the most influential variables, and shows us what makes the tree
messy
library(rpart.plot)
rpart.plot(ChurnTree)
```




```
    # Indiscriminately using all variables makes the decision tree especially messy
    # It does allow us to see that total day minutes and total day charge are the bi
ggest deciding variables
library(rattle)
fancyRpartPlot(ChurnTree,main="ChurnTree Decision Tree")
```




```
# Predict ChrunTree
Churn_Predict<-predict(ChurnTree,churn_testing,type="class")

# Assess Prediction with Confusion Matrix
CrossTable(churn_testing$churn,Churn_Predict,prop.chisq=FALSE,prop.c=FALSE,
           prop.r=FALSE,dnn=c('actual','predicted'))
```

```
##
##
##    Cell Contents
## |-------------------------|
## |                       N |
## |         N / Table Total |
## |-------------------------|
##
##
## Total Observations in Table:  2000
##
##
##              | predicted
##       actual |        no |       yes | Row Total |
## -------------|-----------|-----------|-----------|
##           no |      1683 |        45 |      1728 |
##              |     0.842 |     0.022 |           |
## -------------|-----------|-----------|-----------|
##          yes |        88 |       184 |       272 |
##              |     0.044 |     0.092 |           |
## -------------|-----------|-----------|-----------|
## Column Total |      1771 |       229 |      2000 |
## -------------|-----------|-----------|-----------|
##
##
```

```
    # Out of the 2000 in the churn test group, we properly predicted 1683 no churn c
lients and 184 clients who did churn
    # Our Churn_Predict model had .842+.092 = 93.4% accuracy and 6.6% error
    # This is pretty good accuracy, but the tree is especially confusiong
    # to better that model we will simplify the variables and try not to sacrifice a
ccuracy

## Decision Tree Using rpart (Second Attempt)
ChurnTree2<-rpart(churn~total_day_charge+total_eve_charge+total_intl_charge+
                    number_customer_service_calls,method="class",data=churn_training)
summary(ChurnTree2)
```

```
## Call:
## rpart(formula = churn ~ total_day_charge + total_eve_charge +
##     total_intl_charge + number_customer_service_calls, data = churn_training,
##     method = "class")
##   n= 3000
##
##           CP nsplit rel error    xerror       xstd
```

```
## 1 0.07183908      0 1.0000000 1.0000000 0.04433415
## 2 0.02068966      4 0.7126437 0.7540230 0.03929210
## 3 0.01264368      5 0.6919540 0.7563218 0.03934459
## 4 0.01149425      7 0.6666667 0.7448276 0.03908100
## 5 0.01000000     11 0.6137931 0.7103448 0.03827244
##
## Variable importance
##              total_day_charge number_customer_service_calls
##                            53                             26
##              total_eve_charge             total_intl_charge
##                            20                              1
##
## Node number 1: 3000 observations,    complexity param=0.07183908
##   predicted class=no   expected loss=0.145  P(node) =1
##     class counts:  2565   435
##    probabilities: 0.855 0.145
##   left son=2 (2752 obs) right son=3 (248 obs)
##   Primary splits:
##       total_day_charge             < 43.255 to the left,  improve=82.785200, (0 m
issing)
##       number_customer_service_calls < 3.5    to the left,  improve=70.072190, (0 m
issing)
##       total_intl_charge            < 3.605  to the left,  improve= 8.488149, (0 m
issing)
##       total_eve_charge             < 20.595 to the left,  improve= 6.504094, (0 m
issing)
##
## Node number 2: 2752 observations,    complexity param=0.07183908
##   predicted class=no   expected loss=0.1097384  P(node) =0.9173333
##     class counts:  2450   302
##    probabilities: 0.890 0.110
##   left son=4 (2525 obs) right son=5 (227 obs)
##   Primary splits:
##       number_customer_service_calls < 3.5    to the left,  improve=76.215470, (0 m
issing)
##       total_intl_charge            < 3.605  to the left,  improve= 7.896989, (0 m
issing)
##       total_day_charge             < 37.73  to the left,  improve= 6.300642, (0 m
issing)
##       total_eve_charge             < 21.395 to the left,  improve= 3.999970, (0 m
issing)
##
## Node number 3: 248 observations,    complexity param=0.07183908
##   predicted class=yes  expected loss=0.4637097  P(node) =0.08266667
##     class counts:   115   133
##    probabilities: 0.464 0.536
##   left son=6 (90 obs) right son=7 (158 obs)
```

```
##   Primary splits:
##       total_eve_charge             < 15.695 to the left,  improve=20.5391800, (0
missing)
##       total_day_charge             < 48.765 to the left,  improve=10.2529600, (0
missing)
##       total_intl_charge            < 1.5    to the left,  improve= 1.1635810, (0
missing)
##       number_customer_service_calls < 2.5    to the right, improve= 0.4147391, (0
missing)
##   Surrogate splits:
##       total_intl_charge < 0.77   to the left,  agree=0.649, adj=0.033, (0 split)
##
## Node number 4: 2525 observations,    complexity param=0.01149425
##   predicted class=no   expected loss=0.07445545  P(node) =0.8416667
##     class counts:  2337   188
##    probabilities: 0.926 0.074
##   left son=8 (2121 obs) right son=9 (404 obs)
##   Primary splits:
##       total_day_charge             < 37.425 to the left,  improve=11.3682600, (0
missing)
##       total_intl_charge            < 3.605  to the left,  improve= 8.5834360, (0
missing)
##       total_eve_charge             < 20.595 to the left,  improve= 6.8118000, (0
missing)
##       number_customer_service_calls < 0.5    to the right, improve= 0.2468821, (0
missing)
##
## Node number 5: 227 observations,    complexity param=0.07183908
##   predicted class=yes  expected loss=0.4977974  P(node) =0.07566667
##     class counts:   113   114
##    probabilities: 0.498 0.502
##   left son=10 (144 obs) right son=11 (83 obs)
##   Primary splits:
##       total_day_charge             < 27.2   to the right, improve=39.671830, (0 m
issing)
##       total_eve_charge             < 14.545 to the right, improve= 9.260099, (0 m
issing)
##       number_customer_service_calls < 4.5    to the left,  improve= 5.173402, (0 m
issing)
##       total_intl_charge            < 3.415  to the right, improve= 1.464762, (0 m
issing)
##   Surrogate splits:
##       total_eve_charge             < 9.735  to the right, agree=0.656, adj=0.060,
(0 split)
##       number_customer_service_calls < 5.5    to the left,  agree=0.648, adj=0.036,
(0 split)
##
```

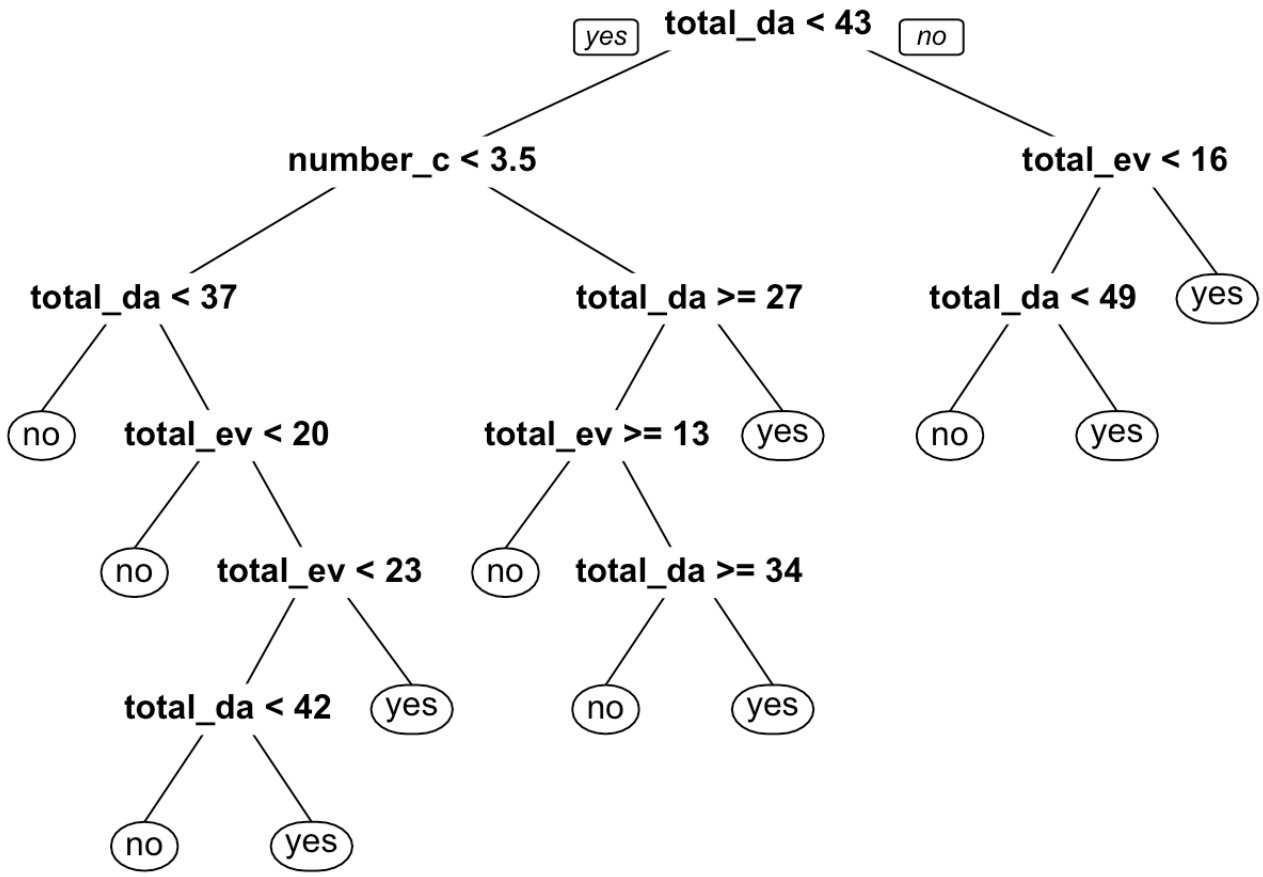
```
## Node number 6: 90 observations,    complexity param=0.02068966
##   predicted class=no   expected loss=0.2666667  P(node) =0.03
##     class counts:    66    24
##    probabilities: 0.733 0.267
##   left son=12 (65 obs) right son=13 (25 obs)
##   Primary splits:
##       total_day_charge             < 48.535 to the left,  improve=11.8276900, (0
missing)
##       total_eve_charge             < 11.77  to the left,  improve= 3.3447150, (0
missing)
##       total_intl_charge            < 3.615  to the left,  improve= 1.4099830, (0
missing)
##       number_customer_service_calls < 2.5    to the right, improve= 0.9308622, (0
missing)
##
## Node number 7: 158 observations
##   predicted class=yes  expected loss=0.3101266  P(node) =0.05266667
##     class counts:    49   109
##    probabilities: 0.310 0.690
##
## Node number 8: 2121 observations
##   predicted class=no   expected loss=0.05374823  P(node) =0.707
##     class counts:  2007   114
##    probabilities: 0.946 0.054
##
## Node number 9: 404 observations,    complexity param=0.01149425
##   predicted class=no   expected loss=0.1831683  P(node) =0.1346667
##     class counts:   330    74
##    probabilities: 0.817 0.183
##   left son=18 (320 obs) right son=19 (84 obs)
##   Primary splits:
##       total_eve_charge             < 20.48  to the left,  improve=24.6113300, (0
missing)
##       total_intl_charge            < 3.635  to the left,  improve= 4.7618410, (0
missing)
##       total_day_charge             < 42.27  to the left,  improve= 0.8372502, (0
missing)
##       number_customer_service_calls < 1.5    to the right, improve= 0.7215814, (0
missing)
##
## Node number 10: 144 observations,    complexity param=0.01264368
##   predicted class=no   expected loss=0.2777778  P(node) =0.048
##     class counts:   104    40
##    probabilities: 0.722 0.278
##   left son=20 (119 obs) right son=21 (25 obs)
##   Primary splits:
##       total_eve_charge             < 13.225 to the right, improve=6.2819790, (0 m
```

```
issing)
##       total_day_charge             < 34.02  to the right, improve=3.2338740, (0 m
issing)
##       number_customer_service_calls < 4.5    to the left,  improve=1.7422850, (0 m
issing)
##       total_intl_charge            < 3.605  to the left,  improve=0.7055536, (0 m
issing)
##
## Node number 11: 83 observations
##   predicted class=yes  expected loss=0.1084337  P(node) =0.02766667
##     class counts:     9    74
##    probabilities: 0.108 0.892
##
## Node number 12: 65 observations
##   predicted class=no   expected loss=0.1076923  P(node) =0.02166667
##     class counts:    58     7
##    probabilities: 0.892 0.108
##
## Node number 13: 25 observations
##   predicted class=yes  expected loss=0.32  P(node) =0.008333333
##     class counts:     8    17
##    probabilities: 0.320 0.680
##
## Node number 18: 320 observations
##   predicted class=no   expected loss=0.09375  P(node) =0.1066667
##     class counts:   290    30
##    probabilities: 0.906 0.094
##
## Node number 19: 84 observations,    complexity param=0.01149425
##   predicted class=yes  expected loss=0.4761905  P(node) =0.028
##     class counts:    40    44
##    probabilities: 0.476 0.524
##   left son=38 (47 obs) right son=39 (37 obs)
##   Primary splits:
##       total_eve_charge             < 22.725 to the left,  improve=4.2325360, (0 m
issing)
##       total_day_charge             < 42.32  to the left,  improve=3.2128700, (0 m
issing)
##       total_intl_charge            < 2.015  to the left,  improve=2.3804380, (0 m
issing)
##       number_customer_service_calls < 1.5    to the right, improve=0.5121873, (0 m
issing)
##   Surrogate splits:
##       total_day_charge  < 37.85  to the right, agree=0.595, adj=0.081, (0 split)
##       total_intl_charge < 1.135  to the right, agree=0.583, adj=0.054, (0 split)
##
## Node number 20: 119 observations
```

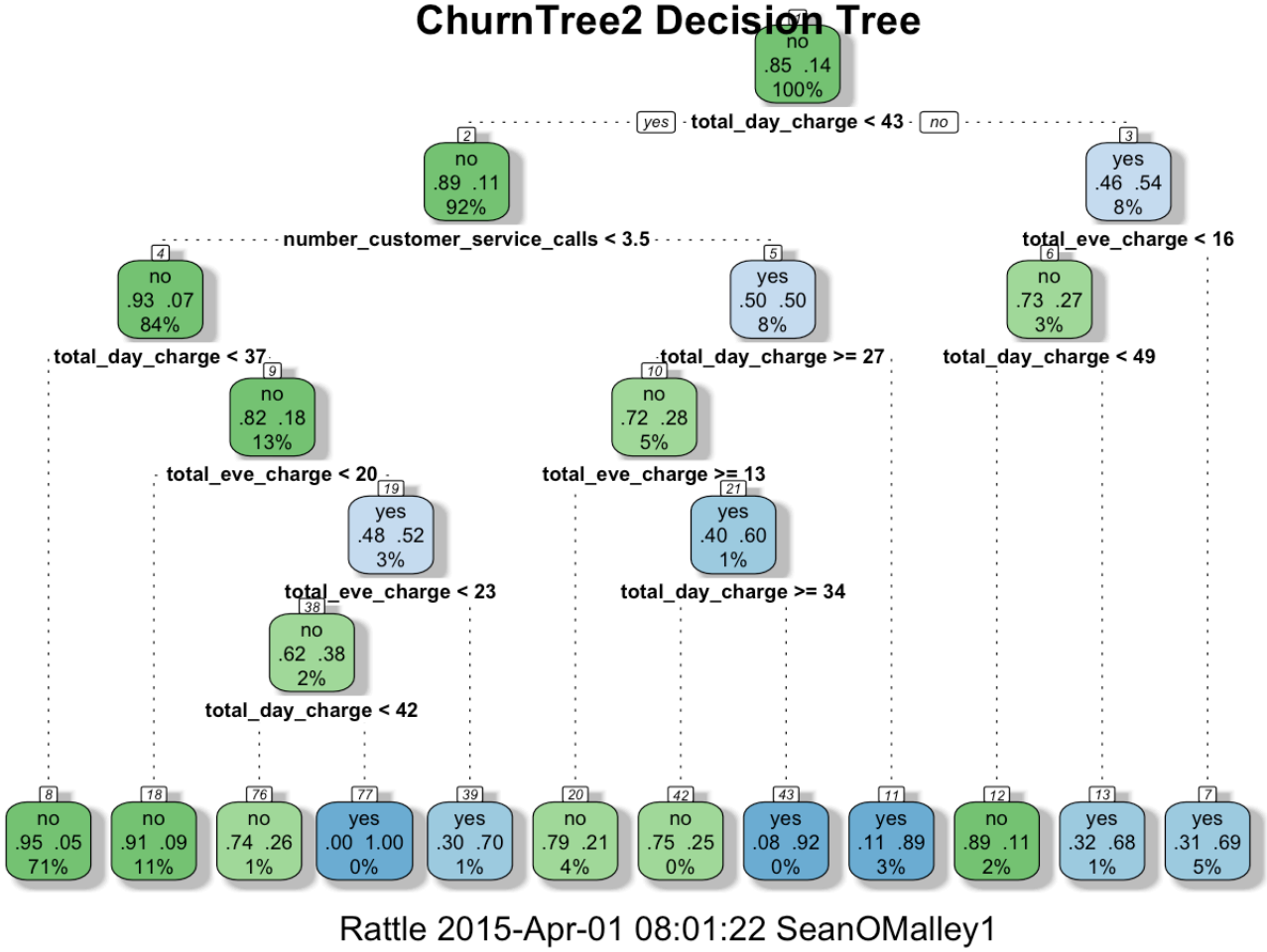
```
##   predicted class=no   expected loss=0.210084  P(node) =0.03966667
##     class counts:    94    25
##    probabilities: 0.790 0.210
##
## Node number 21: 25 observations,    complexity param=0.01264368
##   predicted class=yes  expected loss=0.4  P(node) =0.008333333
##     class counts:    10    15
##    probabilities: 0.400 0.600
##   left son=42 (12 obs) right son=43 (13 obs)
##   Primary splits:
##       total_day_charge             < 33.525 to the right, improve=5.6538460, (0 m
issing)
##       total_eve_charge             < 11.21  to the right, improve=0.8888889, (0 m
issing)
##       total_intl_charge            < 2.62   to the left,  improve=0.6805556, (0 m
issing)
##       number_customer_service_calls < 4.5    to the left,  improve=0.6363636, (0 m
issing)
##   Surrogate splits:
##       total_intl_charge            < 2.955  to the left,  agree=0.68, adj=0.333,
(0 split)
##       total_eve_charge             < 11.21  to the right, agree=0.60, adj=0.167,
(0 split)
##       number_customer_service_calls < 4.5    to the left,  agree=0.60, adj=0.167,
(0 split)
##
## Node number 38: 47 observations,    complexity param=0.01149425
##   predicted class=no   expected loss=0.3829787  P(node) =0.01566667
##     class counts:    29    18
##    probabilities: 0.617 0.383
##   left son=76 (39 obs) right son=77 (8 obs)
##   Primary splits:
##       total_day_charge             < 42.32  to the left,  improve=7.3409710, (0 m
issing)
##       total_intl_charge            < 2.47   to the left,  improve=2.2715890, (0 m
issing)
##       total_eve_charge             < 21.695 to the right, improve=1.8969760, (0 m
issing)
##       number_customer_service_calls < 0.5    to the left,  improve=0.5753391, (0 m
issing)
##   Surrogate splits:
##       total_eve_charge < 20.635 to the right, agree=0.872, adj=0.25, (0 split)
##
## Node number 39: 37 observations
##   predicted class=yes  expected loss=0.2972973  P(node) =0.01233333
##     class counts:    11    26
##    probabilities: 0.297 0.703
```

```
##
## Node number 42: 12 observations
##   predicted class=no   expected loss=0.25  P(node) =0.004
##     class counts:     9     3
##    probabilities: 0.750 0.250
##
## Node number 43: 13 observations
##   predicted class=yes  expected loss=0.07692308  P(node) =0.004333333
##     class counts:     1    12
##    probabilities: 0.077 0.923
##
## Node number 76: 39 observations
##   predicted class=no   expected loss=0.2564103  P(node) =0.013
##     class counts:    29    10
##    probabilities: 0.744 0.256
##
## Node number 77: 8 observations
##   predicted class=yes  expected loss=0  P(node) =0.002666667
##     class counts:     0     8
##    probabilities: 0.000 1.000
```

```
rpart.plot(ChurnTree2)
```




```
    # this plot tells us alot more, and is much easier to understand
fancyRpartPlot(ChurnTree2,main="ChurnTree2 Decision Tree")
```




```
# Predict ChrunTree2
Churn_Predict2<-predict(ChurnTree2,churn_testing,type="class")

# Assess Prediction with Confusion Matrix
CrossTable(churn_testing$churn,Churn_Predict2,prop.chisq=FALSE,prop.c=FALSE,
           prop.r=FALSE,dnn=c('actual','predicted'))
```

```
##
##
##    Cell Contents
## |-------------------------|
## |                       N |
## |         N / Table Total |
## |-------------------------|
##
##
## Total Observations in Table:  2000
##
##
##              | predicted
##       actual |        no |       yes | Row Total |
## -------------|-----------|-----------|-----------|
##           no |      1660 |        68 |      1728 |
##              |     0.830 |     0.034 |           |
## -------------|-----------|-----------|-----------|
##          yes |       120 |       152 |       272 |
##              |     0.060 |     0.076 |           |
## -------------|-----------|-----------|-----------|
## Column Total |      1780 |       220 |      2000 |
## -------------|-----------|-----------|-----------|
##
##
```

```
    # Out of the 2000 in the churn test group, we properly predicted 1660 no churn c
lients and 152 clients who did churn
# Our Churn_Predict model had .83+.076 = 90.6% accuracy and 9.4% error
# This is a decrease of 2.8% accuracy, for a decision tree that is much easier to rea
d
# just to add variety, I want to try another algorithm to increase accuracy as much a
s possible

## Decision Tree Using C5.0 Algorithm (Third Attempt)
library(C50)
ChurnTree3<-C5.0(churn_training[-20],churn_training$churn,trials=10)
    # use C5 alg to create model using all but variable 20 and stopping after 10 bra
nches
summary(ChurnTree3)
```

```
##
## Call:
## C5.0.default(x = churn_training[-20], y = churn_training$churn, trials
##  = 10)
```

```
##
##
## C5.0 [Release 2.07 GPL Edition]      Wed Apr  1 08:01:23 2015
## -------------------------------
##
## Class specified by attribute `outcome'
##
## Read 3000 cases (20 attributes) from undefined.data
##
## -----  Trial 0:  -----
##
## Decision tree:
##
## total_day_minutes > 254.3:
## :...voice_mail_plan = yes: no (54/5)
## :   voice_mail_plan = no:
## :   :...total_eve_minutes <= 200.4:
## :       :...total_day_minutes <= 288.7:
## :       :   :...total_night_charge <= 9.02: no (36)
## :       :   :   total_night_charge > 9.02:
## :       :   :   :...international_plan = no: no (31/13)
## :       :   :       international_plan = yes: yes (4)
## :       :   total_day_minutes > 288.7:
## :       :   :...account_length > 85: yes (15)
## :       :       account_length <= 85:
## :       :       :...total_eve_calls <= 87: yes (3)
## :       :           total_eve_calls > 87: no (4)
## :       total_eve_minutes > 200.4:
## :       :...total_night_charge > 7.73: yes (75)
## :           total_night_charge <= 7.73:
## :           :...total_day_minutes <= 261.8: no (5)
## :               total_day_minutes > 261.8:
## :               :...total_night_minutes <= 127: no (4/1)
## :                   total_night_minutes > 127: yes (17)
## total_day_minutes <= 254.3:
## :...number_customer_service_calls > 3:
##     :...total_day_minutes <= 160:
##     :   :...total_eve_minutes <= 233.6: yes (64)
##     :   :   total_eve_minutes > 233.6:
##     :   :   :...total_day_minutes <= 138.5: yes (12/2)
##     :   :       total_day_minutes > 138.5: no (7)
##     :   total_day_minutes > 160:
##     :   :...international_plan = no:
##     :       :...total_eve_charge <= 13.22: yes (24/9)
##     :       :   total_eve_charge > 13.22: no (106/17)
##     :       international_plan = yes:
##     :       :...total_intl_calls <= 3: yes (6)
```

```
##     :           total_intl_calls > 3:
##     :           :...account_length <= 82: yes (2)
##     :               account_length > 82: no (6)
##     number_customer_service_calls <= 3:
##     :...international_plan = yes:
##         :...total_intl_calls <= 2: yes (46)
##         :   total_intl_calls > 2:
##         :   :...total_intl_minutes <= 13.1: no (147/4)
##         :       total_intl_minutes > 13.1: yes (40)
##         international_plan = no:
##         :...total_day_minutes <= 221.9: no (1968/49)
##             total_day_minutes > 221.9:
##             :...total_eve_minutes <= 240.3: no (258/14)
##                 total_eve_minutes > 240.3:
##                 :...voice_mail_plan = yes: no (13)
##                     voice_mail_plan = no:
##                     :...total_night_minutes > 223.9: yes (20)
##                         total_night_minutes <= 223.9:
##                         :...total_intl_minutes <= 13.1: no (26/8)
##                             total_intl_minutes > 13.1: yes (7)
##
## -----  Trial 1:  -----
##
## Decision tree:
##
## total_day_minutes > 221.9:
## :...total_eve_charge <= 13.32: no (116.5/20.1)
## :   total_eve_charge > 13.32:
## :   :...voice_mail_plan = yes: no (133.4/43.7)
## :       voice_mail_plan = no:
## :       :...total_day_minutes > 265.6: yes (146.9/9.9)
## :           total_day_minutes <= 265.6:
## :           :...total_night_charge <= 7.17: no (44.9/6.1)
## :               total_night_charge > 7.17:
## :               :...total_eve_charge > 20.41: yes (118.6/7.6)
## :                   total_eve_charge <= 20.41:
## :                   :...total_intl_calls > 7: no (11.4)
## :                       total_intl_calls <= 7:
## :                       :...total_eve_minutes <= 166.7: no (12.9)
## :                           total_eve_minutes > 166.7:
## :                           :...area_code = area_code_408: no (29.5/8.9)
## :                               area_code in {area_code_415,area_code_510}:
## :                               :...state in {AK,AL,AR,AZ,CA,CT,DE,FL,IA,ID,IL,
## :                                   :         KS,LA,MA,ME,MI,MO,NJ,NM,NY,OH,OK,
## :                                   :         OR,PA,TN,TX,UT,WA,WI,WV,
## :                                   :         WY}: yes (130.1/22.8)
## :                                   state in {CO,DC,GA,HI,IN,KY,MD,MN,MS,MT,NC,
```

```
## :                                                ND,NE,NH,NV,RI,SC,SD,VA,
## :                                                VT}: no (32.7/2.3)
## total_day_minutes <= 221.9:
## :...number_customer_service_calls > 3:
##     :...total_day_minutes > 192.4: no (83.6/12.7)
##     :   total_day_minutes <= 192.4:
##     :   :...total_eve_charge <= 18.44: yes (151.8/20.3)
##     :       total_eve_charge > 18.44: no (45.2/12.9)
##     number_customer_service_calls <= 3:
##     :...state in {AK,AL,AR,AZ,CT,DE,FL,HI,IA,KS,NH,NJ,OK,OR,RI,SC,VT,
##         :         WI}: no (545.3/14.5)
##         state in {CA,CO,DC,GA,ID,IL,IN,KY,LA,MA,MD,ME,MI,MN,MO,MS,MT,NC,ND,NE,
##         :         NM,NV,NY,OH,PA,SD,TN,TX,UT,VA,WA,WV,WY}:
##         :...total_intl_minutes <= 5.5: no (49.4/0.8)
##             total_intl_minutes > 5.5:
##             :...number_vmail_messages > 41: yes (33.6/12.2)
##                 number_vmail_messages <= 41:
##                 :...total_eve_minutes <= 166.4: no (286/34.2)
##                     total_eve_minutes > 166.4:
##                     :...total_eve_charge <= 14.67: yes (92.2/38.8)
##                         total_eve_charge > 14.67:
##                         :...account_length <= 48: no (69.2/1.5)
##                             account_length > 48:
##                             :...total_night_calls <= 70: no (41.1/0.8)
##                                 total_night_calls > 70:
##                                 :...total_intl_calls > 7: no (61.6/2.3)
##                                     total_intl_calls <= 7:
##                                     :...voice_mail_plan = yes: no (152.3/23)
##                                         voice_mail_plan = no:
##                                         :...state in {ID,IL,ND,NM,PA,
##                                             :         SD}: no (71.5/0.8)
##                                             state in {CA,CO,DC,GA,IN,KY,LA,MA,
##                                             :         MD,ME,MI,MN,MO,MS,MT,NC,
##                                             :         NE,NV,NY,OH,TN,TX,UT,VA,
##                                             :         WA,WV,WY}: [S1]
##
## SubTree [S1]
##
## total_day_minutes > 198.4: yes (139.5/44.9)
## total_day_minutes <= 198.4:
## :...state in {GA,KY,LA,MA,ME,MN,NV,UT,VA,WA}: no (103.4/4.6)
##     state in {CA,CO,DC,IN,MD,MI,MO,MS,MT,NC,NE,NY,OH,TN,TX,WV,WY}:
##     :...total_eve_charge <= 15.73: no (18.3/0.8)
##         total_eve_charge > 15.73:
##         :...total_eve_charge <= 15.98: yes (23/3)
##             total_eve_charge > 15.98:
##             :...total_night_minutes <= 135.2: no (15.2)
```

```
##                 total_night_minutes > 135.2:
##                 :...total_night_calls <= 115: no (169.9/69.5)
##                     total_night_calls > 115: yes (70.9/22.1)
##
## -----  Trial 2:  -----
##
## Decision tree:
##
## international_plan = yes:
## :...total_intl_calls <= 2: yes (113.8)
## :   total_intl_calls > 2:
## :   :...total_intl_minutes > 13.1: yes (89)
## :       total_intl_minutes <= 13.1:
## :       :...total_eve_charge <= 27.39: no (149/29.9)
## :           total_eve_charge > 27.39: yes (11.1/0.6)
## international_plan = no:
## :...total_day_minutes > 241.9:
##     :...total_night_charge <= 9.39:
##     :   :...total_eve_charge <= 18.91: no (100.1/15.9)
##     :   :   total_eve_charge > 18.91: yes (53.8/21.1)
##     :   total_night_charge > 9.39:
##     :   :...voice_mail_plan = no: yes (197.4/29.8)
##     :       voice_mail_plan = yes: no (26.8/8.1)
##     total_day_minutes <= 241.9:
##     :...number_customer_service_calls > 3:
##         :...total_day_minutes <= 173.5: yes (129.6/29.5)
##         :   total_day_minutes > 173.5:
##         :   :...state in {AK,AL,AR,AZ,CA,CO,CT,DC,DE,FL,HI,IA,ID,IL,IN,KY,LA,
##         :       :         MA,MD,ME,MO,NC,ND,NE,NH,NM,NV,OH,OK,OR,PA,RI,SC,SD,
##         :       :         TN,UT,VA,VT,WI,WV,WY}: no (103.8/5.6)
##         :       state in {GA,KS,MI,MN,MS,MT,NJ,NY,TX,WA}: yes (62.1/13.3)
##         number_customer_service_calls <= 3:
##         :...state in {AK,AR,AZ,CT,DE,HI,IA,KS,NH,OK,RI,SC,VT}: no (319.6/2.4)
##             state in {AL,CA,CO,DC,FL,GA,ID,IL,IN,KY,LA,MA,MD,ME,MI,MN,MO,MS,MT,
##             :         NC,ND,NE,NJ,NM,NV,NY,OH,OR,PA,SD,TN,TX,UT,VA,WA,WI,WV,WY}:
##             :...total_day_minutes > 221.9:
##                 :...total_eve_charge > 22.7: yes (35.8/1.2)
##                 :   total_eve_charge <= 22.7:
##                 :   :...total_day_minutes <= 226.9: yes (68.1/23.3)
##                 :       total_day_minutes > 226.9: no (111/16.4)
##                 total_day_minutes <= 221.9:
##                 :...total_eve_charge <= 10.48: no (57.9)
##                     total_eve_charge > 10.48:
##                     :...total_day_minutes > 217.2: no (40.7)
##                         total_day_minutes <= 217.2:
##                         :...total_day_minutes <= 81.7: no (41)
##                             total_day_minutes > 81.7:
```

```
##                                 :...total_intl_minutes <= 8.5: no (288.1/36.9)
##                                     total_intl_minutes > 8.5:
##                                     :...total_night_calls <= 68: no (41)
##                                         total_night_calls > 68:
##                                         :...state in {AL,FL,MA,ME,MO,MS,NJ,OR,SD,
##                                             :         WI}: no (166.2)
##                                             state in {CA,CO,DC,GA,ID,IL,IN,KY,LA,
##                                             :         MD,MI,MN,MT,NC,ND,NE,NM,NV,
##                                             :         NY,OH,PA,TN,TX,UT,VA,WA,WV,
##                                             :         WY}:
##                                             :...total_eve_minutes > 253.4: yes (114.4/
53.1)
##                                                 total_eve_minutes <= 253.4:
##                                                 :...state in {CO,MI,NV,
##                                                     :         WV}: no (87.2)
##                                                     state in {CA,DC,GA,ID,IL,IN,KY,
##                                                     :         LA,MD,MN,MT,NC,ND,NE,
##                                                     :         NM,NY,OH,PA,TN,TX,UT,
##                                                     :         VA,WA,WY}: [S1]
##
## SubTree [S1]
##
## account_length > 169: no (26.6)
## account_length <= 169:
## :...account_length > 146: yes (93.6/34.9)
##     account_length <= 146:
##     :...account_length > 134: no (33.4)
##         account_length <= 134:
##         :...state in {LA,MD,NY,WA,WY}: no (62.6)
##             state in {CA,DC,GA,ID,IL,IN,KY,MN,MT,NC,ND,NE,NM,OH,PA,TN,TX,UT,VA}:
##             :...number_vmail_messages > 32: yes (61.7/21.5)
##                 number_vmail_messages <= 32:
##                 :...total_eve_charge > 19.21: no (47.5)
##                     total_eve_charge <= 19.21:
##                     :...state in {MN,ND,NM,PA,UT,VA}: no (48.1)
##                         state in {CA,DC,GA,ID,IL,IN,KY,MT,NC,NE,OH,TN,TX}:
##                         :...number_vmail_messages > 18: no (16.5)
##                             number_vmail_messages <= 18:
##                             :...total_intl_calls <= 1: yes (28.1/4.2)
##                                 total_intl_calls > 1:
##                                 :...total_day_minutes <= 183.6: yes (128.8/48.5)
##                                     total_day_minutes > 183.6: no (45.4/5.3)
##
## -----  Trial 3:  -----
##
## Decision tree:
##
```

```
## international_plan = yes:
## :...total_intl_calls <= 2: yes (89.8)
##     total_intl_calls > 2:
##     :...total_intl_minutes > 13.1: yes (70.2)
##         total_intl_minutes <= 13.1:
##         :...state in {AK,AL,AZ,CA,DC,DE,FL,HI,IA,IL,IN,KY,LA,MD,MI,MN,MO,NC,ND,
##             :         NE,NJ,NM,NV,NY,OK,OR,PA,RI,UT,VA,WA,WV,
##             :         WY}: no (69.6)
##             state in {AR,CO,CT,GA,ID,KS,MA,ME,MS,MT,NH,OH,SC,SD,TN,TX,VT,
##                       WI}: yes (101/26.3)
## international_plan = no:
## :...total_day_minutes > 264.2:
##     :...total_night_minutes <= 116.1: no (13.4)
##     :   total_night_minutes > 116.1:
##     :   :...total_eve_charge <= 12.3: no (21.7/3.5)
##     :       total_eve_charge > 12.3:
##     :       :...voice_mail_plan = no: yes (132/15.1)
##     :           voice_mail_plan = yes: no (39.8/15.9)
##     total_day_minutes <= 264.2:
##     :...number_customer_service_calls > 3:
##         :...total_day_minutes <= 120: yes (26.1)
##         :   total_day_minutes > 120:
##         :   :...total_intl_calls > 7: no (32/1.4)
##         :       total_intl_calls <= 7:
##         :       :...total_day_calls > 127: yes (14.9/1)
##         :           total_day_calls <= 127:
##         :           :...total_day_calls <= 63: yes (13.4/0.5)
##         :               total_day_calls > 63:
##         :               :...total_intl_calls > 5: no (30/3.7)
##         :                   total_intl_calls <= 5:
##         :                   :...total_day_minutes <= 148.5: yes (14.1)
##         :                       total_day_minutes > 148.5:
##         :                       :...total_night_calls <= 64: yes (10.5/0.5)
##         :                           total_night_calls > 64: no (188.5/65.8)
##         number_customer_service_calls <= 3:
##         :...total_day_minutes > 224.6:
##             :...total_eve_charge > 22.72: yes (43/7.2)
##             :   total_eve_charge <= 22.72:
##             :   :...state in {AK,AL,CO,DC,GA,HI,IL,IN,KY,LA,ME,MN,MS,MT,NC,NE,
##             :       :         NH,NM,NV,OH,OK,PA,RI,SC,SD,VA,VT,WA,
##             :       :         WY}: no (137.8/1.9)
##             :       state in {AR,AZ,CA,CT,DE,FL,IA,ID,KS,MA,MD,MI,MO,ND,NJ,NY,
##             :       :         OR,TN,TX,UT,WI,WV}:
##             :       :...total_intl_minutes <= 9.7: no (78/16)
##             :           total_intl_minutes > 9.7: yes (124.9/49.1)
##             total_day_minutes <= 224.6:
##             :...state in {AK,AR,AZ,CT,DE,FL,HI,IA,KS,MA,NH,NJ,OK,RI,SC,VT,
```

```
##                  :         WI}: no (306.6)
##                  state in {AL,CA,CO,DC,GA,ID,IL,IN,KY,LA,MD,ME,MI,MN,MO,MS,MT,
##                  :         NC,ND,NE,NM,NV,NY,OH,OR,PA,SD,TN,TX,UT,VA,WA,WV,WY}:
##                  :...total_eve_charge <= 10.48: no (46.4)
##                      total_eve_charge > 10.48:
##                      :...total_night_charge > 11.73: no (196.7/65.8)
##                          total_night_charge <= 11.73:
##                          :...state in {GA,IL,ME,NC,ND,NV,OR}: no (183.4)
##                              state in {AL,CA,CO,DC,ID,IN,KY,LA,MD,MI,MN,MO,MS,
##                              :         MT,NE,NM,NY,OH,PA,SD,TN,TX,UT,VA,WA,WV,
##                              :         WY}:
##                              :...area_code = area_code_510: no (239.5/28.3)
##                                  area_code in {area_code_408,area_code_415}:
##                                  :...total_eve_charge > 23.27: no (73.5/4.6)
##                                      total_eve_charge <= 23.27:
##                                      :...total_day_calls <= 96: no (299.7/51.1)
##                                          total_day_calls > 96:
##                                          :...total_eve_calls <= 86: no (59.5)
##                                              total_eve_calls > 86:
##                                              :...account_length <= 48: no (20.2)
##                                                  account_length > 48: [S1]
##
## SubTree [S1]
##
## total_day_minutes <= 108.2: no (20.1)
## total_day_minutes > 108.2:
## :...state in {CA,CO,MD,MO,PA,SD,WA,WY}: no (44.9)
##     state in {AL,DC,ID,IN,KY,LA,MI,MN,MS,MT,NE,NM,NY,OH,TN,TX,UT,VA,WV}:
##     :...total_intl_calls > 7: no (21.4/4.2)
##         total_intl_calls <= 7:
##         :...total_intl_minutes <= 9.3: yes (92.5/30.3)
##             total_intl_minutes > 9.3: no (144.7/59.1)
##
## -----  Trial 4:  -----
##
## Decision tree:
##
## total_day_minutes > 265.6:
## :...account_length <= 52: no (20.4/3)
## :   account_length > 52: yes (217/65.1)
## total_day_minutes <= 265.6:
## :...number_customer_service_calls > 3:
##     :...total_day_minutes > 197.8: no (116.9/44.6)
##     :   total_day_minutes <= 197.8:
##     :   :...total_night_charge <= 7.66: yes (102.1/9.7)
##     :       total_night_charge > 7.66:
##     :       :...total_eve_minutes <= 186: yes (83.1/17.2)
```

```
##     :           total_eve_minutes > 186: no (85.8/22.5)
##     number_customer_service_calls <= 3:
##     :...international_plan = yes:
##         :...total_intl_calls <= 2: yes (56.2)
##         :   total_intl_calls > 2:
##         :   :...total_intl_minutes <= 13.1: no (173.6/20.4)
##         :       total_intl_minutes > 13.1: yes (43.5)
##         international_plan = no:
##         :...total_eve_charge > 20.85:
##             :...voice_mail_plan = yes: no (106.7/8.3)
##             :   voice_mail_plan = no:
##             :   :...total_night_charge <= 8.41: no (96.6/5.8)
##             :       total_night_charge > 8.41:
##             :       :...total_day_minutes <= 184: no (112.6/28.1)
##             :           total_day_minutes > 184: yes (162.5/38.6)
##             total_eve_charge <= 20.85:
##             :...total_eve_charge <= 10.48: no (70.3)
##                 total_eve_charge > 10.48:
##                 :...total_day_minutes <= 96.3: no (58)
##                     total_day_minutes > 96.3:
##                     :...state in {AK,AZ,DE,HI,KS,NH,NM,NV,OK,RI,SC,VT,
##                         :         WI}: no (211.6/11)
##                         state in {AL,AR,CA,CO,CT,DC,FL,GA,IA,ID,IL,IN,KY,LA,MA,
##                         :         MD,ME,MI,MN,MO,MS,MT,NC,ND,NE,NJ,NY,OH,OR,PA,
##                         :         SD,TN,TX,UT,VA,WA,WV,WY}:
##                         :...total_night_charge > 11.73:
##                             :...state in {AL,AR,CA,CO,CT,DC,FL,IN,KY,LA,MA,MD,
##                             :   :         MI,MO,MS,MT,NY,OH,PA,SD,UT,VA,WA,
##                             :   :         WY}: no (62.4)
##                             :   state in {GA,IA,ID,IL,ME,MN,NC,ND,NE,NJ,OR,TN,
##                             :             TX,WV}: yes (130.6/49.1)
##                             total_night_charge <= 11.73:
##                             :...state in {GA,IA,IL,ME,MN,NC,ND,NE,NJ,
##                                 :         OR}: no (212.4)
##                                 state in {AL,AR,CA,CO,CT,DC,FL,ID,IN,KY,LA,MA,
##                                 :         MD,MI,MO,MS,MT,NY,OH,PA,SD,TN,TX,UT,
##                                 :         VA,WA,WV,WY}:
##                                 :...total_intl_minutes > 14.1: no (46.9/0.4)
##                                     total_intl_minutes <= 14.1:
##                                     :...total_day_charge <= 18.53: yes (36.4/14.4)
##                                         total_day_charge > 18.53: no (794.3/198.3)
##
## -----  Trial 5:  -----
##
## Decision tree:
##
## number_customer_service_calls > 3:
```

```
## :...total_day_minutes <= 120: yes (41.5)
## :   total_day_minutes > 120:
## :   :...account_length <= 62: no (57.7/16.6)
## :       account_length > 62:
## :       :...total_day_minutes <= 134.6: yes (16.7)
## :           total_day_minutes > 134.6:
## :           :...total_night_calls > 116: yes (90/17.4)
## :               total_night_calls <= 116:
## :               :...total_eve_charge > 21.54: no (17.2)
## :                   total_eve_charge <= 21.54:
## :                   :...total_day_calls <= 72: yes (32.1/2.2)
## :                       total_day_calls > 72:
## :                       :...account_length <= 145: no (133.5/49.4)
## :                           account_length > 145: yes (43.1/7.3)
## number_customer_service_calls <= 3:
## :...total_intl_minutes <= 4: no (42.7/0.3)
##     total_intl_minutes > 4:
##     :...international_plan = yes:
##         :...total_intl_calls <= 2: yes (53.4)
##         :   total_intl_calls > 2:
##         :   :...total_intl_minutes <= 13.1: no (188.2/44.8)
##         :       total_intl_minutes > 13.1: yes (39.4)
##         international_plan = no:
##         :...total_day_charge > 48.72: yes (75.6/22.4)
##             total_day_charge <= 48.72:
##             :...total_eve_charge <= 10.48: no (72)
##                 total_eve_charge > 10.48:
##                 :...total_day_minutes > 221.9:
##                     :...voice_mail_plan = yes: no (135/23.3)
##                     :   voice_mail_plan = no:
##                     :   :...total_night_charge <= 7.21: no (85.7/7.8)
##                     :       total_night_charge > 7.21:
##                     :       :...total_eve_charge <= 15.48: no (150.2/34)
##                     :           total_eve_charge > 15.48:
##                     :           :...total_eve_charge > 22.72: yes (28.8)
##                     :               total_eve_charge <= 22.72:
##                     :               :...total_day_charge <= 41.96: no (112.2/43.8)
##                     :                   total_day_charge > 41.96: yes (104.8/16.3)
##                     total_day_minutes <= 221.9:
##                     :...state in {AK,AL,AR,AZ,CT,DE,FL,HI,IA,KS,MA,NH,NJ,OK,OR,
##                         :         RI,SC,VT,WI}: no (249.4)
##                         state in {CA,CO,DC,GA,ID,IL,IN,KY,LA,MD,ME,MI,MN,MO,MS,
##                         :         MT,NC,ND,NE,NM,NV,NY,OH,PA,SD,TN,TX,UT,VA,WA,
##                         :         WV,WY}:
##                         :...total_eve_minutes > 322.2: yes (25/7.9)
##                             total_eve_minutes <= 322.2:
##                             :...number_vmail_messages > 43: yes (27.9/10)
```

```
##                                     number_vmail_messages <= 43:
##                                     :...total_intl_minutes <= 8.3: no (202/18.1)
##                                         total_intl_minutes > 8.3:
##                                         :...total_night_calls <= 68: no (33.6)
##                                             total_night_calls > 68:
##                                             :...total_night_minutes <= 119.5: no (26.5
)
##                                                 total_night_minutes > 119.5:
##                                                 :...account_length > 146:
##                                                     :...state in {CA,CO,GA,ID,IL,
##                                                     :   :         KY,ME,MN,MO,MS,
##                                                     :   :         NC,ND,NM,NV,OH,
##                                                     :   :         PA,SD,TN,TX,UT,
##                                                     :   :         VA}: no (57.6)
##                                                     :   state in {DC,IN,LA,MD,MI,
##                                                     :             MT,NE,NY,WA,WV,
##                                                     :             WY}: yes (120.6/38)
##                                                     account_length <= 146:
##                                                     :...state in {LA,MD,ME,MI,MO,
##                                                         :         MS,NY,SD,
##                                                         :         WV}: no (123.2)
##                                                         state in {CA,CO,DC,GA,ID,
##                                                         :         IL,IN,KY,MN,MT,
##                                                         :         NC,ND,NE,NM,NV,
##                                                         :         OH,PA,TN,TX,UT,
##                                                         :         VA,WA,WY}: [S1]
##
## SubTree [S1]
##
## account_length > 134: no (28.1)
## account_length <= 134:
## :...total_intl_calls <= 1: yes (51.7/19.8)
##     total_intl_calls > 1:
##     :...total_night_calls > 127: no (25.5)
##         total_night_calls <= 127:
##         :...state in {GA,KY,NC}: no (56.5)
##             state in {CA,CO,DC,ID,IL,IN,MN,MT,ND,NE,NM,NV,OH,PA,TN,TX,UT,VA,WA,
##             :         WY}:
##             :...total_intl_minutes > 13.5: no (43.7/4.9)
##                 total_intl_minutes <= 13.5:
##                 :...total_intl_charge > 3.62: yes (21.1/1.3)
##                     total_intl_charge <= 3.62:
##                     :...total_night_calls <= 77: yes (54.7/20.2)
##                         total_night_calls > 77:
##                         :...state in {DC,NM,TN,WA,WY}: no (50.8)
##                             state in {CA,CO,ID,IL,IN,MN,MT,ND,NE,NV,OH,PA,TX,
##                             :         UT,VA}:
```

```
##                             :...total_night_calls <= 85: no (15.5)
##                                 total_night_calls > 85:
##                                 :...total_eve_minutes > 274.8: no (15.3)
##                                     total_eve_minutes <= 274.8:
##                                     :...total_eve_calls <= 95: no (66.5/12.6)
##                                         total_eve_calls > 95: [S2]
##
## SubTree [S2]
##
## number_vmail_messages > 39: yes (11.6)
## number_vmail_messages <= 39:
## :...total_day_calls <= 79: no (9.3)
##     total_day_calls > 79:
##     :...voice_mail_plan = no: yes (126.1/46.7)
##         voice_mail_plan = yes: no (38.2/11.6)
##
## -----  Trial 6:  -----
##
## Decision tree:
##
## number_customer_service_calls > 3:
## :...total_day_minutes <= 160: yes (140.6/20.1)
## :   total_day_minutes > 160:
## :   :...total_intl_calls <= 1: yes (26.1/1.5)
## :       total_intl_calls > 1:
## :       :...account_length > 176: no (15.1)
## :           account_length <= 176:
## :           :...state in {AR,PA,SD}: yes (0)
## :               state in {AL,AZ,CA,DC,DE,FL,HI,KY,LA,NE,NM,OK,RI,SC,TN,VA,VT,
## :               :         WI}: no (60.4/0.2)
## :               state in {AK,CO,CT,GA,IA,ID,IL,IN,KS,MA,MD,ME,MI,MN,MO,MS,MT,
## :               :         NC,ND,NH,NJ,NV,NY,OH,OR,TX,UT,WA,WV,WY}:
## :               :...account_length > 154: yes (18.4)
## :                   account_length <= 154:
## :                   :...account_length <= 135: yes (174.9/55.7)
## :                       account_length > 135: no (32.2/6.5)
## number_customer_service_calls <= 3:
## :...international_plan = yes:
##     :...total_intl_calls <= 2: yes (42.6)
##     :   total_intl_calls > 2:
##     :   :...total_intl_minutes > 13.1: yes (31.4)
##     :       total_intl_minutes <= 13.1:
##     :       :...total_day_minutes <= 199.2: no (73)
##     :           total_day_minutes > 199.2: yes (114.3/42)
##     international_plan = no:
##     :...total_day_minutes <= 221.9: no (1548.3/295.8)
##         total_day_minutes > 221.9:
```

```
##         :...voice_mail_plan = yes:
##             :...state in {AK,AL,AR,AZ,CA,CO,CT,DC,DE,GA,HI,IA,ID,IL,IN,KS,KY,
##             :   :         LA,MD,ME,MI,MN,MO,MS,MT,NC,ND,NE,NJ,NM,NY,OH,OK,OR,
##             :   :         PA,RI,SC,SD,TN,TX,UT,VA,VT,WA,WI,WV,
##             :   :         WY}: no (125)
##             :   state in {FL,MA,NH,NV}: yes (43.2/7.4)
##             voice_mail_plan = no:
##             :...total_eve_charge <= 12.35: no (69.4/4.7)
##                 total_eve_charge > 12.35:
##                 :...total_day_minutes > 276.2: yes (55.5/5.2)
##                     total_day_minutes <= 276.2:
##                     :...total_intl_minutes > 14.7: yes (32.5/3.9)
##                         total_intl_minutes <= 14.7:
##                         :...total_intl_calls <= 1: no (26.5/1)
##                             total_intl_calls > 1:
##                             :...total_night_charge <= 9.03: no (145.9/35.1)
##                                 total_night_charge > 9.03:
##                                 :...total_eve_calls > 121: yes (46.1/2.5)
##                                     total_eve_calls <= 121:
##                                     :...total_day_calls <= 82: no (26.3/1.7)
##                                         total_day_calls > 82: yes (152.3/58.2)
##
## -----  Trial 7:  -----
##
## Decision tree:
##
## number_customer_service_calls > 4:
## :...total_day_minutes <= 138.6: yes (31)
## :   total_day_minutes > 138.6:
## :   :...total_intl_calls <= 3: yes (77.3/17.4)
## :       total_intl_calls > 3: no (98.9/30.8)
## number_customer_service_calls <= 4:
## :...total_intl_minutes > 13.4:
##     :...international_plan = yes: yes (30.7)
##     :   international_plan = no:
##     :   :...state in {AK,AL,AR,AZ,CA,CO,FL,GA,HI,IA,ID,IL,IN,KY,LA,MD,ME,MI,MN,
##     :       :         MO,MS,ND,NH,NV,OH,OK,OR,RI,SD,VA,VT,WI,
##     :       :         WY}: no (95/0.8)
##     :       state in {CT,DC,DE,KS,MA,MT,NC,NE,NJ,NM,NY,PA,SC,TN,TX,UT,WA,WV}:
##     :       :...total_intl_calls <= 7: yes (165/48.1)
##     :           total_intl_calls > 7: no (14.2/1.6)
##     total_intl_minutes <= 13.4:
##     :...total_intl_minutes <= 4: no (41.5/1.6)
##         total_intl_minutes > 4:
##         :...total_day_calls <= 69:
##             :...state in {AK,AR,CO,DE,FL,GA,HI,IL,IN,KS,MA,MN,MT,NC,NJ,NV,OR,
##             :   :         SD,TX,UT,WA,WY}: yes (111.4/27)
```

```
##             :   state in {AL,AZ,CA,CT,DC,IA,ID,KY,LA,MD,ME,MI,MO,MS,ND,NE,NH,
##             :             NM,NY,OH,OK,PA,RI,SC,TN,VA,VT,WI,WV}: no (44.4)
##             total_day_calls > 69:
##             :...total_eve_charge > 20.68:
##                 :...total_day_minutes > 213.4:
##                 :   :...voice_mail_plan = no: yes (155.8/29.6)
##                 :   :   voice_mail_plan = yes: no (46.6/8.6)
##                 :   total_day_minutes <= 213.4:
##                 :   :...total_night_minutes <= 203.1: no (112.9/4)
##                 :       total_night_minutes > 203.1:
##                 :       :...state in {AK,AL,AR,AZ,CA,CO,CT,DC,DE,FL,GA,HI,IA,
##                 :           :         ID,IL,IN,KS,KY,LA,MA,MS,NC,ND,NH,NM,OH,
##                 :           :         OK,OR,PA,RI,SD,TN,VT,WA,
##                 :           :         WI}: no (71.4)
##                 :           state in {MD,ME,MI,MN,MO,MT,NE,NJ,NV,NY,SC,TX,UT,
##                 :                     VA,WV,WY}: yes (115.2/37.2)
##                 total_eve_charge <= 20.68:
##                 :...state in {AK,AZ,CO,GA,HI,ID,ME,MO,NC,ND,NE,NH,NM,NV,OK,RI,
##                     :         SC,TX,UT,VA,VT,WV,WY}: no (760.4/99.3)
##                     state in {AL,AR,CA,CT,DC,DE,FL,IA,IL,IN,KS,KY,LA,MA,MD,MI,
##                     :         MN,MS,MT,NJ,NY,OH,OR,PA,SD,TN,WA,WI}:
##                     :...total_intl_calls <= 2:
##                         :...international_plan = yes: yes (15.6)
##                         :   international_plan = no:
##                         :   :...state in {AL,CA,DC,DE,FL,IA,IL,IN,LA,MA,MN,MS,
##                         :       :         TN,WA}: no (51.7/3.3)
##                         :       state in {AR,CT,KS,KY,MD,MI,MT,NJ,NY,OH,OR,PA,
##                         :       :         SD,WI}:
##                         :       :...total_day_calls <= 77: no (12.1)
##                         :           total_day_calls > 77: yes (152.8/59.2)
##                         total_intl_calls > 2:
##                         :...total_day_minutes > 203.5: no (364.9/70.4)
##                             total_day_minutes <= 203.5:
##                             :...number_customer_service_calls > 3: yes (45.4/10.4)
##                                 number_customer_service_calls <= 3:
##                                 :...state in {AL,AR,CT,DE,FL,IA,KY,MD,MI,NJ,NY,
##                                     :         PA,SD,WI}: no (92)
##                                     state in {CA,DC,IL,IN,KS,LA,MA,MN,MS,MT,OH,
##                                     :         OR,TN,WA}:
##                                     :...total_night_calls > 120: no (30.1)
##                                         total_night_calls <= 120:
##                                         :...total_intl_minutes <= 7.8: no (21.4)
##                                             total_intl_minutes > 7.8:
##                                             :...total_eve_calls <= 80: no (17.8)
##                                                 total_eve_calls > 80: [S1]
##
## SubTree [S1]
```

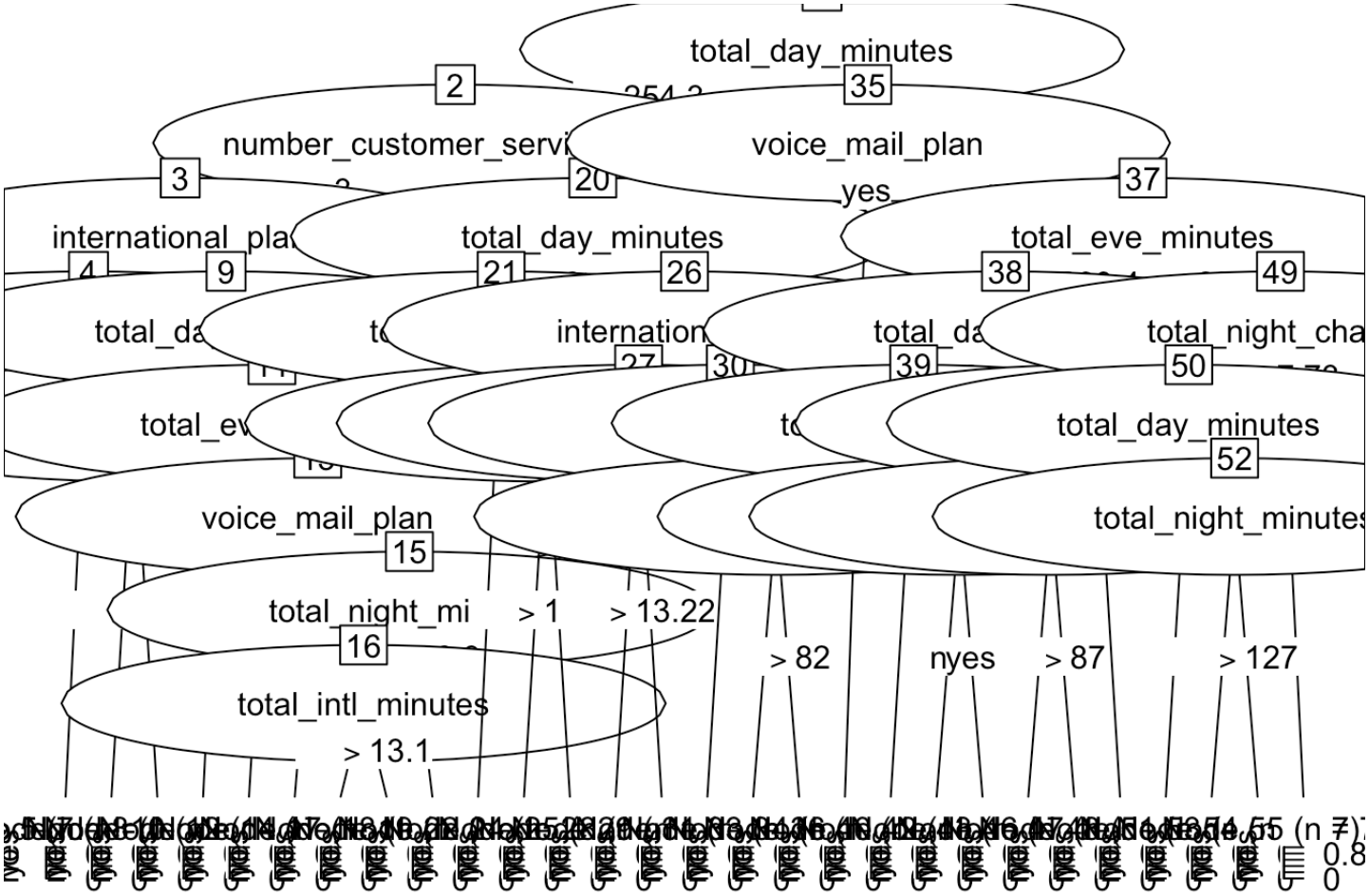
```
##
## total_eve_charge > 19.3: no (13.8/0.7)
## total_eve_charge <= 19.3:
## :...total_intl_minutes <= 12.5: yes (197/66.1)
##     total_intl_minutes > 12.5: no (11.6/0.7)
##
## -----  Trial 8:  -----
##
## Decision tree:
##
## total_day_minutes > 256.5:
## :...voice_mail_plan = yes: no (93.1/20.7)
## :   voice_mail_plan = no:
## :   :...total_eve_charge > 16.09: yes (195.7/21.6)
## :       total_eve_charge <= 16.09:
## :       :...total_day_charge <= 47.04: no (92.6/12.6)
## :           total_day_charge > 47.04: yes (69.9/22)
## total_day_minutes <= 256.5:
## :...number_customer_service_calls > 3:
##     :...total_day_minutes <= 162.8: yes (146/35.8)
##     :   total_day_minutes > 162.8:
##     :   :...total_intl_calls > 6: no (37.8/1.4)
##     :       total_intl_calls <= 6:
##     :       :...total_night_minutes > 303.5: no (15.1)
##     :           total_night_minutes <= 303.5:
##     :           :...total_eve_charge <= 11.48: yes (34.9/6.4)
##     :               total_eve_charge > 11.48:
##     :               :...state in {AK,DC,GA,IA,ID,IL,KS,MD,MN,MO,MS,MT,NC,NH,NJ,
##     :                   :         NY,OH,TX,VT,WA,WY}: yes (152.3/67.1)
##     :                   state in {AL,AR,AZ,CA,CO,CT,DE,FL,HI,IN,KY,LA,MA,ME,MI,
##     :                            ND,NE,NM,NV,OK,OR,PA,RI,SC,SD,TN,UT,VA,WI,
##     :                            WV}: no (79.1)
##     number_customer_service_calls <= 3:
##     :...total_eve_charge <= 14.17: no (383.2/24)
##         total_eve_charge > 14.17:
##         :...international_plan = yes:
##             :...total_intl_calls <= 2: yes (28.8)
##             :   total_intl_calls > 2:
##             :   :...total_intl_minutes <= 13.1: no (132.9/20.4)
##             :       total_intl_minutes > 13.1: yes (19.5)
##             international_plan = no:
##             :...state in {AK,AZ,HI,IA,IL,MA,MD,ME,MO,NH,OK,RI,SC,SD,VT,WI,
##                 :         WY}: no (259.9/2.7)
##                 state in {AL,AR,CA,CO,CT,DC,DE,FL,GA,ID,IN,KS,KY,LA,MI,MN,MS,
##                 :         MT,NC,ND,NE,NJ,NM,NV,NY,OH,OR,PA,TN,TX,UT,VA,WA,WV}:
##                 :...total_night_calls <= 67: no (26.9)
##                     total_night_calls > 67:
```

```
##                     :...total_day_minutes > 198.4:
##                         :...voice_mail_plan = yes: no (81/14.8)
##                         :   voice_mail_plan = no:
##                         :   :...total_eve_minutes > 241.6: yes (153.2/54)
##                         :       total_eve_minutes <= 241.6:
##                         :       :...state in {CA,CO,DC,DE,FL,IN,MN,MS,MT,NC,ND,
##                         :           :         NE,NM,NV,PA,UT,VA,
##                         :           :         WA}: no (84.2)
##                         :           state in {AL,AR,CT,GA,ID,KS,KY,LA,MI,NJ,NY,
##                         :           :         OH,OR,TN,TX,WV}:
##                         :           :...total_day_calls <= 112: yes (138.4/58.5)
##                         :               total_day_calls > 112: no (16.5)
##                         total_day_minutes <= 198.4:
##                         :...state in {AL,AR,CA,CT,DE,FL,GA,ID,KS,KY,LA,MN,ND,
##                             :         NJ,NV,OR,VA}: no (250.9)
##                             state in {CO,DC,IN,MI,MS,MT,NC,NE,NM,NY,OH,PA,TN,
##                             :         TX,UT,WA,WV}:
##                             :...total_intl_minutes <= 7.8: no (44.8)
##                                 total_intl_minutes > 7.8:
##                                 :...account_length <= 57: no (40.4)
##                                     account_length > 57:
##                                     :...account_length <= 61: yes (23.4/3.3)
##                                         account_length > 61:
##                                         :...total_eve_charge > 23.3: no (29)
##                                             total_eve_charge <= 23.3: [S1]
##
## SubTree [S1]
##
## total_night_calls <= 86: no (58.3/4.8)
## total_night_calls > 86:
## :...total_night_charge <= 7.75: yes (81.1/26)
##     total_night_charge > 7.75: no (217.2/65.2)
##
## -----  Trial 9:  -----
##
## Decision tree:
##
## total_day_charge > 43.04:
## :...total_eve_charge <= 11.77: no (57.8/3.3)
## :   total_eve_charge > 11.77:
## :   :...total_night_charge <= 7.25: no (115.3/26.8)
## :       total_night_charge > 7.25:
## :       :...voice_mail_plan = no: yes (244.9/48.6)
## :           voice_mail_plan = yes: no (64.3/19.3)
## total_day_charge <= 43.04:
## :...international_plan = yes:
##     :...total_intl_calls <= 2: yes (55.7)
```

```
##     :   total_intl_calls > 2:
##     :   :...total_intl_minutes > 13.1: yes (44.9)
##     :       total_intl_minutes <= 13.1:
##     :       :...total_eve_charge <= 27.39: no (164.1/17.2)
##     :           total_eve_charge > 27.39: yes (14.7/0.6)
##     international_plan = no:
##     :...number_customer_service_calls > 3:
##         :...total_day_minutes > 180.8: no (237.1/41.9)
##         :   total_day_minutes <= 180.8:
##         :   :...state in {AK,AR,CO,CT,DE,ID,IL,IN,KS,LA,MD,MN,MO,MS,MT,NC,ND,
##         :       :         NH,NJ,NM,NV,OK,OR,PA,RI,SD,TN,UT,WA}: yes (64.2)
##         :       state in {AL,AZ,CA,DC,FL,GA,HI,IA,KY,MA,ME,MI,NE,NY,OH,SC,TX,
##         :       :         VA,VT,WI,WV,WY}:
##         :       :...total_night_charge <= 6.74: yes (10.7)
##         :           total_night_charge > 6.74: no (145.8/37.1)
##         number_customer_service_calls <= 3:
##         :...total_eve_charge <= 14.19: no (258.8)
##             total_eve_charge > 14.19:
##             :...total_day_minutes <= 179.2: no (599.2/29.4)
##                 total_day_minutes > 179.2:
##                 :...total_night_charge <= 8.28: no (254.4/17.9)
##                     total_night_charge > 8.28:
##                     :...voice_mail_plan = yes: no (74.5)
##                         voice_mail_plan = no:
##                         :...total_eve_charge > 20.59:
##                             :...state in {AK,AL,AR,CO,CT,DC,DE,FL,GA,HI,IA,ID,
##                             :   :         IL,IN,KS,KY,LA,MA,MD,ME,MI,MN,MO,MT,
##                             :   :         NC,NH,NJ,NM,OH,OK,OR,PA,RI,SC,SD,TN,
##                             :   :         VA,VT,WI,WV,WY}: no (153.8/39.9)
##                             :   state in {AZ,CA,MS,ND,NE,NV,NY,TX,UT,
##                             :             WA}: yes (50.4/0.3)
##                             total_eve_charge <= 20.59:
##                             :...total_eve_calls > 121: yes (42.3/17.4)
##                                 total_eve_calls <= 121:
##                                 :...total_day_minutes <= 183.2: yes (19.7/5.7)
##                                     total_day_minutes > 183.2: no (294.5/33.9)
##
##
## Evaluation on training data (3000 cases):
##
## Trial        Decision Tree
## -----      ----------------
##    Size      Errors
##
##    0     28  122( 4.1%)
##    1     30  363(12.1%)
##    2     34  391(13.0%)
```

```
##    3     34  271( 9.0%)
##    4     22  304(10.1%)
##    5     44  298( 9.9%)
##    6     22  268( 8.9%)
##    7     29  533(17.8%)
##    8     29  258( 8.6%)
##    9     21  213( 7.1%)
## boost             50( 1.7%)   <<
##
##
##     (a)   (b)    <-classified as
##    ----  ----
##    2563     2    (a): class no
##      48   387    (b): class yes
##
##
##  Attribute usage:
##
##  100.00% international_plan
##  100.00% total_day_minutes
##  100.00% total_day_charge
##  100.00% total_eve_charge
##  100.00% number_customer_service_calls
##   98.97% state
##   97.13% total_intl_minutes
##   90.23% total_day_calls
##   78.47% total_night_charge
##   74.53% total_intl_calls
##   70.40% total_eve_minutes
##   63.27% total_night_calls
##   58.60% voice_mail_plan
##   52.63% account_length
##   47.67% total_night_minutes
##   47.20% number_vmail_messages
##   34.43% area_code
##   29.93% total_eve_calls
##   10.13% total_intl_charge
##
##
## Time: 0.4 secs
```

```
    # simply using the summary attribute shows us favorable confusion matrix
plot(ChurnTree3)
```




```
    # plotting looks messy, but lets see if this is an accurate predictor

# Predict ChrunTree3
Churn_Predict3<-predict(ChurnTree3,churn_testing)

# Assess Prediction with Confusion Matrix
CrossTable(churn_testing$churn,Churn_Predict3,prop.chisq=FALSE,prop.c=FALSE,
           prop.r=FALSE,dnn=c('actual','predicted'))
```

```
##
##
##    Cell Contents
## |-------------------------|
## |                       N |
## |         N / Table Total |
## |-------------------------|
##
##
## Total Observations in Table:  2000
##
##
##              | predicted
##       actual |        no |       yes | Row Total |
## -------------|-----------|-----------|-----------|
##           no |      1714 |        14 |      1728 |
##              |     0.857 |     0.007 |           |
## -------------|-----------|-----------|-----------|
##          yes |        71 |       201 |       272 |
##              |     0.035 |     0.101 |           |
## -------------|-----------|-----------|-----------|
## Column Total |      1785 |       215 |      2000 |
## -------------|-----------|-----------|-----------|
##
##
```

```
    # Out of the 2000 churn test group, my model correctly predicted that 1714 didn't churn and 201 did churn
    # Resulting in an accuracy of .857+.101 = 95.8% and an error of 4.2%
    # This is the best accuracy yet! In fact it is an increase of 2.4% over our best model.
    # This tree output is messy, but with an increase of 5.2% accuracy over the easy to read model, is it worth it to keep?
```