Telecom Churn Case Study BY: P.V. S. SREENATH

Problem Statement

Business Problem Overview

In the telecom industry, customers are able to choose from multiple service providers and actively switch from one operator to another. In this highly competitive market, the telecommunications industry experiences an average of 15-25% annual churn rate. Given the fact that it costs 5-10 times more to acquire a new customer than to retain an existing one, customer retention has now become even more important than customer acquisition.

For many incumbent operators, retaining high profitable customers is the number one business goal.

To reduce customer churn, telecom companies need to predict which customers are at high risk of churn.

In this project, we will analyse customer-level data of a leading telecom firm, build predictive models to identify customers at high risk of churn and identify the main indicators of churn.

Understanding and Defining Churn

There are two main models of payment in the telecom industry - postpaid (customers pay a monthly/annual bill after using the services) and prepaid (customers pay/recharge with a certain amount in advance and then use the services).

In the postpaid model, when customers want to switch to another operator, they usually inform the existing operator to terminate the services, and we directly know that this is an instance of churn.

However, in the prepaid model, customers who want to switch to another network can simply stop using the services without any notice, and it is hard to know whether someone has actually churned or is simply not using the services temporarily (e.g. someone may be on a trip abroad for a month or two and then intend to resume using the services again).

Thus, churn prediction is usually more critical (and non-trivial) for prepaid customers, and the term ‘churn’ should be defined carefully. Also, prepaid is the most common model in India and southeast Asia, while postpaid is more common in Europe in North America.

This project is based on the Indian and Southeast Asian market.

Definitions of Churn

There are various ways to define churn, such as:

Revenue-based churn: Customers who have not utilised any revenue-generating facilities such as mobile internet, outgoing calls, SMS etc. over a given period of time. One could also use aggregate metrics such as 'customers who have generated less than INR 4 per month in total/average/median revenue'.

The main shortcoming of this definition is that there are customers who only receive calls/SMSes from their wage-earning counterparts, i.e. they don't generate revenue but use the services. For example, many users in rural areas only receive calls from their wage-earning siblings in urban areas.

Usage-based churn: Customers who have not done any usage, either incoming or outgoing - in terms of calls, internet etc. over a period of time.

A potential shortcoming of this definition is that when the customer has stopped using the services for a while, it may be too late to take any corrective actions to retain them. For e.g., if we define churn based on a 'two-months zero usage' period, predicting churn could be useless since by that time the customer would have already switched to another operator.

In this project, we will use the **usage-based** definition to define churn.

High-value Churn

In the Indian and the southeast Asian market, approximately 80% of revenue comes from the top 20% customers (called high-value customers). Thus, if we can reduce churn of the high-value customers, we will be able to reduce significant revenue leakage.

In this project, we will define high-value customers based on a certain metric (mentioned later below) and predict churn only on high-value customers.

Understanding the Business Objective and the Data

The dataset contains customer-level information for a span of four consecutive months - June, July, August and September. The months are encoded as 6, 7, 8 and 9, respectively.

The business objective is to predict the churn in the last (i.e. the ninth) month using the data (features) from the first three months. To do this task well, understanding the typical customer behaviour during churn will be helpful.

Understanding Customer Behaviour During Churn

Customers usually do not decide to switch to another competitor instantly, but rather over a period of time (this is especially applicable to high-value customers). In churn prediction, we assume that there are three phases of customer lifecycle :

1. **The 'good' phase:** In this phase, the customer is happy with the service and behaves as usual.

2. **The 'action' phase:** The customer experience starts to sore in this phase, for e.g. he/she gets a compelling offer from a competitor, faces unjust charges, becomes unhappy with service quality etc. In this phase, the customer usually shows different

behaviour than the 'good' months. Also, it is crucial to identify high-churn-risk customers in this phase, since some corrective actions can be taken at this point (such as matching the competitor's offer/improving the service quality etc.)

3. **The 'churn' phase:** In this phase, the customer is said to have churned. We define churn based on this phase. Also, it is important to note that at the time of prediction (i.e. the action months), this data is not available to us for prediction. Thus, after tagging churn as 1/0 based on this phase, we discard all data corresponding to this phase.

In this case, since we are working over a four-month window, the first two months are the 'good' phase, the third month is the 'action' phase, while the fourth month is the 'churn' phase.

Dataset and Data Dictionary

The dataset can be downloaded from here.

Data dictionary is uploaded. The data dictionary contains meanings of abbreviations. Some frequent ones are loc (local), IC (incoming), OG (outgoing), T2T (telecom operator to telecom operator), T2O (telecom operator to another operator), RECH (recharge) etc.

The attributes containing 6, 7, 8, 9 as suffixes imply that those correspond to the months 6, 7, 8, 9 respectively.

Data Preparation

The following data preparation steps are crucial for this problem:

1. **Derive new features** This is one of the most important parts of data preparation since good features are often the differentiators between good and bad models. We will use our business understanding to derive features that we think could be important indicators of churn.

2. **Filter high-value customers** As mentioned above, we need to predict churn only for the high-value customers. Define high-value customers as follows: Those who have recharged with an amount more than or equal to X, where X is the 70th percentile of the average recharge amount in the first two months (the good phase).

3. **Tag churners and remove attributes of the churn phase** Now tag the churned customers (churn=1, else 0) based on the fourth month as follows: Those who have not made any calls (either incoming or outgoing) AND have not used mobile internet even once in the churn phase. The attributes we need to use to tag churners are:

- total_ic_mou_9
- total_og_mou_9
- vol_2g_mb_9
- vol_3g_mb_9

After tagging churners, we need to remove all the attributes corresponding to the churn phase (all attributes having ' _9', etc. in their names).

Modelling

Build models to predict churn. The predictive model that we are going to build will serve two purposes:

1. It will be used to predict whether a high-value customer will churn or not, in near future (i.e. churn phase). By knowing this, the company can take action steps such as providing special plans, discounts on recharge etc.

2. It will be used to identify important variables that are strong predictors of churn. These variables may also indicate why customers choose to switch to other networks.

In some cases, both of the above-stated goals can be achieved by a single machine learning model. But here, we have a large number of attributes, and thus we should try using a dimensionality reduction technique such as PCA and then build a predictive model. After PCA, we can use any classification model.

Also, since the rate of churn is typically low (about 5-10%, this is called class-imbalance) - we will try using techniques to handle class imbalance.

We can take the following suggestive steps to build the model:

1. Preprocess data (convert columns to appropriate formats, handle missing values, etc.)
2. Conduct appropriate exploratory analysis to extract useful insights (whether directly useful for business or for eventual modelling/feature engineering).
3. Derive new features.
4. Reduce the number of variables using PCA.
5. Train a variety of models, tune model hyperparameters, etc. (handle class imbalance using appropriate techniques).
6. Evaluate the models using appropriate evaluation metrics. Note that it is more important to identify churners than the non-churners accurately - choose an appropriate evaluation metric which reflects this business goal.
7. Finally, choose a model based on some evaluation metric.

The above model will only be able to achieve one of the two goals - to predict customers who will churn. We can't use the above model to identify the important features for churn. That's because PCA usually creates components which are not easy to interpret.

Therefore, we will build another model with the main objective of identifying important predictor attributes which help the business understand indicators of churn. A good choice to identify important variables is a logistic regression model or a model from the tree family. In case of logistic regression, we will make sure to handle multi-collinearity.

After identifying important predictors, display them visually - we can use plots, summary tables etc. - whatever we think best conveys the importance of features.

Finally, recommend strategies to manage customer churn based on our observations.

Problem statement:-

To reduce customer churn, telecom companies need to predict which customers are at high risk of churn. In this project, we will analyse customer-level data of a leading telecom firm, build predictive models to identify customers at high risk of churn and identify the main indicators of churn.

Retaining high profitable customers is the main business goal here.

Steps:-

1. Reading, understanding and visualising the data
2. Preparing the data for modelling
3. Building the model
4. Evaluate the model

```
# Importing the libraries
import pandas as pd
import numpy as np

import matplotlib.pyplot as plt
%matplotlib inline
import seaborn as sns

import warnings
warnings.filterwarnings('ignore')

pd.set_option('display.max_columns', 500)
```

Reading and understanding the data

```
# Reading the dataset
df = pd.read_csv('telecom_churn_data.csv')
df.head()
```

```
   mobile_number  circle_id  loc_og_t2o_mou  std_og_t2o_mou  
loc_ic_t2o_mou  \
0     7000842753        109             0.0             0.0  
0.0
1     7001865778        109             0.0             0.0  
0.0
2     7001625959        109             0.0             0.0  
0.0
3     7001204172        109             0.0             0.0  
0.0
4     7000142493        109             0.0             0.0  
0.0
```

```
  last_date_of_month_6 last_date_of_month_7 last_date_of_month_8  \
0            6/30/2014            7/31/2014            8/31/2014   
1            6/30/2014            7/31/2014            8/31/2014   
2            6/30/2014            7/31/2014            8/31/2014   
3            6/30/2014            7/31/2014            8/31/2014   
4            6/30/2014            7/31/2014            8/31/2014   

  last_date_of_month_9   arpu_6   arpu_7   arpu_8   arpu_9  
onnet_mou_6  \
0            9/30/2014  197.385  214.816  213.803   21.100  
NaN   
1            9/30/2014   34.047  355.074  268.321   86.285  
24.11   
2            9/30/2014  167.690  189.058  210.226  290.714  
11.54   
3            9/30/2014  221.338  251.102  508.054  389.500  
99.91   
4            9/30/2014  261.636  309.876  238.174  163.426  
50.31   

   onnet_mou_7  onnet_mou_8  onnet_mou_9  offnet_mou_6  
offnet_mou_7  \
0          NaN         0.00          NaN           NaN           NaN   

1        78.68         7.68        18.34         15.74         99.84   

2        55.24        37.26        74.81        143.33        220.59   

3        54.39       310.98       241.71        123.31        109.01   

4       149.44        83.89        58.78         76.96         91.88   


   offnet_mou_8  offnet_mou_9  roam_ic_mou_6  roam_ic_mou_7  
roam_ic_mou_8  \
0          0.00           NaN            NaN            NaN  
0.00   
1        304.76         53.76            0.0           0.00  
0.00   
2        208.36        118.91            0.0           0.00  
0.00   
3         71.68        113.54            0.0          54.86  
44.38   
4        124.26         45.81            0.0           0.00  
0.00   

   roam_ic_mou_9  roam_og_mou_6  roam_og_mou_7  roam_og_mou_8  
roam_og_mou_9  \
0            NaN            NaN            NaN           0.00  
NaN   
```

```
1           0.00             0.0            0.00            0.00
0.00
2          38.49             0.0            0.00            0.00
70.94
3           0.00             0.0           28.09           39.04
0.00
4           0.00             0.0            0.00            0.00
0.00

   loc_og_t2t_mou_6  loc_og_t2t_mou_7  loc_og_t2t_mou_8
loc_og_t2t_mou_9  \
0               NaN               NaN              0.00
NaN
1             23.88             74.56              7.68
18.34
2              7.19             28.74             13.58
14.39
3             73.68             34.81             10.61
15.49
4             50.31            149.44             83.89
58.78

   loc_og_t2m_mou_6  loc_og_t2m_mou_7  loc_og_t2m_mou_8
loc_og_t2m_mou_9  \
0               NaN               NaN              0.00
NaN
1             11.51             75.94            291.86
53.76
2             29.34             16.86             38.46
28.16
3            107.43             83.21             22.46
65.46
4             67.64             91.88            124.26
37.89

   loc_og_t2f_mou_6  loc_og_t2f_mou_7  loc_og_t2f_mou_8
loc_og_t2f_mou_9  \
0               NaN               NaN              0.00
NaN
1              0.00              0.00              0.00
0.00
2             24.11             21.79             15.61
22.24
3              1.91              0.65              4.91
2.06
4              0.00              0.00              0.00
1.93

   loc_og_t2c_mou_6  loc_og_t2c_mou_7  loc_og_t2c_mou_8
loc_og_t2c_mou_9  \
```

```
0                NaN                NaN                0.00
NaN
1                0.0               2.91                0.00
0.00
2                0.0             135.54               45.76
0.48
3                0.0               0.00                0.00
0.00
4                0.0               0.00                0.00
0.00

   loc_og_mou_6  loc_og_mou_7  loc_og_mou_8  loc_og_mou_9
std_og_t2t_mou_6  \
0           NaN           NaN          0.00           NaN
NaN
1         35.39        150.51        299.54         72.11
0.23
2         60.66         67.41         67.66         64.81
4.34
3        183.03        118.68         37.99         83.03
26.23
4        117.96        241.33        208.16         98.61
0.00

   std_og_t2t_mou_7  std_og_t2t_mou_8  std_og_t2t_mou_9
std_og_t2m_mou_6  \
0               NaN              0.00               NaN
NaN
1              4.11              0.00              0.00
0.00
2             26.49             22.58              8.76
41.81
3             14.89            289.58            226.21
2.99
4              0.00              0.00              0.00
9.31

   std_og_t2m_mou_7  std_og_t2m_mou_8  std_og_t2m_mou_9
std_og_t2f_mou_6  \
0               NaN              0.00               NaN
NaN
1              0.46              0.13              0.00
0.00
2             67.41             75.53              9.28
1.48
3              1.73              6.53              9.99
0.00
4              0.00              0.00              0.00
0.00
```

```
   std_og_t2f_mou_7  std_og_t2f_mou_8  std_og_t2f_mou_9
std_og_t2c_mou_6  \
0               NaN              0.00               NaN
NaN
1              0.00              0.00               0.0
0.0
2             14.76             22.83               0.0
0.0
3              0.00              0.00               0.0
0.0
4              0.00              0.00               0.0
0.0

   std_og_t2c_mou_7  std_og_t2c_mou_8  std_og_t2c_mou_9  std_og_mou_6
\
0               NaN               0.0               NaN           NaN

1               0.0               0.0               0.0          0.23

2               0.0               0.0               0.0         47.64

3               0.0               0.0               0.0         29.23

4               0.0               0.0               0.0          9.31


   std_og_mou_7  std_og_mou_8  std_og_mou_9  isd_og_mou_6
isd_og_mou_7  \
0           NaN          0.00           NaN           NaN
NaN
1          4.58          0.13          0.00           0.0
0.0
2        108.68        120.94         18.04           0.0
0.0
3         16.63        296.11        236.21           0.0
0.0
4          0.00          0.00          0.00           0.0
0.0

   isd_og_mou_8  isd_og_mou_9  spl_og_mou_6  spl_og_mou_7
spl_og_mou_8  \
0           0.0           NaN           NaN           NaN
0.00
1           0.0           0.0          4.68         23.43
12.76
2           0.0           0.0         46.56        236.84
96.84
3           0.0           0.0         10.96          0.00
18.09
4           0.0           0.0          0.00          0.00
```

```
0.00

   spl_og_mou_9  og_others_6  og_others_7  og_others_8  og_others_9  \
0           NaN          NaN          NaN          0.0          NaN
1          0.00         0.00          0.0          0.0          0.0
2         42.08         0.45          0.0          0.0          0.0
3         43.29         0.00          0.0          0.0          0.0
4          5.98         0.00          0.0          0.0          0.0

   total_og_mou_6  total_og_mou_7  total_og_mou_8  total_og_mou_9  \
0            0.00            0.00            0.00            0.00
1           40.31          178.53          312.44           72.11
2          155.33          412.94          285.46          124.94
3          223.23          135.31          352.21          362.54
4          127.28          241.33          208.16          104.59

   loc_ic_t2t_mou_6  loc_ic_t2t_mou_7  loc_ic_t2t_mou_8
loc_ic_t2t_mou_9  \
0               NaN               NaN              0.16
NaN
1              1.61             29.91             29.23
116.09
2            115.69             71.11             67.46
148.23
3             62.08             19.98              8.04
41.73
4            105.68             88.49            233.81
154.56

   loc_ic_t2m_mou_6  loc_ic_t2m_mou_7  loc_ic_t2m_mou_8
loc_ic_t2m_mou_9  \
0               NaN               NaN              4.13
NaN
1             17.48             65.38            375.58
56.93
2             14.38             15.44             38.89
38.98
3            113.96             64.51             20.28
52.86
4            106.84            109.54            104.13
48.24

   loc_ic_t2f_mou_6  loc_ic_t2f_mou_7  loc_ic_t2f_mou_8
loc_ic_t2f_mou_9  \
0               NaN               NaN              1.15
NaN
1              0.00              8.93              3.61
0.00
2             99.48            122.29             49.63
158.19
```

```
3              57.43              27.09              19.84
65.59
4               1.50               0.00               0.00
0.00

   loc_ic_mou_6  loc_ic_mou_7  loc_ic_mou_8  loc_ic_mou_9
std_ic_t2t_mou_6  \
0           NaN           NaN          5.44           NaN
NaN
1         19.09        104.23        408.43        173.03
0.00
2        229.56        208.86        155.99        345.41
72.41
3        233.48        111.59         48.18        160.19
43.48
4        214.03        198.04        337.94        202.81
0.00

   std_ic_t2t_mou_7  std_ic_t2t_mou_8  std_ic_t2t_mou_9
std_ic_t2m_mou_6  \
0               NaN              0.00               NaN
NaN
1              0.00              2.35              0.00
5.90
2             71.29             28.69             49.44
45.18
3             66.44              0.00            129.84
1.33
4              0.00              0.86              2.31
1.93

   std_ic_t2m_mou_7  std_ic_t2m_mou_8  std_ic_t2m_mou_9
std_ic_t2f_mou_6  \
0               NaN              0.00               NaN
NaN
1              0.00             12.49             15.01
0.00
2            177.01            167.09            118.18
21.73
3             38.56              4.94             13.98
1.18
4              0.25              0.00              0.00
0.00

   std_ic_t2f_mou_7  std_ic_t2f_mou_8  std_ic_t2f_mou_9
std_ic_t2o_mou_6  \
0               NaN              0.00               NaN
NaN
1              0.00              0.00              0.00
0.0
```

```
2              58.34              43.23              3.86
0.0
3               0.00               0.00              0.00
0.0
4               0.00               0.00              0.00
0.0

   std_ic_t2o_mou_7  std_ic_t2o_mou_8  std_ic_t2o_mou_9  std_ic_mou_6
\
0               NaN               0.0               NaN           NaN

1               0.0               0.0               0.0          5.90

2               0.0               0.0               0.0        139.33

3               0.0               0.0               0.0         45.99

4               0.0               0.0               0.0          1.93


   std_ic_mou_7  std_ic_mou_8  std_ic_mou_9  total_ic_mou_6
total_ic_mou_7  \
0           NaN          0.00           NaN            0.00
0.00
1          0.00         14.84         15.01           26.83
104.23
2        306.66        239.03        171.49          370.04
519.53
3        105.01          4.94        143.83          280.08
216.61
4          0.25          0.86          2.31          216.44
198.29

   total_ic_mou_8  total_ic_mou_9  spl_ic_mou_6  spl_ic_mou_7
spl_ic_mou_8  \
0            5.44            0.00           NaN           NaN
0.0
1          423.28          188.04          0.00           0.0
0.0
2          395.03          517.74          0.21           0.0
0.0
3           53.13          305.38          0.59           0.0
0.0
4          338.81          205.31          0.00           0.0
0.0

   spl_ic_mou_9  isd_ic_mou_6  isd_ic_mou_7  isd_ic_mou_8
isd_ic_mou_9  \
0           NaN           NaN           NaN           0.0
NaN
```

```
1          0.00          1.83          0.00            0.0
0.00
2          0.45          0.00          0.85            0.0
0.01
3          0.55          0.00          0.00            0.0
0.00
4          0.18          0.00          0.00            0.0
0.00

   ic_others_6  ic_others_7  ic_others_8  ic_others_9
total_rech_num_6  \
0          NaN          NaN          0.0          NaN
4
1         0.00         0.00          0.0         0.00
4
2         0.93         3.14          0.0         0.36
5
3         0.00         0.00          0.0         0.80
10
4         0.48         0.00          0.0         0.00
5

   total_rech_num_7  total_rech_num_8  total_rech_num_9
total_rech_amt_6  \
0                 3                 2                 6
362
1                 9                11                 5
74
2                 4                 2                 7
168
3                11                18                14
230
4                 6                 3                 4
196

   total_rech_amt_7  total_rech_amt_8  total_rech_amt_9
max_rech_amt_6  \
0               252               252                 0
252
1               384               283               121
44
2               315               116               358
86
3               310               601               410
60
4               350               287               200
56

   max_rech_amt_7  max_rech_amt_8  max_rech_amt_9 date_of_last_rech_6
\
```

```
0            252             252               0         6/21/2014

1            154              65              50         6/29/2014

2            200              86             100         6/17/2014

3             50              50              50         6/28/2014

4            110             110              50         6/26/2014


  date_of_last_rech_7 date_of_last_rech_8 date_of_last_rech_9  \
0           7/16/2014            8/8/2014           9/28/2014
1           7/31/2014           8/28/2014           9/30/2014
2           7/24/2014           8/14/2014           9/29/2014
3           7/31/2014           8/31/2014           9/30/2014
4           7/28/2014            8/9/2014           9/28/2014

   last_day_rch_amt_6  last_day_rch_amt_7  last_day_rch_amt_8  \
0                 252                 252                 252
1                  44                  23                  30
2                   0                 200                  86
3                  30                  50                  50
4                  50                 110                 110

   last_day_rch_amt_9 date_of_last_rech_data_6
date_of_last_rech_data_7  \
0                   0                6/21/2014
7/16/2014
1                   0                      NaN
7/25/2014
2                   0                      NaN
NaN
3                  30                      NaN
NaN
4                  50                 6/4/2014
NaN

  date_of_last_rech_data_8 date_of_last_rech_data_9  total_rech_data_6
\
0                 8/8/2014                      NaN                1.0

1                8/10/2014                      NaN                NaN

2                      NaN                9/17/2014                NaN

3                      NaN                      NaN                NaN

4                      NaN                      NaN                1.0
```

```
   total_rech_data_7  total_rech_data_8  total_rech_data_9  
max_rech_data_6  \
0                1.0                1.0                NaN  
252.0
1                1.0                2.0                NaN  
NaN
2                NaN                NaN                1.0  
NaN
3                NaN                NaN                NaN  
NaN
4                NaN                NaN                NaN  
56.0

   max_rech_data_7  max_rech_data_8  max_rech_data_9  count_rech_2g_6  
\
0            252.0            252.0              NaN              0.0   

1            154.0             25.0              NaN              NaN   

2              NaN              NaN             46.0              NaN   

3              NaN              NaN              NaN              NaN   

4              NaN              NaN              NaN              1.0   


   count_rech_2g_7  count_rech_2g_8  count_rech_2g_9  count_rech_3g_6  
\
0              0.0              0.0              NaN              1.0   

1              1.0              2.0              NaN              NaN   

2              NaN              NaN              1.0              NaN   

3              NaN              NaN              NaN              NaN   

4              NaN              NaN              NaN              0.0   


   count_rech_3g_7  count_rech_3g_8  count_rech_3g_9  
av_rech_amt_data_6  \
0              1.0              1.0              NaN  
252.0
1              0.0              0.0              NaN  
NaN
2              NaN              NaN              0.0  
NaN
3              NaN              NaN              NaN  
NaN
4              NaN              NaN              NaN  
56.0
```

```
   av_rech_amt_data_7  av_rech_amt_data_8  av_rech_amt_data_9
vol_2g_mb_6  \
0               252.0               252.0                 NaN
30.13
1               154.0                50.0                 NaN
0.00
2                 NaN                 NaN                46.0
0.00
3                 NaN                 NaN                 NaN
0.00
4                 NaN                 NaN                 NaN
0.00

   vol_2g_mb_7  vol_2g_mb_8  vol_2g_mb_9  vol_3g_mb_6  vol_3g_mb_7  \
0         1.32         5.75          0.0        83.57       150.76
1       108.07       365.47          0.0         0.00         0.00
2         0.00         0.00          0.0         0.00         0.00
3         0.00         0.00          0.0         0.00         0.00
4         0.00         0.00          0.0         0.00         0.00

   vol_3g_mb_8  vol_3g_mb_9  arpu_3g_6  arpu_3g_7  arpu_3g_8
arpu_3g_9  \
0       109.61         0.00     212.17     212.17     212.17
NaN
1         0.00         0.00        NaN       0.00       0.00
NaN
2         0.00         8.42        NaN        NaN        NaN
2.84
3         0.00         0.00        NaN        NaN        NaN
NaN
4         0.00         0.00       0.00        NaN        NaN
NaN

   arpu_2g_6  arpu_2g_7  arpu_2g_8  arpu_2g_9  night_pck_user_6  \
0     212.17     212.17     212.17        NaN               0.0
1        NaN      28.61       7.60        NaN               NaN
2        NaN        NaN        NaN        0.0               NaN
3        NaN        NaN        NaN        NaN               NaN
4       0.00        NaN        NaN        NaN               0.0

   night_pck_user_7  night_pck_user_8  night_pck_user_9  monthly_2g_6
\
0               0.0               0.0               NaN             0

1               0.0               0.0               NaN             0

2               NaN               NaN               0.0             0

3               NaN               NaN               NaN             0
```

```
4                NaN                NaN                NaN            0

   monthly_2g_7  monthly_2g_8  monthly_2g_9  sachet_2g_6  sachet_2g_7
\
0             0             0             0            0            0

1             1             0             0            0            0

2             0             0             0            0            0

3             0             0             0            0            0

4             0             0             0            1            0

   sachet_2g_8  sachet_2g_9  monthly_3g_6  monthly_3g_7  monthly_3g_8
\
0            0            0             1             1             1

1            2            0             0             0             0

2            0            1             0             0             0

3            0            0             0             0             0

4            0            0             0             0             0

   monthly_3g_9  sachet_3g_6  sachet_3g_7  sachet_3g_8  sachet_3g_9  \
0             0            0            0            0            0
1             0            0            0            0            0
2             0            0            0            0            0
3             0            0            0            0            0
4             0            0            0            0            0

   fb_user_6  fb_user_7  fb_user_8  fb_user_9   aon  aug_vbc_3g
jul_vbc_3g  \
0        1.0        1.0        1.0        NaN   968        30.4
0.0
1        NaN        1.0        1.0        NaN  1006         0.0
0.0
2        NaN        NaN        NaN        1.0  1103         0.0
0.0
3        NaN        NaN        NaN        NaN  2491         0.0
0.0
4        0.0        NaN        NaN        NaN  1526         0.0
0.0

   jun_vbc_3g  sep_vbc_3g
```

```
0      101.20        3.58
1        0.00        0.00
2        4.17        0.00
3        0.00        0.00
4        0.00        0.00
```

```
df.shape
```

```
(99999, 226)
```

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 99999 entries, 0 to 99998
Columns: 226 entries, mobile_number to sep_vbc_3g
dtypes: float64(179), int64(35), object(12)
memory usage: 172.4+ MB
```

```
df.describe()
```

```
       mobile_number  circle_id  loc_og_t2o_mou  std_og_t2o_mou  \
count   9.999900e+04    99999.0         98981.0         98981.0
mean    7.001207e+09      109.0             0.0             0.0
std     6.956694e+05        0.0             0.0             0.0
min     7.000000e+09      109.0             0.0             0.0
25%     7.000606e+09      109.0             0.0             0.0
50%     7.001205e+09      109.0             0.0             0.0
75%     7.001812e+09      109.0             0.0             0.0
max     7.002411e+09      109.0             0.0             0.0

       loc_ic_t2o_mou        arpu_6        arpu_7        arpu_8
arpu_9  \
count         98981.0  99999.000000  99999.000000  99999.000000
99999.000000
mean              0.0    282.987358    278.536648    279.154731
261.645069
std               0.0    328.439770    338.156291    344.474791
341.998630
min               0.0  -2258.709000  -2014.045000   -945.808000  -
1899.505000
25%               0.0     93.411500     86.980500     84.126000
62.685000
50%               0.0    197.704000    191.640000    192.080000
176.849000
75%               0.0    371.060000    365.344500    369.370500
353.466500
max               0.0  27731.088000  35145.834000  33543.624000
38805.617000

        onnet_mou_6   onnet_mou_7   onnet_mou_8   onnet_mou_9
offnet_mou_6  \
```

```
count  96062.000000  96140.000000  94621.000000  92254.000000
96062.000000
mean     132.395875    133.670805    133.018098    130.302327
197.935577
std      297.207406    308.794148    308.951589    308.477668
316.851613
min        0.000000      0.000000      0.000000      0.000000
0.000000
25%        7.380000      6.660000      6.460000      5.330000
34.730000
50%       34.310000     32.330000     32.360000     29.840000
96.310000
75%      118.740000    115.595000    115.860000    112.130000
231.860000
max     7376.710000   8157.780000  10752.560000  10427.460000
8362.360000

       offnet_mou_7  offnet_mou_8  offnet_mou_9  roam_ic_mou_6
roam_ic_mou_7  \
count  96140.000000  94621.000000  92254.000000   96062.000000
96140.000000
mean     197.045133    196.574803    190.337222       9.950013
7.149898
std      325.862803    327.170662    319.396092      72.825411
73.447948
min        0.000000      0.000000      0.000000       0.000000
0.000000
25%       32.190000     31.630000     27.130000       0.000000
0.000000
50%       91.735000     92.140000     87.290000       0.000000
0.000000
75%      226.815000    228.260000    220.505000       0.000000
0.000000
max     9667.130000  14007.340000  10310.760000   13724.380000
15371.040000

       roam_ic_mou_8  roam_ic_mou_9  roam_og_mou_6  roam_og_mou_7  \
count   94621.000000   92254.000000   96062.000000   96140.000000
mean        7.292981       6.343841      13.911337       9.818732
std        68.402466      57.137537      71.443196      58.455762
min         0.000000       0.000000       0.000000       0.000000
25%         0.000000       0.000000       0.000000       0.000000
50%         0.000000       0.000000       0.000000       0.000000
75%         0.000000       0.000000       0.000000       0.000000
max     13095.360000    8464.030000    3775.110000    2812.040000

       roam_og_mou_8  roam_og_mou_9  loc_og_t2t_mou_6
loc_og_t2t_mou_7  \
count   94621.000000   92254.000000      96062.000000
96140.000000
```

```
mean        9.971890       8.555519         47.100763
46.473010
std        64.713221      58.438186        150.856393
155.318705
min         0.000000       0.000000          0.000000
0.000000
25%         0.000000       0.000000          1.660000
1.630000
50%         0.000000       0.000000         11.910000
11.610000
75%         0.000000       0.000000         40.960000
39.910000
max      5337.040000    4428.460000       6431.330000
7400.660000

       loc_og_t2t_mou_8  loc_og_t2t_mou_9  loc_og_t2m_mou_6
loc_og_t2m_mou_7  \
count      94621.000000      92254.000000      96062.000000
96140.000000
mean          45.887806         44.584446         93.342088
91.397131
std          151.184830        147.995390        162.780544
157.492308
min            0.000000          0.000000          0.000000
0.000000
25%            1.600000          1.360000          9.880000
10.025000
50%           11.730000         11.260000         41.030000
40.430000
75%           40.110000         39.280000        110.390000
107.560000
max        10752.560000      10389.240000       4729.740000
4557.140000

       loc_og_t2m_mou_8  loc_og_t2m_mou_9  loc_og_t2f_mou_6
loc_og_t2f_mou_7  \
count      94621.000000      92254.000000      96062.000000
96140.000000
mean          91.755128         90.463192          3.751013
3.792985
std          156.537048        158.681454         14.230438
14.264986
min            0.000000          0.000000          0.000000
0.000000
25%            9.810000          8.810000          0.000000
0.000000
50%           40.360000         39.120000          0.000000
0.000000
75%          109.090000        106.810000          2.080000
```

```
2.090000
max         4961.330000       4429.880000       1466.030000
1196.430000

       loc_og_t2f_mou_8  loc_og_t2f_mou_9  loc_og_t2c_mou_6
loc_og_t2c_mou_7  \
count      94621.000000      92254.000000      96062.000000
96140.000000
mean           3.677991          3.655123          1.123056
1.368500
std           13.270996         13.457549          5.448946
7.533445
min            0.000000          0.000000          0.000000
0.000000
25%            0.000000          0.000000          0.000000
0.000000
50%            0.000000          0.000000          0.000000
0.000000
75%            2.040000          1.940000          0.000000
0.000000
max          928.490000        927.410000        342.860000
916.240000

       loc_og_t2c_mou_8  loc_og_t2c_mou_9  loc_og_mou_6  loc_og_mou_7
\
count      94621.000000      92254.000000  96062.000000  96140.000000

mean           1.433821          1.232726    144.201175    141.670476

std            6.783335          5.619021    251.751489    248.731086

min            0.000000          0.000000      0.000000      0.000000

25%            0.000000          0.000000     17.110000     17.480000

50%            0.000000          0.000000     65.110000     63.685000

75%            0.000000          0.000000    168.270000    164.382500

max          502.090000        339.840000  10643.380000   7674.780000


       loc_og_mou_8  loc_og_mou_9  std_og_t2t_mou_6  std_og_t2t_mou_7
\
count  94621.000000  92254.000000      96062.000000      96140.000000

mean     141.328209    138.709970         79.829870         83.299598

std      245.914311    245.934517        252.476533        263.631042

min        0.000000      0.000000          0.000000          0.000000
```

```
25%       17.110000     15.560000          0.000000          0.000000
50%       63.730000     61.840000          0.000000          0.000000
75%      166.110000    162.225000         30.807500         31.132500
max    11039.910000  11099.260000       7366.580000       8133.660000

       std_og_t2t_mou_8  std_og_t2t_mou_9  std_og_t2m_mou_6
std_og_t2m_mou_7  \
count      94621.000000      92254.000000      96062.000000
96140.000000
mean          83.282673         82.342919         87.299624
90.804137
std          265.486090        267.184991        255.617850
269.347911
min            0.000000          0.000000          0.000000
0.000000
25%            0.000000          0.000000          0.000000
0.000000
50%            0.000000          0.000000          3.950000
3.635000
75%           30.580000         28.230000         53.290000
54.040000
max         8014.430000       9382.580000       8314.760000
9284.740000

       std_og_t2m_mou_8  std_og_t2m_mou_9  std_og_t2f_mou_6
std_og_t2f_mou_7  \
count      94621.000000      92254.000000      96062.000000
96140.000000
mean          89.838390         86.276622          1.129011
1.115010
std          271.757783        261.407396          7.984970
8.599406
min            0.000000          0.000000          0.000000
0.000000
25%            0.000000          0.000000          0.000000
0.000000
50%            3.310000          2.500000          0.000000
0.000000
75%           52.490000         48.560000          0.000000
0.000000
max        13950.040000      10223.430000        628.560000
544.630000

       std_og_t2f_mou_8  std_og_t2f_mou_9  std_og_t2c_mou_6
std_og_t2c_mou_7  \
```

```
count      94621.000000      92254.000000            96062.0
96140.0
mean           1.067792          1.042362                0.0
0.0
std            7.905971          8.261770                0.0
0.0
min            0.000000          0.000000                0.0
0.0
25%            0.000000          0.000000                0.0
0.0
50%            0.000000          0.000000                0.0
0.0
75%            0.000000          0.000000                0.0
0.0
max          516.910000        808.490000                0.0
0.0

       std_og_t2c_mou_8  std_og_t2c_mou_9  std_og_mou_6  std_og_mou_7
\
count           94621.0           92254.0  96062.000000  96140.000000

mean                0.0               0.0    168.261218    175.221436

std                 0.0               0.0    389.948499    408.922934

min                 0.0               0.0      0.000000      0.000000

25%                 0.0               0.0      0.000000      0.000000

50%                 0.0               0.0     11.640000     11.090000

75%                 0.0               0.0    144.837500    150.615000

max                 0.0               0.0   8432.990000  10936.730000


       std_og_mou_8  std_og_mou_9  isd_og_mou_6  isd_og_mou_7
isd_og_mou_8  \
count  94621.000000  92254.000000  96062.000000  96140.000000
94621.000000
mean     174.191498    169.664466      0.798277      0.776572
0.791247
std      411.633049    405.138658     25.765248     25.603052
25.544471
min        0.000000      0.000000      0.000000      0.000000
0.000000
25%        0.000000      0.000000      0.000000      0.000000
0.000000
50%       10.410000      8.410000      0.000000      0.000000
0.000000
```

```
75%       147.940000    142.105000      0.000000      0.000000
0.000000
max     13980.060000  11495.310000   5900.660000   5490.280000
5681.540000

       isd_og_mou_9  spl_og_mou_6  spl_og_mou_7  spl_og_mou_8
spl_og_mou_9  \
count  92254.000000  96062.000000  96140.000000  94621.000000
92254.000000
mean       0.723892      3.916811      4.978279      5.053769
4.412767
std       21.310751     14.936449     20.661570     17.855111
16.328227
min        0.000000      0.000000      0.000000      0.000000
0.000000
25%        0.000000      0.000000      0.000000      0.000000
0.000000
50%        0.000000      0.000000      0.000000      0.000000
0.000000
75%        0.000000      2.430000      3.710000      3.990000
3.230000
max     4244.530000   1023.210000   2372.510000   1390.880000
1635.710000

        og_others_6   og_others_7   og_others_8   og_others_9
total_og_mou_6  \
count  96062.000000  96140.000000  94621.000000  92254.000000
99999.000000
mean       0.454157      0.030235      0.033372      0.047456
305.133424
std        4.125911      2.161717      2.323464      3.635466
463.419481
min        0.000000      0.000000      0.000000      0.000000
0.000000
25%        0.000000      0.000000      0.000000      0.000000
44.740000
50%        0.000000      0.000000      0.000000      0.000000
145.140000
75%        0.000000      0.000000      0.000000      0.000000
372.860000
max      800.890000    370.130000    394.930000    787.790000
10674.030000

       total_og_mou_7  total_og_mou_8  total_og_mou_9
loc_ic_t2t_mou_6  \
count    99999.000000    99999.000000    99999.000000
96062.000000
mean       310.231175      304.119513      289.279198
47.922365
std        480.031178      478.150031      468.980002
```

```
140.258485
min          0.000000       0.000000       0.000000
0.000000
25%         43.010000      38.580000      25.510000
2.990000
50%        141.530000     138.610000     125.460000
15.690000
75%        378.570000     369.900000     353.480000
46.840000
max      11365.310000   14043.060000   11517.730000
6626.930000

       loc_ic_t2t_mou_7  loc_ic_t2t_mou_8  loc_ic_t2t_mou_9
loc_ic_t2m_mou_6  \
count      96140.000000      94621.000000      92254.000000
96062.000000
mean          47.990520         47.211362         46.281794
107.475650
std          145.795055        137.239552        140.130610
171.713903
min            0.000000          0.000000          0.000000
0.000000
25%            3.230000          3.280000          3.290000
17.290000
50%           15.740000         16.030000         15.660000
56.490000
75%           45.810000         46.290000         45.180000
132.387500
max         9324.660000      10696.230000      10598.830000
4693.860000

       loc_ic_t2m_mou_7  loc_ic_t2m_mou_8  loc_ic_t2m_mou_9
loc_ic_t2f_mou_6  \
count      96140.000000      94621.000000      92254.000000
96062.000000
mean         107.120493        108.460515        106.155471
12.084305
std          169.423620        169.723759        165.492803
40.140895
min            0.000000          0.000000          0.000000
0.000000
25%           18.590000         18.930000         18.560000
0.000000
50%           57.080000         58.240000         56.610000
0.880000
75%          130.960000        133.930000        130.490000
8.140000
max         4455.830000       6274.190000       5463.780000
1872.340000
```

```
       loc_ic_t2f_mou_7  loc_ic_t2f_mou_8  loc_ic_t2f_mou_9
loc_ic_mou_6  \
count      96140.000000      94621.000000      92254.000000
96062.000000
mean          12.599697         11.751834         12.173105
167.491059
std           42.977442         39.125379         43.840776
254.124029
min            0.000000          0.000000          0.000000
0.000000
25%            0.000000          0.000000          0.000000
30.390000
50%            0.930000          0.930000          0.960000
92.160000
75%            8.282500          8.110000          8.140000
208.075000
max         1983.010000       2433.060000       4318.280000
7454.630000

       loc_ic_mou_7  loc_ic_mou_8  loc_ic_mou_9  std_ic_t2t_mou_6  \
count  96140.000000  94621.000000  92254.000000      96062.000000
mean     167.719540    167.432575    164.619293          9.575993
std      256.242707    250.025523    249.845070         54.330607
min        0.000000      0.000000      0.000000          0.000000
25%       32.460000     32.740000     32.290000          0.000000
50%       92.550000     93.830000     91.640000          0.000000
75%      205.837500    207.280000    202.737500          4.060000
max     9669.910000  10830.160000  10796.290000       5459.560000

       std_ic_t2t_mou_7  std_ic_t2t_mou_8  std_ic_t2t_mou_9
std_ic_t2m_mou_6  \
count      96140.000000      94621.000000      92254.000000
96062.000000
mean          10.011904          9.883921          9.432479
20.722240
std           57.411971         55.073186         53.376273
80.793414
min            0.000000          0.000000          0.000000
0.000000
25%            0.000000          0.000000          0.000000
0.000000
50%            0.000000          0.000000          0.000000
2.030000
75%            4.230000          4.080000          3.510000
15.030000
max         5800.930000       4309.290000       3819.830000
5647.160000

       std_ic_t2m_mou_7  std_ic_t2m_mou_8  std_ic_t2m_mou_9
std_ic_t2f_mou_6  \
```

```
count      96140.000000      94621.000000      92254.000000
96062.000000
mean          21.656415         21.183211         19.620913
2.156397
std           86.521393         83.683565         74.913050
16.495594
min            0.000000          0.000000          0.000000
0.000000
25%            0.000000          0.000000          0.000000
0.000000
50%            2.040000          2.030000          1.740000
0.000000
75%           15.740000         15.360000         14.260000
0.000000
max         6141.880000       5645.860000       5689.760000
1351.110000

       std_ic_t2f_mou_7  std_ic_t2f_mou_8  std_ic_t2f_mou_9
std_ic_t2o_mou_6  \
count      96140.000000      94621.000000      92254.000000
96062.0
mean           2.216923          2.085004          2.173419
0.0
std           16.454061         15.812580         15.978601
0.0
min            0.000000          0.000000          0.000000
0.0
25%            0.000000          0.000000          0.000000
0.0
50%            0.000000          0.000000          0.000000
0.0
75%            0.000000          0.000000          0.000000
0.0
max         1136.080000       1394.890000       1431.960000
0.0

       std_ic_t2o_mou_7  std_ic_t2o_mou_8  std_ic_t2o_mou_9
std_ic_mou_6  \
count           96140.0           94621.0           92254.0
96062.000000
mean                0.0               0.0               0.0
32.457179
std                 0.0               0.0               0.0
106.283386
min                 0.0               0.0               0.0
0.000000
25%                 0.0               0.0               0.0
0.000000
50%                 0.0               0.0               0.0
```

```
5.890000
75%                   0.0                 0.0                 0.0
26.930000
max                   0.0                 0.0                 0.0
5712.110000

       std_ic_mou_7  std_ic_mou_8  std_ic_mou_9  total_ic_mou_6  \
count  96140.000000  94621.000000  92254.000000    99999.000000
mean      33.887833     33.154735     31.229344      200.130037
std      113.720168    110.127008    101.982303      291.651671
min        0.000000      0.000000      0.000000        0.000000
25%        0.000000      0.010000      0.000000       38.530000
50%        5.960000      5.880000      5.380000      114.740000
75%       28.310000     27.710000     25.690000      251.670000
max     6745.760000   5957.140000   5956.660000     7716.140000

       total_ic_mou_7  total_ic_mou_8  total_ic_mou_9  spl_ic_mou_6  \
count    99999.000000    99999.000000    99999.000000  96062.000000
mean       202.853055      198.750783      189.214260      0.061557
std        298.124954      289.321094      284.823024      0.160920
min          0.000000        0.000000        0.000000      0.000000
25%         41.190000       38.290000       32.370000      0.000000
50%        116.340000      114.660000      105.890000      0.000000
75%        250.660000      248.990000      236.320000      0.000000
max       9699.010000    10830.380000    10796.590000     19.760000

       spl_ic_mou_7  spl_ic_mou_8  spl_ic_mou_9  isd_ic_mou_6
isd_ic_mou_7  \
count  96140.000000  94621.000000  92254.000000  96062.000000
96140.000000
mean       0.033585      0.040361      0.163137      7.460608
8.334936
std        0.155725      0.146147      0.527860     59.722948
65.219829
min        0.000000      0.000000      0.000000      0.000000
0.000000
25%        0.000000      0.000000      0.000000      0.000000
0.000000
50%        0.000000      0.000000      0.000000      0.000000
0.000000
75%        0.000000      0.000000      0.060000      0.000000
0.000000
max       21.330000     16.860000     62.380000   6789.410000
5289.540000

       isd_ic_mou_8  isd_ic_mou_9   ic_others_6   ic_others_7
ic_others_8  \
count  94621.000000  92254.000000  96062.000000  96140.000000
94621.000000
mean       8.442001      8.063003      0.854656      1.012960
```

```
0.970800
std       63.813098     63.505379     11.955164     12.673099
13.284348
min        0.000000      0.000000      0.000000      0.000000
0.000000
25%        0.000000      0.000000      0.000000      0.000000
0.000000
50%        0.000000      0.000000      0.000000      0.000000
0.000000
75%        0.000000      0.000000      0.000000      0.000000
0.000000
max     4127.010000   5057.740000   1362.940000   1495.940000
2327.510000

        ic_others_9  total_rech_num_6  total_rech_num_7
total_rech_num_8  \
count  92254.000000      99999.000000      99999.000000
99999.000000
mean       1.017162          7.558806          7.700367
7.212912
std       12.381172          7.078405          7.070422
7.203753
min        0.000000          0.000000          0.000000
0.000000
25%        0.000000          3.000000          3.000000
3.000000
50%        0.000000          6.000000          6.000000
5.000000
75%        0.000000          9.000000         10.000000
9.000000
max     1005.230000        307.000000        138.000000
196.000000

       total_rech_num_9  total_rech_amt_6  total_rech_amt_7
total_rech_amt_8  \
count      99999.000000      99999.000000      99999.000000
99999.000000
mean           6.893019        327.514615        322.962970
324.157122
std            7.096261        398.019701        408.114237
416.540455
min            0.000000          0.000000          0.000000
0.000000
25%            3.000000        109.000000        100.000000
90.000000
50%            5.000000        230.000000        220.000000
225.000000
75%            9.000000        437.500000        428.000000
434.500000
```

```
max          131.000000      35190.000000      40335.000000
45320.000000

       total_rech_amt_9  max_rech_amt_6  max_rech_amt_7
max_rech_amt_8  \
count      99999.000000    99999.000000    99999.000000
99999.000000
mean         303.345673      104.637486      104.752398
107.728207
std          404.588583      120.614894      124.523970
126.902505
min            0.000000        0.000000        0.000000
0.000000
25%           52.000000       30.000000       30.000000
30.000000
50%          200.000000      110.000000      110.000000
98.000000
75%          415.000000      120.000000      128.000000
144.000000
max        37235.000000     4010.000000     4010.000000
4449.000000

       max_rech_amt_9  last_day_rch_amt_6  last_day_rch_amt_7  \
count    99999.000000        99999.000000        99999.000000
mean       101.943889           63.156252           59.385804
std        125.375109           97.356649           95.915385
min          0.000000            0.000000            0.000000
25%         28.000000            0.000000            0.000000
50%         61.000000           30.000000           30.000000
75%        144.000000          110.000000          110.000000
max       3399.000000         4010.000000         4010.000000

       last_day_rch_amt_8  last_day_rch_amt_9  total_rech_data_6  \
count        99999.000000        99999.000000       25153.000000
mean            62.641716           43.901249           2.463802
std            104.431816           90.809712           2.789128
min              0.000000            0.000000           1.000000
25%              0.000000            0.000000           1.000000
50%             30.000000            0.000000           1.000000
75%            130.000000           50.000000           3.000000
max           4449.000000         3399.000000          61.000000

       total_rech_data_7  total_rech_data_8  total_rech_data_9  \
count       25571.000000       26339.000000       25922.000000
mean            2.666419           2.651999           2.441170
std             3.031593           3.074987           2.516339
min             1.000000           1.000000           1.000000
25%             1.000000           1.000000           1.000000
50%             1.000000           1.000000           2.000000
75%             3.000000           3.000000           3.000000
```

```
max            54.000000          60.000000          84.000000

       max_rech_data_6  max_rech_data_7  max_rech_data_8
max_rech_data_9  \
count     25153.000000     25571.000000     26339.000000
25922.00000
mean        126.393392       126.729459       125.717301
124.94144
std         108.477235       109.765267       109.437851
111.36376
min           1.000000         1.000000         1.000000
1.00000
25%          25.000000        25.000000        25.000000
25.00000
50%         145.000000       145.000000       145.000000
145.00000
75%         177.000000       177.000000       179.000000
179.00000
max        1555.000000      1555.000000      1555.000000
1555.00000

       count_rech_2g_6  count_rech_2g_7  count_rech_2g_8
count_rech_2g_9  \
count     25153.000000     25571.000000     26339.000000
25922.000000
mean          1.864668         2.044699         2.016288
1.781807
std           2.570254         2.768332         2.720132
2.214701
min           0.000000         0.000000         0.000000
0.000000
25%           1.000000         1.000000         1.000000
1.000000
50%           1.000000         1.000000         1.000000
1.000000
75%           2.000000         2.000000         2.000000
2.000000
max          42.000000        48.000000        44.000000
40.000000

       count_rech_3g_6  count_rech_3g_7  count_rech_3g_8
count_rech_3g_9  \
count     25153.000000     25571.000000     26339.000000
25922.000000
mean          0.599133         0.621720         0.635711
0.659363
std           1.274428         1.394524         1.422827
1.411513
min           0.000000         0.000000         0.000000
0.000000
```

```
25%           0.000000        0.000000        0.000000
0.000000
50%           0.000000        0.000000        0.000000
0.000000
75%           1.000000        1.000000        1.000000
1.000000
max          29.000000       35.000000       45.000000
49.000000

       av_rech_amt_data_6  av_rech_amt_data_7  av_rech_amt_data_8  \
count        25153.000000        25571.000000        26339.000000
mean           192.600982          200.981292          197.526489
std            192.646318          196.791224          191.301305
min              1.000000            0.500000            0.500000
25%             82.000000           92.000000           87.000000
50%            154.000000          154.000000          154.000000
75%            252.000000          252.000000          252.000000
max           7546.000000         4365.000000         4076.000000

       av_rech_amt_data_9   vol_2g_mb_6   vol_2g_mb_7   vol_2g_mb_8  \
count        25922.000000  99999.000000  99999.000000  99999.000000
mean           192.734315     51.904956     51.229937     50.170154
std            188.400286    213.356445    212.302217    212.347892
min              1.000000      0.000000      0.000000      0.000000
25%             69.000000      0.000000      0.000000      0.000000
50%            164.000000      0.000000      0.000000      0.000000
75%            252.000000      0.000000      0.000000      0.000000
max           4061.000000  10285.900000   7873.550000  11117.610000

        vol_2g_mb_9   vol_3g_mb_6   vol_3g_mb_7   vol_3g_mb_8
vol_3g_mb_9  \
count  99999.000000  99999.000000  99999.000000  99999.000000
99999.000000
mean      44.719701    121.396219    128.995847    135.410689
136.056613
std      198.653570    544.247227    541.494013    558.775335
577.394194
min        0.000000      0.000000      0.000000      0.000000
0.000000
25%        0.000000      0.000000      0.000000      0.000000
0.000000
50%        0.000000      0.000000      0.000000      0.000000
0.000000
75%        0.000000      0.000000      0.000000      0.000000
0.000000
max     8993.950000  45735.400000  28144.120000  30036.060000
39221.270000

          arpu_3g_6     arpu_3g_7     arpu_3g_8     arpu_3g_9
arpu_2g_6  \
```

```
count  25153.000000  25571.000000  26339.000000  25922.000000
25153.000000
mean      89.555057     89.384120     91.173849    100.264116
86.398003
std      193.124653    195.893924    188.180936    216.291992
172.767523
min      -30.820000    -26.040000    -24.490000    -71.090000    -
35.830000
25%        0.000000      0.000000      0.000000      0.000000
0.000000
50%        0.480000      0.420000      0.880000      2.605000
10.830000
75%      122.070000    119.560000    122.070000    140.010000
122.070000
max     6362.280000   4980.900000   3716.900000  13884.310000
6433.760000

          arpu_2g_7     arpu_2g_8     arpu_2g_9  night_pck_user_6  \
count  25571.000000  26339.000000  25922.000000      25153.000000
mean      85.914450     86.599478     93.712026          0.025086
std      176.379871    168.247852    171.384224          0.156391
min      -15.480000    -55.830000    -45.740000          0.000000
25%        0.000000      0.000000      0.000000          0.000000
50%        8.810000      9.270000     14.800000          0.000000
75%      122.070000    122.070000    140.010000          0.000000
max     4809.360000   3483.170000   3467.170000          1.000000

       night_pck_user_7  night_pck_user_8  night_pck_user_9
monthly_2g_6  \
count      25571.000000      26339.000000      25922.000000
99999.000000
mean           0.023034          0.020844          0.015971
0.079641
std            0.150014          0.142863          0.125366
0.295058
min            0.000000          0.000000          0.000000
0.000000
25%            0.000000          0.000000          0.000000
0.000000
50%            0.000000          0.000000          0.000000
0.000000
75%            0.000000          0.000000          0.000000
0.000000
max            1.000000          1.000000          1.000000
4.000000

       monthly_2g_7  monthly_2g_8  monthly_2g_9   sachet_2g_6
sachet_2g_7  \
count  99999.000000  99999.000000  99999.000000  99999.000000
99999.000000
```

```
mean       0.083221      0.081001      0.068781      0.389384
0.439634
std        0.304395      0.299568      0.278120      1.497320
1.636230
min        0.000000      0.000000      0.000000      0.000000
0.000000
25%        0.000000      0.000000      0.000000      0.000000
0.000000
50%        0.000000      0.000000      0.000000      0.000000
0.000000
75%        0.000000      0.000000      0.000000      0.000000
0.000000
max        5.000000      5.000000      4.000000     42.000000
48.000000

        sachet_2g_8   sachet_2g_9  monthly_3g_6  monthly_3g_7
monthly_3g_8  \
count  99999.000000  99999.000000  99999.000000  99999.000000
99999.000000
mean       0.450075      0.393104      0.075921      0.078581
0.082941
std        1.630263      1.347140      0.363371      0.387231
0.384947
min        0.000000      0.000000      0.000000      0.000000
0.000000
25%        0.000000      0.000000      0.000000      0.000000
0.000000
50%        0.000000      0.000000      0.000000      0.000000
0.000000
75%        0.000000      0.000000      0.000000      0.000000
0.000000
max       44.000000     40.000000     14.000000     16.000000
16.000000

       monthly_3g_9   sachet_3g_6   sachet_3g_7   sachet_3g_8
sachet_3g_9  \
count  99999.000000  99999.000000  99999.000000  99999.000000
99999.000000
mean       0.086341      0.074781      0.080401      0.084501
0.084581
std        0.384978      0.568344      0.628334      0.660234
0.650457
min        0.000000      0.000000      0.000000      0.000000
0.000000
25%        0.000000      0.000000      0.000000      0.000000
0.000000
50%        0.000000      0.000000      0.000000      0.000000
0.000000
75%        0.000000      0.000000      0.000000      0.000000
```

```
0.000000
max        11.000000     29.000000     35.000000     41.000000
49.000000

          fb_user_6     fb_user_7     fb_user_8     fb_user_9
aon  \
count  25153.000000  25571.000000  26339.000000  25922.000000
99999.000000
mean       0.914404      0.908764      0.890808      0.860968
1219.854749
std        0.279772      0.287950      0.311885      0.345987
954.733842
min        0.000000      0.000000      0.000000      0.000000
180.000000
25%        1.000000      1.000000      1.000000      1.000000
467.000000
50%        1.000000      1.000000      1.000000      1.000000
863.000000
75%        1.000000      1.000000      1.000000      1.000000
1807.500000
max        1.000000      1.000000      1.000000      1.000000
4337.000000

         aug_vbc_3g    jul_vbc_3g    jun_vbc_3g    sep_vbc_3g
count  99999.000000  99999.000000  99999.000000  99999.000000
mean      68.170248     66.839062     60.021204      3.299373
std      267.580450    271.201856    253.938223     32.408353
min        0.000000      0.000000      0.000000      0.000000
25%        0.000000      0.000000      0.000000      0.000000
50%        0.000000      0.000000      0.000000      0.000000
75%        0.000000      0.000000      0.000000      0.000000
max    12916.220000   9165.600000  11166.210000   2618.570000
```

Handling missing values

Handling missing values in columns

```
# Cheking percent of missing values in columns
df_missing_columns =
(round(((df.isnull().sum()/len(df.index))*100),2).to_frame('null')).so
rt_values('null', ascending=False)
df_missing_columns
```

	null
arpu_3g_6	74.85
night_pck_user_6	74.85
total_rech_data_6	74.85
arpu_2g_6	74.85
max_rech_data_6	74.85

```
fb_user_6                   74.85
av_rech_amt_data_6          74.85
date_of_last_rech_data_6    74.85
count_rech_2g_6             74.85
count_rech_3g_6             74.85
date_of_last_rech_data_7    74.43
total_rech_data_7           74.43
fb_user_7                   74.43
max_rech_data_7             74.43
night_pck_user_7            74.43
count_rech_2g_7             74.43
av_rech_amt_data_7          74.43
arpu_2g_7                   74.43
count_rech_3g_7             74.43
arpu_3g_7                   74.43
total_rech_data_9           74.08
count_rech_3g_9             74.08
fb_user_9                   74.08
max_rech_data_9             74.08
arpu_3g_9                   74.08
date_of_last_rech_data_9    74.08
night_pck_user_9            74.08
arpu_2g_9                   74.08
count_rech_2g_9             74.08
av_rech_amt_data_9          74.08
...                           ...
circle_id                    0.00
total_og_mou_8               0.00
vol_3g_mb_7                  0.00
total_og_mou_7               0.00
total_og_mou_6               0.00
arpu_9                       0.00
arpu_8                       0.00
arpu_7                       0.00
arpu_6                       0.00
last_date_of_month_6         0.00
total_rech_num_8             0.00
total_rech_num_9             0.00
total_rech_amt_6             0.00
total_rech_amt_7             0.00
vol_3g_mb_6                  0.00
vol_2g_mb_9                  0.00
vol_2g_mb_8                  0.00
vol_2g_mb_7                  0.00
vol_2g_mb_6                  0.00
last_day_rch_amt_9           0.00
last_day_rch_amt_8           0.00
last_day_rch_amt_7           0.00
last_day_rch_amt_6           0.00
```

```
max_rech_amt_9              0.00
max_rech_amt_8              0.00
max_rech_amt_7              0.00
max_rech_amt_6              0.00
total_rech_amt_9            0.00
total_rech_amt_8            0.00
sep_vbc_3g                  0.00

[226 rows x 1 columns]
```

```
# List the columns having more than 30% missing values
col_list_missing_30 =
list(df_missing_columns.index[df_missing_columns['null'] > 30])

# Delete the columns having more than 30% missing values
df = df.drop(col_list_missing_30, axis=1)

df.shape

(99999, 186)
```

Deleting the date columns as the date columns are not required in our analysis

```
# List the date columns
date_cols = [k for k in df.columns.to_list() if 'date' in k]
print(date_cols)

['last_date_of_month_6', 'last_date_of_month_7',
'last_date_of_month_8', 'last_date_of_month_9', 'date_of_last_rech_6',
'date_of_last_rech_7', 'date_of_last_rech_8', 'date_of_last_rech_9']

# Dropping date columns
df = df.drop(date_cols, axis=1)
```

Dropping circle_id column as this column has only one unique value. Hence there will be no impact of this column on the data analysis.

```
# Drop circle_id column
df = df.drop('circle_id', axis=1)

df.shape

(99999, 177)
```

Filter high-value customers

Creating column `avg_rech_amt_6_7` by summing up total recharge amount of month 6 and 7. Then taking the average of the sum.

```
df['avg_rech_amt_6_7'] = (df['total_rech_amt_6'] +
df['total_rech_amt_7'])/2
```

Finding the 70th percentile of the avg_rech_amt_6_7

```
X = df['avg_rech_amt_6_7'].quantile(0.7)
X

368.5
```

Filter the customers, who have recharged more than or equal to X.

```
df = df[df['avg_rech_amt_6_7'] >= X]
df.head()

    mobile_number  loc_og_t2o_mou  std_og_t2o_mou  loc_ic_t2o_mou
arpu_6  \
7      7000701601             0.0             0.0             0.0
1069.180
8      7001524846             0.0             0.0             0.0
378.721
13     7002191713             0.0             0.0             0.0
492.846
16     7000875565             0.0             0.0             0.0
430.975
17     7000187447             0.0             0.0             0.0
690.008

      arpu_7    arpu_8   arpu_9  onnet_mou_6  onnet_mou_7  onnet_mou_8
\
7   1349.850  3171.480  500.000        57.84        54.68        52.29

8    492.223   137.362  166.787       413.69       351.03        35.08

13   205.671   593.260  322.732       501.76       108.39       534.24

16   299.869   187.894  206.490        50.51        74.01        70.61

17    18.980    25.499  257.583      1185.91         9.28         7.79


    onnet_mou_9  offnet_mou_6  offnet_mou_7  offnet_mou_8
offnet_mou_9  \
7           NaN        453.43        567.16        325.91
NaN
8         33.46         94.66         80.63        136.48
108.71
13       244.81        413.31        119.28        482.46
214.06
16        31.34        296.29        229.74        162.76
224.39
17       558.51         61.64          0.00          5.54
87.89
```

```
    roam_ic_mou_6  roam_ic_mou_7  roam_ic_mou_8  roam_ic_mou_9  
roam_og_mou_6  \
7           16.23          33.49          31.64            NaN  
23.74   
8            0.00           0.00           0.00           0.00  
0.00   
13          23.53         144.24          72.11         136.78  
7.98   
16           0.00           2.83           0.00           0.00  
0.00   
17           0.00           4.76           4.81           0.00  
0.00   

    roam_og_mou_7  roam_og_mou_8  roam_og_mou_9  loc_og_t2t_mou_6  \
7           12.59          38.06            NaN             51.39   
8            0.00           0.00           0.00            297.13   
13          35.26           1.44          12.78             49.63   
16          17.74           0.00           0.00             42.61   
17           8.46          13.34          17.98             38.99   

    loc_og_t2t_mou_7  loc_og_t2t_mou_8  loc_og_t2t_mou_9  
loc_og_t2m_mou_6  \
7              31.38             40.28               NaN  
308.63   
8             217.59             12.49             26.13  
80.96   
13              6.19             36.01              6.14  
151.13   
16             65.16             67.38             26.88  
273.29   
17              0.00              0.00             36.41  
58.54   

    loc_og_t2m_mou_7  loc_og_t2m_mou_8  loc_og_t2m_mou_9  
loc_og_t2f_mou_6  \
7             447.38            162.28               NaN  
62.13   
8              70.58             50.54             34.58  
0.00   
13             47.28            294.46            108.24  
4.54   
16            145.99            128.28            201.49  
0.00   
17              0.00              0.00              9.38  
0.00   

    loc_og_t2f_mou_7  loc_og_t2f_mou_8  loc_og_t2f_mou_9  
loc_og_t2c_mou_6  \
7              55.14             53.23               NaN  
```

```
0.0
8                0.00              0.00              0.00
0.0
13               0.00             23.51              5.29
0.0
16               4.48             10.26              4.66
0.0
17               0.00              0.00              0.00
0.0

    loc_og_t2c_mou_7  loc_og_t2c_mou_8  loc_og_t2c_mou_9  loc_og_mou_6
\
7                0.0              0.00               NaN        422.16

8                0.0              7.15               0.0        378.09

13               0.0              0.49               0.0        205.31

16               0.0              0.00               0.0        315.91

17               0.0              0.00               0.0         97.54


    loc_og_mou_7  loc_og_mou_8  loc_og_mou_9  std_og_t2t_mou_6  \
7         533.91        255.79           NaN              4.30
8         288.18         63.04         60.71            116.56
13         53.48        353.99        119.69            446.41
16        215.64        205.93        233.04              7.89
17          0.00          0.00         45.79           1146.91

    std_og_t2t_mou_7  std_og_t2t_mou_8  std_og_t2t_mou_9
std_og_t2m_mou_6  \
7              23.29             12.01               NaN
49.89
8             133.43             22.58              7.33
13.69
13             85.98            498.23            230.38
255.36
16              2.58              3.23              4.46
22.99
17              0.81              0.00            504.11
1.55

    std_og_t2m_mou_7  std_og_t2m_mou_8  std_og_t2m_mou_9
std_og_t2f_mou_6  \
7              31.76             49.14               NaN
6.66
8              10.04             75.69             74.13
0.00
13             52.94            156.94             96.01
```

```
0.00
16              64.51              18.29              13.79
0.00
17               0.00               0.00              78.51
0.00

    std_og_t2f_mou_7  std_og_t2f_mou_8  std_og_t2f_mou_9
std_og_t2c_mou_6  \
7              20.08              16.68                NaN
0.0
8               0.00               0.00               0.00
0.0
13              0.00               0.00               0.00
0.0
16              0.00               0.00               4.43
0.0
17              0.00               0.00               0.00
0.0

    std_og_t2c_mou_7  std_og_t2c_mou_8  std_og_t2c_mou_9  std_og_mou_6
\
7                0.0               0.0               NaN         60.86

8                0.0               0.0               0.0        130.26

13               0.0               0.0               0.0        701.78

16               0.0               0.0               0.0         30.89

17               0.0               0.0               0.0       1148.46


    std_og_mou_7  std_og_mou_8  std_og_mou_9  isd_og_mou_6
isd_og_mou_7  \
7          75.14         77.84           NaN           0.0
0.18
8         143.48         98.28         81.46           0.0
0.00
13        138.93        655.18        326.39           0.0
0.00
16         67.09         21.53         22.69           0.0
0.00
17          0.81          0.00        582.63           0.0
0.00

    isd_og_mou_8  isd_og_mou_9  spl_og_mou_6  spl_og_mou_7
spl_og_mou_8  \
7          10.01           NaN          4.50          0.00
6.50
8           0.00           0.0          0.00          0.00
```

```
10.23
13         1.29          0.0          0.00          0.00
4.78
16         0.00          0.0          0.00          3.26
5.91
17         0.00          0.0          2.58          0.00
0.00

    spl_og_mou_9  og_others_6  og_others_7  og_others_8
og_others_9  \
7            NaN         0.00          0.0          0.0          NaN

8           0.00         0.00          0.0          0.0          0.0

13          0.00         0.00          0.0          0.0          0.0

16          0.00         0.00          0.0          0.0          0.0

17          2.64         0.93          0.0          0.0          0.0


    total_og_mou_6  total_og_mou_7  total_og_mou_8  total_og_mou_9  \
7           487.53          609.24          350.16            0.00
8           508.36          431.66          171.56          142.18
13          907.09          192.41         1015.26          446.09
16          346.81          286.01          233.38          255.74
17         1249.53            0.81            0.00          631.08

    loc_ic_t2t_mou_6  loc_ic_t2t_mou_7  loc_ic_t2t_mou_8
loc_ic_t2t_mou_9  \
7              58.14             32.26             27.31
NaN
8              23.84              9.84              0.31
4.03
13             67.88              7.58             52.58
24.98
16             41.33             71.44             28.89
50.23
17             34.54              0.00              0.00
40.91

    loc_ic_t2m_mou_6  loc_ic_t2m_mou_7  loc_ic_t2m_mou_8
loc_ic_t2m_mou_9  \
7             217.56            221.49            121.19
NaN
8              57.58             13.98             15.48
17.34
13            142.88             18.53            195.18
104.79
16            226.81            149.69            150.16
```

```
172.86
17             47.41              2.31              0.00
43.86

    loc_ic_t2f_mou_6  loc_ic_t2f_mou_7  loc_ic_t2f_mou_8
loc_ic_t2f_mou_9  \
7             152.16            101.46             39.53
NaN
8               0.00              0.00              0.00
0.00
13              4.81              0.00              7.49
8.51
16              8.71              8.68             32.71
65.21
17              0.00              0.00              0.00
0.71

    loc_ic_mou_6  loc_ic_mou_7  loc_ic_mou_8  loc_ic_mou_9
std_ic_t2t_mou_6  \
7         427.88        355.23        188.04           NaN
36.89
8          81.43         23.83         15.79         21.38
0.00
13        215.58         26.11        255.26        138.29
115.68
16        276.86        229.83        211.78        288.31
68.79
17         81.96          2.31          0.00         85.49
8.63

    std_ic_t2t_mou_7  std_ic_t2t_mou_8  std_ic_t2t_mou_9
std_ic_t2m_mou_6  \
7              11.83             30.39               NaN
91.44
8               0.58              0.10              0.00
22.43
13             38.29            154.58             62.39
308.13
16             78.64              6.33             16.66
18.68
17              0.00              0.00              0.00
1.28

    std_ic_t2m_mou_7  std_ic_t2m_mou_8  std_ic_t2m_mou_9
std_ic_t2f_mou_6  \
7             126.99            141.33               NaN
52.19
8               4.08              0.65             13.53
0.00
13             29.79            317.91            151.51
```

```
0.00
16              73.08             73.93             29.58
0.51
17               0.00              0.00              1.63
0.00

    std_ic_t2f_mou_7  std_ic_t2f_mou_8  std_ic_t2f_mou_9
std_ic_t2o_mou_6  \
7              34.24             22.21               NaN
0.0
8               0.00              0.00               0.0
0.0
13              0.00              1.91               0.0
0.0
16              0.00              2.18               0.0
0.0
17              0.00              0.00               0.0
0.0

    std_ic_t2o_mou_7  std_ic_t2o_mou_8  std_ic_t2o_mou_9  std_ic_mou_6
\
7                0.0               0.0               NaN        180.54

8                0.0               0.0               0.0         22.43

13               0.0               0.0               0.0        423.81

16               0.0               0.0               0.0         87.99

17               0.0               0.0               0.0          9.91


    std_ic_mou_7  std_ic_mou_8  std_ic_mou_9  total_ic_mou_6
total_ic_mou_7  \
7         173.08        193.94           NaN          626.46
558.04
8           4.66          0.75         13.53          103.86
28.49
13         68.09        474.41        213.91          968.61
172.58
16        151.73         82.44         46.24          364.86
381.56
17          0.00          0.00          1.63           91.88
2.31

    total_ic_mou_8  total_ic_mou_9  spl_ic_mou_6  spl_ic_mou_7
spl_ic_mou_8  \
7           428.74            0.00          0.21           0.0
0.0
8            16.54           34.91          0.00           0.0
```

```
0.0
13         1144.53          631.86          0.45           0.0
0.0
16          294.46          334.56          0.00           0.0
0.0
17            0.00           87.13          0.00           0.0
0.0

    spl_ic_mou_9  isd_ic_mou_6  isd_ic_mou_7  isd_ic_mou_8
isd_ic_mou_9  \
7            NaN          2.06         14.53         31.59
NaN
8            0.0          0.00          0.00          0.00
0.00
13           0.0        245.28         62.11        393.39
259.33
16           0.0          0.00          0.00          0.23
0.00
17           0.0          0.00          0.00          0.00
0.00

    ic_others_6  ic_others_7  ic_others_8  ic_others_9
total_rech_num_6  \
7         15.74        15.19        15.14          NaN
5
8          0.00         0.00         0.00         0.00
19
13        83.48        16.24        21.44        20.31
6
16         0.00         0.00         0.00         0.00
10
17         0.00         0.00         0.00         0.00
19

    total_rech_num_7  total_rech_num_8  total_rech_num_9
total_rech_amt_6  \
7                  5                 7                 3
1580
8                 21                14                15
437
13                 4                11                 7
507
16                 6                 2                 1
570
17                 2                 4                10
816

    total_rech_amt_7  total_rech_amt_8  total_rech_amt_9
max_rech_amt_6  \
7                790              3638                 0
```

```
1580
8                601                120                186
90
13               253                717                353
110
16               348                160                220
110
17                 0                 30                335
110

    max_rech_amt_7  max_rech_amt_8  max_rech_amt_9  last_day_rch_amt_6
\
7              790            1580               0                   0

8              154              30              36                  50

13             110             130             130                 110

16             110             130             220                 100

17               0              30             130                  30


    last_day_rch_amt_7  last_day_rch_amt_8  last_day_rch_amt_9
vol_2g_mb_6  \
7                    0                 779                   0
0.0
8                    0                  10                   0
0.0
13                  50                   0                   0
0.0
16                 100                 130                 220
0.0
17                   0                   0                   0
0.0

    vol_2g_mb_7  vol_2g_mb_8  vol_2g_mb_9  vol_3g_mb_6  vol_3g_mb_7  \
7           0.0         0.00          0.0          0.0         0.00
8         356.0         0.03          0.0          0.0       750.95
13          0.0         0.02          0.0          0.0         0.00
16          0.0         0.00          0.0          0.0         0.00
17          0.0         0.00          0.0          0.0         0.00

    vol_3g_mb_8  vol_3g_mb_9  monthly_2g_6  monthly_2g_7  monthly_2g_8
\
7          0.00          0.0             0             0             0

8         11.94          0.0             0             1             0

13         0.00          0.0             0             0             0
```

```
16         0.00          0.0             0             0             0
17         0.00          0.0             0             0             0

    monthly_2g_9  sachet_2g_6  sachet_2g_7  sachet_2g_8  
sachet_2g_9  \
7              0            0            0            0            0
8              0            0            1            3            0
13             0            0            0            3            0
16             0            0            0            0            0
17             0            0            0            0            0

    monthly_3g_6  monthly_3g_7  monthly_3g_8  monthly_3g_9  
sachet_3g_6  \
7              0             0             0             0  
0
8              0             0             0             0  
0
13             0             0             0             0  
0
16             0             0             0             0  
0
17             0             0             0             0  
0

    sachet_3g_7  sachet_3g_8  sachet_3g_9   aon  aug_vbc_3g  
jul_vbc_3g  \
7             0            0            0   802       57.74  
19.38
8             0            0            0   315       21.03  
910.65
13            0            0            0  2607        0.00  
0.00
16            0            0            0   511        0.00  
2.45
17            0            0            0   667        0.00  
0.00

    jun_vbc_3g  sep_vbc_3g  avg_rech_amt_6_7
7        18.74         0.0            1185.0
8       122.16         0.0             519.0
13        0.00         0.0             380.0
```

```
16        21.89          0.0               459.0
17         0.00          0.0               408.0
```

```python
df.shape
```

```
(30011, 178)
```

We can see that we have around ***~30K*** rows after filtering

Handling missing values in rows

```python
# Count the rows having more than 50% missing values
df_missing_rows_50 = df[(df.isnull().sum(axis=1)) >
(len(df.columns)//2)]
df_missing_rows_50.shape
```

```
(114, 178)
```

```python
# Deleting the rows having more than 50% missing values
df = df.drop(df_missing_rows_50.index)
df.shape
```

```
(29897, 178)
```

```python
# Checking the missing values in columns again
df_missing_columns =
(round(((df.isnull().sum()/len(df.index))*100),2).to_frame('null')).so
rt_values('null', ascending=False)
df_missing_columns
```

	null
loc_ic_mou_9	5.32
og_others_9	5.32
loc_og_t2t_mou_9	5.32
loc_ic_t2t_mou_9	5.32
loc_og_t2m_mou_9	5.32
loc_og_t2f_mou_9	5.32
loc_og_t2c_mou_9	5.32
std_ic_t2m_mou_9	5.32
loc_og_mou_9	5.32
std_og_t2t_mou_9	5.32
roam_og_mou_9	5.32
std_ic_t2o_mou_9	5.32
std_og_t2m_mou_9	5.32
std_og_t2f_mou_9	5.32
spl_og_mou_9	5.32
std_og_t2c_mou_9	5.32
std_og_mou_9	5.32
isd_og_mou_9	5.32
std_ic_t2t_mou_9	5.32
std_ic_mou_9	5.32

```
onnet_mou_9          5.32
spl_ic_mou_9         5.32
ic_others_9          5.32
isd_ic_mou_9         5.32
loc_ic_t2f_mou_9     5.32
offnet_mou_9         5.32
loc_ic_t2m_mou_9     5.32
std_ic_t2f_mou_9     5.32
roam_ic_mou_9        5.32
loc_og_t2t_mou_8     2.76
...                   ...
total_ic_mou_8       0.00
std_og_t2o_mou       0.00
loc_ic_t2o_mou       0.00
arpu_6               0.00
arpu_7               0.00
arpu_8               0.00
arpu_9               0.00
total_og_mou_6       0.00
total_og_mou_7       0.00
total_og_mou_8       0.00
total_og_mou_9       0.00
loc_og_t2o_mou       0.00
total_ic_mou_6       0.00
total_ic_mou_7       0.00
total_ic_mou_9       0.00
last_day_rch_amt_7   0.00
total_rech_num_6     0.00
total_rech_num_7     0.00
total_rech_num_8     0.00
total_rech_num_9     0.00
total_rech_amt_6     0.00
total_rech_amt_7     0.00
total_rech_amt_8     0.00
total_rech_amt_9     0.00
max_rech_amt_6       0.00
max_rech_amt_7       0.00
max_rech_amt_8       0.00
max_rech_amt_9       0.00
last_day_rch_amt_6   0.00
avg_rech_amt_6_7     0.00

[178 rows x 1 columns]
```

Looks like MOU for all the types of calls for the month of September (9) have missing values together for any particular record.

Lets check the records for the MOU for Sep(9), in which these coulmns have missing values together.

```
# Listing the columns of MOU Sep(9)
print(((df_missing_columns[df_missing_columns['null'] ==
5.32]).index).to_list())
```

```
['loc_ic_mou_9', 'og_others_9', 'loc_og_t2t_mou_9',
'loc_ic_t2t_mou_9', 'loc_og_t2m_mou_9', 'loc_og_t2f_mou_9',
'loc_og_t2c_mou_9', 'std_ic_t2m_mou_9', 'loc_og_mou_9',
'std_og_t2t_mou_9', 'roam_og_mou_9', 'std_ic_t2o_mou_9',
'std_og_t2m_mou_9', 'std_og_t2f_mou_9', 'spl_og_mou_9',
'std_og_t2c_mou_9', 'std_og_mou_9', 'isd_og_mou_9',
'std_ic_t2t_mou_9', 'std_ic_mou_9', 'onnet_mou_9', 'spl_ic_mou_9',
'ic_others_9', 'isd_ic_mou_9', 'loc_ic_t2f_mou_9', 'offnet_mou_9',
'loc_ic_t2m_mou_9', 'std_ic_t2f_mou_9', 'roam_ic_mou_9']
```

```
# Creating a dataframe with the condition, in which MOU for Sep(9) are
null
df_null_mou_9 = df[(df['loc_og_t2m_mou_9'].isnull()) &
(df['loc_ic_t2f_mou_9'].isnull()) & (df['roam_og_mou_9'].isnull()) &
(df['std_ic_t2m_mou_9'].isnull()) &
  (df['loc_og_t2t_mou_9'].isnull()) &
(df['std_ic_t2t_mou_9'].isnull()) & (df['loc_og_t2f_mou_9'].isnull())
& (df['loc_ic_mou_9'].isnull()) &
  (df['loc_og_t2c_mou_9'].isnull()) & (df['loc_og_mou_9'].isnull()) &
(df['std_og_t2t_mou_9'].isnull()) & (df['roam_ic_mou_9'].isnull()) &
  (df['loc_ic_t2m_mou_9'].isnull()) &
(df['std_og_t2m_mou_9'].isnull()) & (df['loc_ic_t2t_mou_9'].isnull())
& (df['std_og_t2f_mou_9'].isnull()) &
  (df['std_og_t2c_mou_9'].isnull()) & (df['og_others_9'].isnull()) &
(df['std_og_mou_9'].isnull()) & (df['spl_og_mou_9'].isnull()) &
  (df['std_ic_t2f_mou_9'].isnull()) & (df['isd_og_mou_9'].isnull()) &
(df['std_ic_mou_9'].isnull()) & (df['offnet_mou_9'].isnull()) &
  (df['isd_ic_mou_9'].isnull()) & (df['ic_others_9'].isnull()) &
(df['std_ic_t2o_mou_9'].isnull()) & (df['onnet_mou_9'].isnull()) &
  (df['spl_ic_mou_9'].isnull())]

df_null_mou_9.head()
```

```
     mobile_number  loc_og_t2o_mou  std_og_t2o_mou  loc_ic_t2o_mou
arpu_6  \
7       7000701601             0.0             0.0             0.0
1069.180
97      7000589828             0.0             0.0             0.0
374.863
111     7001300706             0.0             0.0             0.0
596.301
143     7000106299             0.0             0.0             0.0
695.609
188     7000340381             0.0             0.0             0.0
734.641
```

```
       arpu_7    arpu_8  arpu_9  onnet_mou_6  onnet_mou_7  onnet_mou_8
\
7    1349.850  3171.480   500.0        57.84        54.68        52.29

97    294.023   183.043     0.0       433.59       415.66       221.06

111   146.073     0.000     0.0        55.19         3.26          NaN

143    39.981     0.000     0.0      1325.91        28.61          NaN

188   183.668     0.000     0.0         4.38         0.98          NaN


     onnet_mou_9  offnet_mou_6  offnet_mou_7  offnet_mou_8
offnet_mou_9  \
7            NaN        453.43        567.16        325.91
NaN
97           NaN         74.54         43.66         31.86
NaN
111          NaN         45.51         12.34           NaN
NaN
143          NaN         13.91          1.89           NaN
NaN
188          NaN        105.16         39.39           NaN
NaN

     roam_ic_mou_6  roam_ic_mou_7  roam_ic_mou_8  roam_ic_mou_9  \
7            16.23          33.49          31.64            NaN
97            0.00           0.00           6.16            NaN
111           0.00           0.00            NaN            NaN
143           0.00           8.94            NaN            NaN
188           0.00           0.00            NaN            NaN

     roam_og_mou_6  roam_og_mou_7  roam_og_mou_8  roam_og_mou_9  \
7            23.74          12.59          38.06            NaN
97            0.00           0.00          23.91            NaN
111           0.00           0.00            NaN            NaN
143           0.00           8.53            NaN            NaN
188           0.00           0.00            NaN            NaN

     loc_og_t2t_mou_6  loc_og_t2t_mou_7  loc_og_t2t_mou_8
loc_og_t2t_mou_9  \
7               51.39             31.38             40.28
NaN
97               2.83             16.19              9.73
NaN
111             55.19              3.26               NaN
NaN
143             18.89              6.83               NaN
NaN
```

```
188                4.38                0.98                 NaN
NaN

     loc_og_t2m_mou_6  loc_og_t2m_mou_7  loc_og_t2m_mou_8
loc_og_t2m_mou_9  \
7              308.63              447.38              162.28
NaN
97              16.99               23.14               17.79
NaN
111             43.83               12.34                 NaN
NaN
143              8.58                1.56                 NaN
NaN
188             99.81               38.98                 NaN
NaN

     loc_og_t2f_mou_6  loc_og_t2f_mou_7  loc_og_t2f_mou_8
loc_og_t2f_mou_9  \
7               62.13               55.14               53.23
NaN
97               3.54                1.46                1.83
NaN
111              0.00                0.00                 NaN
NaN
143              0.00                0.00                 NaN
NaN
188              5.34                0.41                 NaN
NaN

     loc_og_t2c_mou_6  loc_og_t2c_mou_7  loc_og_t2c_mou_8
loc_og_t2c_mou_9  \
7                0.00                 0.0                 0.0
NaN
97               0.40                 0.0                 0.0
NaN
111              0.00                 0.0                 NaN
NaN
143              2.09                 0.0                 NaN
NaN
188              0.00                 0.0                 NaN
NaN

     loc_og_mou_6  loc_og_mou_7  loc_og_mou_8  loc_og_mou_9
std_og_t2t_mou_6  \
7          422.16        533.91        255.79           NaN
4.30
97          23.38         40.81         29.36           NaN
430.76
111         99.03         15.61           NaN           NaN
0.00
```

```
143          27.48          8.39            NaN            NaN
1307.01
188         109.54         40.38            NaN            NaN
0.00

     std_og_t2t_mou_7  std_og_t2t_mou_8  std_og_t2t_mou_9
std_og_t2m_mou_6  \
7                23.29             12.01               NaN
49.89
97              399.46            191.31               NaN
53.59
111               0.00               NaN               NaN
0.00
143              13.58               NaN               NaN
1.95
188               0.00               NaN               NaN
0.00

     std_og_t2m_mou_7  std_og_t2m_mou_8  std_og_t2m_mou_9
std_og_t2f_mou_6  \
7                31.76             49.14               NaN
6.66
97               13.81              8.33               NaN
0.00
111               0.00               NaN               NaN
1.30
143               0.00               NaN               NaN
0.00
188               0.00               NaN               NaN
0.00

     std_og_t2f_mou_7  std_og_t2f_mou_8  std_og_t2f_mou_9
std_og_t2c_mou_6  \
7                20.08             16.68               NaN
0.0
97                0.00              0.00               NaN
0.0
111               0.00               NaN               NaN
0.0
143               0.00               NaN               NaN
0.0
188               0.00               NaN               NaN
0.0

     std_og_t2c_mou_7  std_og_t2c_mou_8  std_og_t2c_mou_9
std_og_mou_6  \
7                  0.0               0.0               NaN
60.86
97                 0.0               0.0               NaN
484.36
```

```
111              0.0              NaN              NaN
1.30
143              0.0              NaN              NaN
1308.96
188              0.0              NaN              NaN
0.00

     std_og_mou_7  std_og_mou_8  std_og_mou_9  isd_og_mou_6
isd_og_mou_7  \
7           75.14         77.84           NaN           0.0
0.18
97         413.28        199.64           NaN           0.0
0.00
111          0.00           NaN           NaN           0.0
0.00
143         13.58           NaN           NaN           0.0
0.00
188          0.00           NaN           NaN           0.0
0.00

     isd_og_mou_8  isd_og_mou_9  spl_og_mou_6  spl_og_mou_7
spl_og_mou_8  \
7           10.01           NaN          4.50          0.00
6.50
97           0.00           NaN          2.54         11.81
2.01
111           NaN           NaN          0.38          2.71
NaN
143           NaN           NaN          3.38          0.00
NaN
188           NaN           NaN          0.00          0.00
NaN

     spl_og_mou_9  og_others_6  og_others_7  og_others_8  og_others_9
\
7             NaN         0.00          0.0          0.0          NaN

97            NaN         0.86          0.0          0.0          NaN

111           NaN         1.29          0.0          NaN          NaN

143           NaN         1.20          0.0          NaN          NaN

188           NaN         0.00          0.0          NaN          NaN


     total_og_mou_6  total_og_mou_7  total_og_mou_8  total_og_mou_9  \
7            487.53          609.24          350.16             0.0
97           511.16          465.91          231.03             0.0
111          102.01           18.33            0.00             0.0
```

```
143       1341.03          21.98          0.00              0.0
188        109.54          40.38          0.00              0.0

     loc_ic_t2t_mou_6  loc_ic_t2t_mou_7  loc_ic_t2t_mou_8  
loc_ic_t2t_mou_9  \
7               58.14             32.26             27.31               
NaN   
97              11.61             32.89              4.46               
NaN   
111             50.01             16.66               NaN               
NaN   
143             30.19              7.06               NaN               
NaN   
188             21.18             13.44               NaN               
NaN   

     loc_ic_t2m_mou_6  loc_ic_t2m_mou_7  loc_ic_t2m_mou_8  
loc_ic_t2m_mou_9  \
7              217.56            221.49            121.19               
NaN   
97              16.94             26.94             26.63               
NaN   
111            160.68             58.53               NaN               
NaN   
143             27.98              1.35               NaN               
NaN   
188            217.03             56.63               NaN               
NaN   

     loc_ic_t2f_mou_6  loc_ic_t2f_mou_7  loc_ic_t2f_mou_8  
loc_ic_t2f_mou_9  \
7              152.16            101.46             39.53               
NaN   
97               0.98              0.63              0.00               
NaN   
111              5.06              0.40               NaN               
NaN   
143             10.13              0.00               NaN               
NaN   
188             18.28              2.94               NaN               
NaN   

     loc_ic_mou_6  loc_ic_mou_7  loc_ic_mou_8  loc_ic_mou_9  
std_ic_t2t_mou_6  \
7          427.88        355.23        188.04           NaN   
36.89   
97          29.54         60.48         31.09           NaN   
0.49   
111        215.76         75.59           NaN           NaN   
0.00   
```

```
143          68.31           8.41             NaN             NaN
25.56
188         256.49          73.03             NaN             NaN
0.00

     std_ic_t2t_mou_7  std_ic_t2t_mou_8  std_ic_t2t_mou_9
std_ic_t2m_mou_6  \
7                11.83             30.39               NaN
91.44
97                1.36              1.06               NaN
0.00
111               0.00               NaN               NaN
0.00
143               0.00               NaN               NaN
0.00
188               0.00               NaN               NaN
0.00

     std_ic_t2m_mou_7  std_ic_t2m_mou_8  std_ic_t2m_mou_9
std_ic_t2f_mou_6  \
7               126.99            141.33               NaN
52.19
97                4.16              0.00               NaN
0.00
111               0.00               NaN               NaN
1.13
143               0.00               NaN               NaN
0.00
188               0.00               NaN               NaN
0.00

     std_ic_t2f_mou_7  std_ic_t2f_mou_8  std_ic_t2f_mou_9
std_ic_t2o_mou_6  \
7                34.24             22.21               NaN
0.0
97                0.00              0.00               NaN
0.0
111               0.00               NaN               NaN
0.0
143               0.00               NaN               NaN
0.0
188               0.00               NaN               NaN
0.0

     std_ic_t2o_mou_7  std_ic_t2o_mou_8  std_ic_t2o_mou_9
std_ic_mou_6  \
7                  0.0               0.0               NaN
180.54
97                 0.0               0.0               NaN
0.49
```

```
111                 0.0                 NaN                 NaN
1.13
143                 0.0                 NaN                 NaN
25.56
188                 0.0                 NaN                 NaN
0.00

     std_ic_mou_7  std_ic_mou_8  std_ic_mou_9  total_ic_mou_6
total_ic_mou_7  \
7          173.08        193.94           NaN          626.46
558.04
97           5.53          1.06           NaN           32.04
67.84
111          0.00           NaN           NaN          217.04
75.59
143          0.00           NaN           NaN           93.88
8.41
188          0.00           NaN           NaN          256.49
73.03

     total_ic_mou_8  total_ic_mou_9  spl_ic_mou_6  spl_ic_mou_7
spl_ic_mou_8  \
7            428.74             0.0          0.21           0.0
0.0
97            32.16             0.0          0.63           0.0
0.0
111            0.00             0.0          0.00           0.0
NaN
143            0.00             0.0          0.00           0.0
NaN
188            0.00             0.0          0.00           0.0
NaN

     spl_ic_mou_9  isd_ic_mou_6  isd_ic_mou_7  isd_ic_mou_8
isd_ic_mou_9  \
7             NaN          2.06         14.53         31.59
NaN
97            NaN          0.00          0.00          0.00
NaN
111           NaN          0.00          0.00           NaN
NaN
143           NaN          0.00          0.00           NaN
NaN
188           NaN          0.00          0.00           NaN
NaN

     ic_others_6  ic_others_7  ic_others_8  ic_others_9
total_rech_num_6  \
7          15.74        15.19        15.14          NaN
5
```

```
97          1.36         1.83         0.00         NaN
14
111         0.15         0.00          NaN         NaN
12
143         0.00         0.00          NaN         NaN
31
188         0.00         0.00          NaN         NaN
6

     total_rech_num_7  total_rech_num_8  total_rech_num_9
total_rech_amt_6  \
7                   5                 7                 3
1580
97                 17                14                 3
432
111                 8                 5                 2
704
143                 6                 4                 2
796
188                 1                 0                 0
864

     total_rech_amt_7  total_rech_amt_8  total_rech_amt_9
max_rech_amt_6  \
7                 790              3638                 0
1580
97                328               206                 0
36
111               178                 0                 0
154
143                40                 0                 0
90
188               120                 0                 0
252

     max_rech_amt_7  max_rech_amt_8  max_rech_amt_9
last_day_rch_amt_6  \
7               790            1580               0
0
97               44              36               0
30
111              50               0               0
154
143              30               0               0
10
188             120               0               0
252

     last_day_rch_amt_7  last_day_rch_amt_8  last_day_rch_amt_9
vol_2g_mb_6  \
```

```
7                      0                  779                    0
0.00
97                    20                    0                    0
0.00
111                   30                    0                    0
284.50
143                    0                    0                    0
0.00
188                  120                    0                    0
58.44

     vol_2g_mb_7  vol_2g_mb_8  vol_2g_mb_9  vol_3g_mb_6
vol_3g_mb_7  \
7            0.0          0.0          0.0          0.0          0.0

97           0.0          0.0          0.0          0.0          0.0

111          0.0          0.0          0.0          0.0          0.0

143          0.0          0.0          0.0          0.0          0.0

188          0.0          0.0          0.0       1522.4          0.0


     vol_3g_mb_8  vol_3g_mb_9  monthly_2g_6  monthly_2g_7
monthly_2g_8  \
7            0.0          0.0             0             0
0
97           0.0          0.0             0             0
0
111          0.0          0.0             1             0
0
143          0.0          0.0             0             0
0
188          0.0          0.0             0             0
0

     monthly_2g_9  sachet_2g_6  sachet_2g_7  sachet_2g_8  sachet_2g_9
\
7               0            0            0            0            0

97              0            0            0            0            0

111             0            0            0            0            0

143             0            0            0            0            0

188             0            0            0            0            0


     monthly_3g_6  monthly_3g_7  monthly_3g_8  monthly_3g_9
```

```
sachet_3g_6  \
7                0             0             0             0
0
97               0             0             0             0
0
111              0             0             0             0
1
143              0             0             0             0
0
188              2             0             0             0
0

     sachet_3g_7  sachet_3g_8  sachet_3g_9  aon  aug_vbc_3g
jul_vbc_3g  \
7              0            0            0  802       57.74
19.38
97             0            0            0  502        0.00
0.00
111            0            0            0  332        0.00
0.00
143            0            0            0  264        0.00
0.00
188            0            0            0  244        0.00
831.48

     jun_vbc_3g  sep_vbc_3g  avg_rech_amt_6_7
7         18.74         0.0            1185.0
97         0.00         0.0             380.0
111        0.00         0.0             441.0
143        0.00         0.0             418.0
188     1223.04         0.0             492.0
```

```
df_null_mou_9.shape
```

```
(1590, 178)
```

```
# Deleting the records for which MOU for Sep(9) are null
df = df.drop(df_null_mou_9.index)
```

```
# Again Cheking percent of missing values in columns
df_missing_columns =
(round(((df.isnull().sum()/len(df.index))*100),2).to_frame('null')).so
rt_values('null', ascending=False)
df_missing_columns
```

	null
isd_og_mou_8	0.55
roam_ic_mou_8	0.55
loc_og_mou_8	0.55
std_ic_t2o_mou_8	0.55
roam_og_mou_8	0.55

```
loc_ic_t2f_mou_8  0.55
loc_og_t2t_mou_8  0.55
std_ic_t2f_mou_8  0.55
std_og_t2m_mou_8  0.55
loc_og_t2m_mou_8  0.55
std_og_t2t_mou_8  0.55
std_ic_t2m_mou_8  0.55
loc_og_t2f_mou_8  0.55
spl_og_mou_8      0.55
loc_ic_mou_8      0.55
loc_og_t2c_mou_8  0.55
std_ic_t2t_mou_8  0.55
loc_ic_t2m_mou_8  0.55
std_og_t2f_mou_8  0.55
spl_ic_mou_8      0.55
std_ic_mou_8      0.55
offnet_mou_8      0.55
ic_others_8       0.55
og_others_8       0.55
loc_ic_t2t_mou_8  0.55
onnet_mou_8       0.55
isd_ic_mou_8      0.55
std_og_t2c_mou_8  0.55
std_og_mou_8      0.55
isd_og_mou_6      0.50
...                ...
arpu_9            0.00
arpu_8            0.00
arpu_7            0.00
arpu_6            0.00
loc_ic_t2o_mou    0.00
std_og_t2o_mou    0.00
std_og_mou_9      0.00
spl_og_mou_9      0.00
isd_ic_mou_9      0.00
og_others_9       0.00
spl_ic_mou_9      0.00
total_ic_mou_9    0.00
total_ic_mou_8    0.00
total_ic_mou_7    0.00
total_ic_mou_6    0.00
std_ic_mou_9      0.00
std_ic_t2o_mou_9  0.00
std_ic_t2f_mou_9  0.00
std_ic_t2m_mou_9  0.00
std_ic_t2t_mou_9  0.00
loc_ic_mou_9      0.00
loc_ic_t2f_mou_9  0.00
loc_og_t2o_mou    0.00
```

```
loc_ic_t2m_mou_9  0.00
loc_ic_t2t_mou_9  0.00
total_og_mou_9    0.00
total_og_mou_8    0.00
total_og_mou_7    0.00
total_og_mou_6    0.00
avg_rech_amt_6_7  0.00

[178 rows x 1 columns]
```

Looks like MOU for all the types of calls for the month of Aug (8) have missing values together for any particular record.

Lets check the records for the MOU for Aug(8), in which these coulmns have missing values together.

```
# Listing the columns of MOU Aug(8)
print(((df_missing_columns[df_missing_columns['null'] ==
0.55]).index).to_list())

['isd_og_mou_8', 'roam_ic_mou_8', 'loc_og_mou_8', 'std_ic_t2o_mou_8',
'roam_og_mou_8', 'loc_ic_t2f_mou_8', 'loc_og_t2t_mou_8',
'std_ic_t2f_mou_8', 'std_og_t2m_mou_8', 'loc_og_t2m_mou_8',
'std_og_t2t_mou_8', 'std_ic_t2m_mou_8', 'loc_og_t2f_mou_8',
'spl_og_mou_8', 'loc_ic_mou_8', 'loc_og_t2c_mou_8',
'std_ic_t2t_mou_8', 'loc_ic_t2m_mou_8', 'std_og_t2f_mou_8',
'spl_ic_mou_8', 'std_ic_mou_8', 'offnet_mou_8', 'ic_others_8',
'og_others_8', 'loc_ic_t2t_mou_8', 'onnet_mou_8', 'isd_ic_mou_8',
'std_og_t2c_mou_8', 'std_og_mou_8']

# Creating a dataframe with the condition, in which MOU for Aug(8) are
null
df_null_mou_8 = df[(df['loc_og_t2m_mou_8'].isnull()) &
(df['loc_ic_t2f_mou_8'].isnull()) & (df['roam_og_mou_8'].isnull()) &
(df['std_ic_t2m_mou_8'].isnull()) &
  (df['loc_og_t2t_mou_8'].isnull()) &
(df['std_ic_t2t_mou_8'].isnull()) & (df['loc_og_t2f_mou_8'].isnull())
& (df['loc_ic_mou_8'].isnull()) &
  (df['loc_og_t2c_mou_8'].isnull()) & (df['loc_og_mou_8'].isnull()) &
(df['std_og_t2t_mou_8'].isnull()) & (df['roam_ic_mou_8'].isnull()) &
  (df['loc_ic_t2m_mou_8'].isnull()) &
(df['std_og_t2m_mou_8'].isnull()) & (df['loc_ic_t2t_mou_8'].isnull())
& (df['std_og_t2f_mou_8'].isnull()) &
  (df['std_og_t2c_mou_8'].isnull()) & (df['og_others_8'].isnull()) &
(df['std_og_mou_8'].isnull()) & (df['spl_og_mou_8'].isnull()) &
  (df['std_ic_t2f_mou_8'].isnull()) & (df['isd_og_mou_8'].isnull()) &
(df['std_ic_mou_8'].isnull()) & (df['offnet_mou_8'].isnull()) &
  (df['isd_ic_mou_8'].isnull()) & (df['ic_others_8'].isnull()) &
(df['std_ic_t2o_mou_8'].isnull()) & (df['onnet_mou_8'].isnull()) &
  (df['spl_ic_mou_8'].isnull())]
```

```
df_null_mou_8.head()

      mobile_number  loc_og_t2o_mou  std_og_t2o_mou  loc_ic_t2o_mou
arpu_6  \
375      7002252754             0.0             0.0             0.0
580.477
578      7000248548             0.0             0.0             0.0
569.612
788      7000636808             0.0             0.0             0.0
532.742
1802     7000516213             0.0             0.0             0.0
810.455
4837     7002192662             0.0             0.0             0.0
649.150

       arpu_7  arpu_8   arpu_9  onnet_mou_6  onnet_mou_7  onnet_mou_8
\
375   111.878     0.0  378.881       249.43        39.64          NaN

578   237.289     0.0    4.440       718.01       212.73          NaN

788   546.756     0.0  269.274      1173.39       891.83          NaN

1802    0.000     0.0    0.000        91.33          NaN          NaN

4837  149.572     0.0    0.250      1354.24        85.13          NaN


      onnet_mou_9  offnet_mou_6  offnet_mou_7  offnet_mou_8
offnet_mou_9  \
375        245.06         62.24         37.24           NaN
144.53
578          0.00        487.06        139.71           NaN
1.26
788        149.34         61.59        137.14           NaN
428.36
1802         0.00       1371.04           NaN           NaN
0.00
4837         0.43         50.63         37.13           NaN
0.00

      roam_ic_mou_6  roam_ic_mou_7  roam_ic_mou_8  roam_ic_mou_9  \
375           25.49          19.43            NaN           0.00
578            0.00           2.01            NaN           6.43
788            0.00           1.48            NaN           0.00
1802           1.21            NaN            NaN           0.00
4837           0.00          12.84            NaN           1.25

      roam_og_mou_6  roam_og_mou_7  roam_og_mou_8  roam_og_mou_9  \
```

```
375          312.59         78.58           NaN          0.00
578            0.00          6.30           NaN          1.26
788            0.00         14.43           NaN          0.00
1802          11.23           NaN           NaN          3.91
4837           0.00         44.78           NaN          0.43

      loc_og_t2t_mou_6  loc_og_t2t_mou_7  loc_og_t2t_mou_8
loc_og_t2t_mou_9  \
375               0.00              0.00               NaN
11.54
578              11.28             27.89               NaN
0.00
788              31.06             27.49               NaN
7.39
1802             17.86               NaN               NaN
0.00
4837              6.71              1.35               NaN
0.00

      loc_og_t2m_mou_6  loc_og_t2m_mou_7  loc_og_t2m_mou_8
loc_og_t2m_mou_9  \
375               0.00              0.00               NaN
25.31
578              42.24             46.94               NaN
0.00
788              34.66             60.86               NaN
34.23
1802             84.51               NaN               NaN
0.00
4837             15.18             15.76               NaN
0.00

      loc_og_t2f_mou_6  loc_og_t2f_mou_7  loc_og_t2f_mou_8
loc_og_t2f_mou_9  \
375                0.0               0.0               NaN
0.0
578                0.0               0.0               NaN
0.0
788                0.0               0.0               NaN
0.0
1802               0.0               NaN               NaN
0.0
4837               0.0               0.0               NaN
0.0

      loc_og_t2c_mou_6  loc_og_t2c_mou_7  loc_og_t2c_mou_8
loc_og_t2c_mou_9  \
375               0.00               0.0               NaN
0.41
578               2.33               0.0               NaN
```

```
0.00
788                0.00                0.0                NaN
5.58
1802              10.29                NaN                NaN
0.00
4837               0.00                0.0                NaN
0.00

      loc_og_mou_6  loc_og_mou_7  loc_og_mou_8  loc_og_mou_9  \
375           0.00          0.00           NaN         36.86
578          53.53         74.84           NaN          0.00
788          65.73         88.36           NaN         41.63
1802        102.38           NaN           NaN          0.00
4837         21.89         17.11           NaN          0.00

      std_og_t2t_mou_6  std_og_t2t_mou_7  std_og_t2t_mou_8
std_og_t2t_mou_9  \
375               0.00              0.00               NaN
233.51
578             706.73            178.53               NaN
0.00
788            1142.33            854.08               NaN
141.94
1802             73.46               NaN               NaN
0.00
4837           1347.53             48.48               NaN
0.00

      std_og_t2m_mou_6  std_og_t2m_mou_7  std_og_t2m_mou_8
std_og_t2m_mou_9  \
375               0.00              0.00               NaN
118.79
578             442.48             92.76               NaN
0.00
788              26.93             67.24               NaN
388.54
1802           1207.86               NaN               NaN
0.00
4837             35.44             11.88               NaN
0.00

      std_og_t2f_mou_6  std_og_t2f_mou_7  std_og_t2f_mou_8
std_og_t2f_mou_9  \
375                0.0               0.0               NaN
0.0
578                0.0               0.0               NaN
0.0
788                0.0               0.0               NaN
0.0
1802               0.0               NaN               NaN
```

```
0.0
4837                0.0                0.0                NaN
0.0

      std_og_t2c_mou_6  std_og_t2c_mou_7  std_og_t2c_mou_8
std_og_t2c_mou_9  \
375                0.0                0.0                NaN
0.0
578                0.0                0.0                NaN
0.0
788                0.0                0.0                NaN
0.0
1802               0.0                NaN                NaN
0.0
4837               0.0                0.0                NaN
0.0

      std_og_mou_6  std_og_mou_7  std_og_mou_8  std_og_mou_9
isd_og_mou_6  \
375           0.00          0.00           NaN        352.31
0.0
578        1149.21        271.29           NaN          0.00
0.0
788        1169.26        921.33           NaN        530.49
0.0
1802       1281.33           NaN           NaN          0.00
0.0
4837       1382.98         60.36           NaN          0.00
0.0

      isd_og_mou_7  isd_og_mou_8  isd_og_mou_9  spl_og_mou_6
spl_og_mou_7  \
375            0.0           NaN           0.0          0.00
0.00
578            0.0           NaN           0.0          2.58
1.21
788            0.0           NaN           0.0          0.00
4.85
1802           NaN           NaN           0.0         91.94
NaN
4837           0.0           NaN           0.0          0.00
0.00

      spl_og_mou_8  spl_og_mou_9  og_others_6  og_others_7
og_others_8  \
375            NaN          4.78         0.00          0.0
NaN
578            NaN          0.00         1.55          0.0
NaN
788            NaN          5.58         0.00          0.0
```

```
NaN
1802           NaN          0.00         1.53           NaN
NaN
4837           NaN          0.00         0.00           0.0
NaN

      og_others_9  total_og_mou_6  total_og_mou_7  total_og_mou_8  \
375           0.0            0.00            0.00             0.0
578           0.0         1206.88          347.36             0.0
788           0.0         1234.99         1014.54             0.0
1802          0.0         1477.19            0.00             0.0
4837          0.0         1404.88           77.48             0.0

      total_og_mou_9  loc_ic_t2t_mou_6  loc_ic_t2t_mou_7
loc_ic_t2t_mou_8  \
375           393.96              0.00              0.00
NaN
578             0.00             48.01             63.39
NaN
788           577.71             54.19             52.64
NaN
1802            0.00             17.68               NaN
NaN
4837            0.00            104.46              3.15
NaN

      loc_ic_t2t_mou_9  loc_ic_t2m_mou_6  loc_ic_t2m_mou_7
loc_ic_t2m_mou_8  \
375               6.74              0.00              0.00
NaN
578               0.00             83.09             64.31
NaN
788              12.51             54.69            187.96
NaN
1802              0.00             39.46               NaN
NaN
4837              0.00            162.01             17.94
NaN

      loc_ic_t2m_mou_9  loc_ic_t2f_mou_6  loc_ic_t2f_mou_7
loc_ic_t2f_mou_8  \
375              38.53              0.00              0.00
NaN
578               0.00              0.00              0.00
NaN
788              81.83              1.16              2.01
NaN
1802              0.00              0.70               NaN
NaN
4837              0.00              0.00              0.00
```

```
NaN

      loc_ic_t2f_mou_9  loc_ic_mou_6  loc_ic_mou_7  loc_ic_mou_8  \
375                0.0          0.00          0.00           NaN
578                0.0        131.11        127.71           NaN
788                0.0        110.06        242.63           NaN
1802               0.0         57.84           NaN           NaN
4837               0.0        266.48         21.09           NaN

      loc_ic_mou_9  std_ic_t2t_mou_6  std_ic_t2t_mou_7
std_ic_t2t_mou_8  \
375          45.28              0.00              0.00
NaN
578           0.00             24.98             46.43
NaN
788          94.34             14.55              5.48
NaN
1802          0.00              1.88               NaN
NaN
4837          0.00             35.11             31.96
NaN

      std_ic_t2t_mou_9  std_ic_t2m_mou_6  std_ic_t2m_mou_7
std_ic_t2m_mou_8  \
375               8.31              0.00              0.00
NaN
578               0.00              1.63             16.69
NaN
788              25.61             11.49             62.19
NaN
1802              0.00             11.98               NaN
NaN
4837              0.00             48.48              0.00
NaN

      std_ic_t2m_mou_9  std_ic_t2f_mou_6  std_ic_t2f_mou_7
std_ic_t2f_mou_8  \
375              27.31              0.00               0.0
NaN
578               0.00              0.00               0.0
NaN
788              13.93              0.00               0.0
NaN
1802              0.00              0.00               NaN
NaN
4837              0.00              0.28               0.0
NaN

      std_ic_t2f_mou_9  std_ic_t2o_mou_6  std_ic_t2o_mou_7
std_ic_t2o_mou_8  \
```

```
375                   0.0                 0.0                 0.0
NaN
578                   0.0                 0.0                 0.0
NaN
788                   0.0                 0.0                 0.0
NaN
1802                  0.0                 0.0                 NaN
NaN
4837                  0.0                 0.0                 0.0
NaN

      std_ic_t2o_mou_9  std_ic_mou_6  std_ic_mou_7  std_ic_mou_8  \
375                0.0          0.00          0.00           NaN
578                0.0         26.61         63.13           NaN
788                0.0         26.04         67.68           NaN
1802               0.0         13.86           NaN           NaN
4837               0.0         83.88         31.96           NaN

      std_ic_mou_9  total_ic_mou_6  total_ic_mou_7  total_ic_mou_8  \
375          35.63            0.00            0.00             0.0
578           0.00          157.73          190.84             0.0
788          39.54          140.74          310.31             0.0
1802          0.00           71.71            0.00             0.0
4837          0.00          350.36           53.06             0.0

      total_ic_mou_9  spl_ic_mou_6  spl_ic_mou_7  spl_ic_mou_8
spl_ic_mou_9  \
375            80.91          0.00           0.0           NaN
0.00
578             0.00          0.00           0.0           NaN
0.00
788           134.14          0.73           0.0           NaN
0.25
1802            0.00          0.00           NaN           NaN
0.00
4837            0.00          0.00           0.0           NaN
0.00

      isd_ic_mou_6  isd_ic_mou_7  isd_ic_mou_8  isd_ic_mou_9
ic_others_6  \
375            0.0           0.0           NaN           0.0
0.00
578            0.0           0.0           NaN           0.0
0.00
788            0.0           0.0           NaN           0.0
3.89
1802           0.0           NaN           NaN           0.0
0.00
4837           0.0           0.0           NaN           0.0
0.00
```

```
      ic_others_7  ic_others_8  ic_others_9  total_rech_num_6  \
375           0.0          NaN          0.0                17
578           0.0          NaN          0.0                19
788           0.0          NaN          0.0                10
1802          NaN          NaN          0.0                21
4837          0.0          NaN          0.0                11

      total_rech_num_7  total_rech_num_8  total_rech_num_9
total_rech_amt_6  \
375                  6                 3                11
700
578                 10                 0                 4
717
788                  7                 4                 5
714
1802                 3                 0                 0
955
4837                 6                 3                 4
666

      total_rech_amt_7  total_rech_amt_8  total_rech_amt_9
max_rech_amt_6  \
375                130                 0               440
80
578                220                 0                 0
110
788                494                 0               336
128
1802                 0                 0                 0
110
4837               176                 0                 0
110

      max_rech_amt_7  max_rech_amt_8  max_rech_amt_9
last_day_rch_amt_6  \
375               50               0              50
30
578               50               0               0
27
788              128               0             130
128
1802               0               0               0
30
4837             110               0               0
20

      last_day_rch_amt_7  last_day_rch_amt_8  last_day_rch_amt_9
vol_2g_mb_6  \
375                    0                   0                  30
```

```
0.0
578                    30                    0                   0
0.0
788                     0                    0                 130
0.0
1802                    0                    0                   0
0.0
4837                    0                    0                   0
0.0

      vol_2g_mb_7  vol_2g_mb_8  vol_2g_mb_9  vol_3g_mb_6  vol_3g_mb_7
\
375           0.0          0.0          0.0          0.0          0.0

578           0.0          0.0          0.0          0.0          0.0

788           0.0          0.0          0.0          0.0          0.0

1802          0.0          0.0          0.0          0.0          0.0

4837          0.0          0.0          0.0          0.0          0.0


      vol_3g_mb_8  vol_3g_mb_9  monthly_2g_6  monthly_2g_7
monthly_2g_8  \
375           0.0          0.0             0             0
0
578           0.0          0.0             0             0
0
788           0.0          0.0             0             0
0
1802          0.0          0.0             0             0
0
4837          0.0          0.0             0             0
0

      monthly_2g_9  sachet_2g_6  sachet_2g_7  sachet_2g_8  sachet_2g_9
\
375              0            0            0            0            0

578              0            0            0            0            0

788              0            0            0            0            0

1802             0            0            0            0            0

4837             0            0            0            0            0


      monthly_3g_6  monthly_3g_7  monthly_3g_8  monthly_3g_9
sachet_3g_6  \
```

```
375              0             0             0             0
0
578              0             0             0             0
0
788              0             0             0             0
0
1802             0             0             0             0
0
4837             0             0             0             0
0

      sachet_3g_7  sachet_3g_8  sachet_3g_9   aon  aug_vbc_3g
jul_vbc_3g  \
375             0            0            0  1102         0.0
0.0
578             0            0            0   274         0.0
0.0
788             0            0            0   936         0.0
0.0
1802            0            0            0   755         0.0
0.0
4837            0            0            0   520         0.0
0.0

      jun_vbc_3g  sep_vbc_3g  avg_rech_amt_6_7
375          0.0         0.0             415.0
578          0.0         0.0             468.5
788          0.0         0.0             604.0
1802         0.0         0.0             477.5
4837         0.0         0.0             421.0
```

```
# Deleting the records for which MOU for Aug(8) are null
df = df.drop(df_null_mou_8.index)

# Again cheking percent of missing values in columns
df_missing_columns =
(round(((df.isnull().sum()/len(df.index))*100),2).to_frame('null')).so
rt_values('null', ascending=False)
df_missing_columns
```

```
                  null
roam_ic_mou_6     0.44
spl_og_mou_6      0.44
og_others_6       0.44
loc_ic_t2t_mou_6  0.44
loc_og_t2m_mou_6  0.44
loc_og_t2c_mou_6  0.44
loc_ic_t2m_mou_6  0.44
isd_og_mou_6      0.44
loc_og_t2t_mou_6  0.44
```

```
std_og_t2m_mou_6  0.44
loc_ic_t2f_mou_6  0.44
ic_others_6       0.44
roam_og_mou_6     0.44
loc_ic_mou_6      0.44
std_og_mou_6      0.44
loc_og_t2f_mou_6  0.44
isd_ic_mou_6      0.44
std_ic_t2t_mou_6  0.44
std_ic_mou_6      0.44
std_og_t2t_mou_6  0.44
std_ic_t2o_mou_6  0.44
std_og_t2f_mou_6  0.44
std_ic_t2f_mou_6  0.44
spl_ic_mou_6      0.44
onnet_mou_6       0.44
std_og_t2c_mou_6  0.44
std_ic_t2m_mou_6  0.44
offnet_mou_6      0.44
loc_og_mou_6      0.44
std_og_t2f_mou_7  0.16
...                ...
loc_ic_t2m_mou_8  0.00
std_ic_t2o_mou_8  0.00
std_ic_t2f_mou_9  0.00
std_ic_t2f_mou_8  0.00
std_ic_t2m_mou_9  0.00
std_ic_t2m_mou_8  0.00
std_ic_t2t_mou_9  0.00
std_ic_t2t_mou_8  0.00
loc_ic_mou_9      0.00
loc_ic_mou_8      0.00
loc_ic_t2f_mou_9  0.00
loc_ic_t2f_mou_8  0.00
loc_og_t2o_mou    0.00
loc_ic_t2m_mou_9  0.00
loc_ic_t2t_mou_9  0.00
std_og_t2c_mou_9  0.00
loc_ic_t2t_mou_8  0.00
total_og_mou_9    0.00
total_og_mou_8    0.00
total_og_mou_7    0.00
total_og_mou_6    0.00
og_others_9       0.00
og_others_8       0.00
spl_og_mou_9      0.00
spl_og_mou_8      0.00
isd_og_mou_9      0.00
isd_og_mou_8      0.00
```

```
std_og_mou_9      0.00
std_og_mou_8      0.00
avg_rech_amt_6_7  0.00

[178 rows x 1 columns]
```

Looks like MOU for all the types of calls for the month of Jun (6) have missing values together for any particular record.

Lets check the records for the MOU for Jun(6), in which these coulmns have missing values together.

```
# Listing the columns of MOU Jun(6)
print(((df_missing_columns[df_missing_columns['null'] ==
0.44]).index).to_list())

['roam_ic_mou_6', 'spl_og_mou_6', 'og_others_6', 'loc_ic_t2t_mou_6',
'loc_og_t2m_mou_6', 'loc_og_t2c_mou_6', 'loc_ic_t2m_mou_6',
'isd_og_mou_6', 'loc_og_t2t_mou_6', 'std_og_t2m_mou_6',
'loc_ic_t2f_mou_6', 'ic_others_6', 'roam_og_mou_6', 'loc_ic_mou_6',
'std_og_mou_6', 'loc_og_t2f_mou_6', 'isd_ic_mou_6',
'std_ic_t2t_mou_6', 'std_ic_mou_6', 'std_og_t2t_mou_6',
'std_ic_t2o_mou_6', 'std_og_t2f_mou_6', 'std_ic_t2f_mou_6',
'spl_ic_mou_6', 'onnet_mou_6', 'std_og_t2c_mou_6', 'std_ic_t2m_mou_6',
'offnet_mou_6', 'loc_og_mou_6']

# Creating a dataframe with the condition, in which MOU for Jun(6) are
null
df_null_mou_6 = df[(df['loc_og_t2m_mou_6'].isnull()) &
(df['loc_ic_t2f_mou_6'].isnull()) & (df['roam_og_mou_6'].isnull()) &
(df['std_ic_t2m_mou_6'].isnull()) &
  (df['loc_og_t2t_mou_6'].isnull()) &
(df['std_ic_t2t_mou_6'].isnull()) & (df['loc_og_t2f_mou_6'].isnull())
& (df['loc_ic_mou_6'].isnull()) &
  (df['loc_og_t2c_mou_6'].isnull()) & (df['loc_og_mou_6'].isnull()) &
(df['std_og_t2t_mou_6'].isnull()) & (df['roam_ic_mou_6'].isnull()) &
  (df['loc_ic_t2m_mou_6'].isnull()) &
(df['std_og_t2m_mou_6'].isnull()) & (df['loc_ic_t2t_mou_6'].isnull())
& (df['std_og_t2f_mou_6'].isnull()) &
  (df['std_og_t2c_mou_6'].isnull()) & (df['og_others_6'].isnull()) &
(df['std_og_mou_6'].isnull()) & (df['spl_og_mou_6'].isnull()) &
  (df['std_ic_t2f_mou_6'].isnull()) & (df['isd_og_mou_6'].isnull()) &
(df['std_ic_mou_6'].isnull()) & (df['offnet_mou_6'].isnull()) &
  (df['isd_ic_mou_6'].isnull()) & (df['ic_others_6'].isnull()) &
(df['std_ic_t2o_mou_6'].isnull()) & (df['onnet_mou_6'].isnull()) &
  (df['spl_ic_mou_6'].isnull())]

df_null_mou_6.head()
```

```
      mobile_number  loc_og_t2o_mou  std_og_t2o_mou  loc_ic_t2o_mou
arpu_6  \
77       7001328263             0.0             0.0             0.0
30.000
364      7002168045             0.0             0.0             0.0
0.000
423      7000635248             0.0             0.0             0.0
213.802
934      7002152278             0.0             0.0             0.0
48.000
1187     7000486275             0.0             0.0             0.0
0.000

       arpu_7   arpu_8   arpu_9  onnet_mou_6  onnet_mou_7  onnet_mou_8
\
77     82.378  674.950  158.710          NaN        34.23       149.69

364   792.112  989.368  923.040          NaN       433.49       198.96

423   304.194  149.710  329.643          NaN         0.00         0.00

934   764.152  500.030  194.400          NaN        14.24        17.48

1187  757.170  995.719    0.000          NaN      1366.71      2268.91


      onnet_mou_9  offnet_mou_6  offnet_mou_7  offnet_mou_8
offnet_mou_9  \
77           6.31           NaN         39.44        179.18
57.68
364        571.99           NaN        845.11        923.58
828.29
423          0.00           NaN         10.03          1.45
0.34
934          7.69           NaN         16.99         76.86
43.64
1187         0.00           NaN          7.78         36.13
0.00

      roam_ic_mou_6  roam_ic_mou_7  roam_ic_mou_8  roam_ic_mou_9  \
77              NaN            0.0           0.00            0.0
364             NaN            0.0           0.00            0.0
423             NaN            0.0           0.00            0.0
934             NaN            0.0           8.81            0.0
1187            NaN            0.0           8.08            0.0

      roam_og_mou_6  roam_og_mou_7  roam_og_mou_8  roam_og_mou_9  \
77              NaN            0.0           0.00           0.00
364             NaN            0.0           0.00           0.00
423             NaN            0.0           0.00           0.00
934             NaN            0.0           1.56           0.00
```

```
1187             NaN             0.0           25.23            0.21

      loc_og_t2t_mou_6  loc_og_t2t_mou_7  loc_og_t2t_mou_8
loc_og_t2t_mou_9  \
77                 NaN             34.23            149.69
6.31
364                NaN             28.78              7.46
64.73
423                NaN              0.00              0.00
0.00
934                NaN              0.08             17.48
7.69
1187               NaN              4.76             46.18
0.00

      loc_og_t2m_mou_6  loc_og_t2m_mou_7  loc_og_t2m_mou_8
loc_og_t2m_mou_9  \
77                 NaN             32.18            101.63
29.41
364                NaN             78.78            584.76
490.71
423                NaN              0.00              0.58
0.33
934                NaN             16.99             63.23
39.99
1187               NaN              7.78             31.29
0.00

      loc_og_t2f_mou_6  loc_og_t2f_mou_7  loc_og_t2f_mou_8
loc_og_t2f_mou_9  \
77                 NaN              0.91             29.86
28.26
364                NaN             21.58              9.43
0.00
423                NaN              0.00              0.00
0.00
934                NaN              0.00             12.08
3.65
1187               NaN              0.00              0.00
0.00

      loc_og_t2c_mou_6  loc_og_t2c_mou_7  loc_og_t2c_mou_8
loc_og_t2c_mou_9  \
77                 NaN               0.0               3.9
0.00
364                NaN               0.0               0.0
2.78
423                NaN               0.0               0.0
0.00
934                NaN               0.0               0.0
```

```
0.00
1187                 NaN                 0.0                 0.0
0.00

      loc_og_mou_6  loc_og_mou_7  loc_og_mou_8  loc_og_mou_9  \
77             NaN         67.33        281.19         63.99
364            NaN        129.14        601.66        555.44
423            NaN          0.00          0.58          0.33
934            NaN         17.08         92.79         51.34
1187           NaN         12.54         77.48          0.00

      std_og_t2t_mou_6  std_og_t2t_mou_7  std_og_t2t_mou_8
std_og_t2t_mou_9  \
77                 NaN              0.00              0.00
0.00
364                NaN            404.71            191.49
507.26
423                NaN              0.00              0.00
0.00
934                NaN             14.16              0.00
0.00
1187               NaN           1361.94           2202.03
0.00

      std_og_t2m_mou_6  std_og_t2m_mou_7  std_og_t2m_mou_8
std_og_t2m_mou_9  \
77                 NaN              0.00              0.00
0.00
364                NaN            722.01            321.41
302.91
423                NaN              0.00              0.25
0.00
934                NaN              0.00              0.00
0.00
1187               NaN              0.00              1.13
0.00

      std_og_t2f_mou_6  std_og_t2f_mou_7  std_og_t2f_mou_8
std_og_t2f_mou_9  \
77                 NaN              6.35             40.09
0.0
364                NaN              0.00              0.00
0.0
423                NaN              0.00              0.61
0.0
934                NaN              0.00              0.00
0.0
1187               NaN              0.00              0.00
0.0
```

```
      std_og_t2c_mou_6  std_og_t2c_mou_7  std_og_t2c_mou_8
std_og_t2c_mou_9  \
77                 NaN               0.0               0.0
0.0
364                NaN               0.0               0.0
0.0
423                NaN               0.0               0.0
0.0
934                NaN               0.0               0.0
0.0
1187               NaN               0.0               0.0
0.0

      std_og_mou_6  std_og_mou_7  std_og_mou_8  std_og_mou_9
isd_og_mou_6  \
77             NaN          6.35         40.09          0.00
NaN
364            NaN       1126.73        512.91        810.18
NaN
423            NaN          0.00          0.86          0.00
NaN
934            NaN         14.16          0.00          0.00
NaN
1187           NaN       1361.94       2203.16          0.00
NaN

      isd_og_mou_7  isd_og_mou_8  isd_og_mou_9  spl_og_mou_6
spl_og_mou_7  \
77            2.93         28.04          3.25           NaN
0.00
364           0.00          0.00          0.00           NaN
45.14
423          10.03          0.00          0.01           NaN
0.00
934          20.13          8.41          0.00           NaN
0.00
1187          0.00          0.00          0.00           NaN
3.34

      spl_og_mou_8  spl_og_mou_9  og_others_6  og_others_7
og_others_8  \
77            7.58          0.00          NaN          0.0
0.0
364          13.84         37.74          NaN          0.0
0.0
423           0.00          0.00          NaN          0.0
0.0
934           0.00          0.00          NaN          0.0
0.0
1187          1.78          0.00          NaN          0.0
```

```
0.0

      og_others_9  total_og_mou_6  total_og_mou_7  total_og_mou_8  \
77            0.0             0.0           76.61          356.93
364           0.0             0.0         1301.03         1128.43
423           0.0             0.0           10.03            1.45
934           0.0             0.0           51.38          101.21
1187          0.0             0.0         1377.84         2282.43

      total_og_mou_9  loc_ic_t2t_mou_6  loc_ic_t2t_mou_7
loc_ic_t2t_mou_8  \
77             67.24               NaN             79.46
191.24
364          1403.38               NaN              7.41
10.23
423             0.34               NaN              0.00
0.00
934            51.34               NaN              0.39
20.09
1187            0.00               NaN             19.34
56.38

      loc_ic_t2t_mou_9  loc_ic_t2m_mou_6  loc_ic_t2m_mou_7
loc_ic_t2m_mou_8  \
77                5.26               NaN             43.31
94.18
364              17.46               NaN             69.39
93.48
423               0.00               NaN              0.00
0.00
934              12.19               NaN              4.53
51.16
1187              0.00               NaN             28.19
16.31

      loc_ic_t2m_mou_9  loc_ic_t2f_mou_6  loc_ic_t2f_mou_7
loc_ic_t2f_mou_8  \
77               16.39               NaN              2.03
0.00
364              44.89               NaN              0.00
0.83
423               0.00               NaN              0.00
0.00
934              59.83               NaN              7.80
17.08
1187              0.00               NaN              0.00
0.00

      loc_ic_t2f_mou_9  loc_ic_mou_6  loc_ic_mou_7  loc_ic_mou_8  \
77               15.78           NaN        124.81        285.43
```

```
364                 0.00            NaN          76.81         104.54
423                 0.00            NaN           0.00           0.00
934                 5.13            NaN          12.73          88.34
1187                0.00            NaN          47.54          72.69

      loc_ic_mou_9  std_ic_t2t_mou_6  std_ic_t2t_mou_7
std_ic_t2t_mou_8  \
77           37.44               NaN              8.00
0.00
364          62.36               NaN              5.81
10.09
423           0.00               NaN              0.00
0.00
934          77.16               NaN              0.00
0.00
1187          0.00               NaN            125.44
149.81

      std_ic_t2t_mou_9  std_ic_t2m_mou_6  std_ic_t2m_mou_7
std_ic_t2m_mou_8  \
77                0.00               NaN              0.00
0.00
364              22.36               NaN             37.94
86.63
423               0.00               NaN              0.00
0.00
934               0.00               NaN              0.00
0.00
1187              0.00               NaN              9.84
17.06

      std_ic_t2m_mou_9  std_ic_t2f_mou_6  std_ic_t2f_mou_7
std_ic_t2f_mou_8  \
77                0.00               NaN               0.0
0.00
364              34.49               NaN               0.0
0.00
423               0.00               NaN               0.0
0.36
934               0.00               NaN               0.0
0.00
1187              0.00               NaN               0.0
0.00

      std_ic_t2f_mou_9  std_ic_t2o_mou_6  std_ic_t2o_mou_7
std_ic_t2o_mou_8  \
77               15.93               NaN               0.0
0.0
364               0.00               NaN               0.0
0.0
```

```
423             0.00             NaN             0.0
0.0
934             0.00             NaN             0.0
0.0
1187            0.00             NaN             0.0
0.0

      std_ic_t2o_mou_9  std_ic_mou_6  std_ic_mou_7  std_ic_mou_8  \
77                 0.0           NaN          8.00          0.00
364                0.0           NaN         43.76         96.73
423                0.0           NaN          0.00          0.36
934                0.0           NaN          0.00          0.00
1187               0.0           NaN        135.29        166.88

      std_ic_mou_9  total_ic_mou_6  total_ic_mou_7  total_ic_mou_8  \
77           15.93             0.0          135.38          289.33
364          56.86             0.0          185.14          219.59
423           0.00             0.0            8.31            0.36
934           0.00             0.0           14.69          100.94
1187          0.00             0.0          182.84          239.58

      total_ic_mou_9  spl_ic_mou_6  spl_ic_mou_7  spl_ic_mou_8
spl_ic_mou_9  \
77             53.38           NaN           0.0           0.0
0.0
364           129.19           NaN           0.0           0.0
0.0
423             0.00           NaN           0.0           0.0
0.0
934            78.99           NaN           0.0           0.0
0.0
1187            0.00           NaN           0.0           0.0
0.0

      isd_ic_mou_6  isd_ic_mou_7  isd_ic_mou_8  isd_ic_mou_9
ic_others_6  \
77             NaN          2.56          0.50          0.00
NaN
364            NaN         64.56         18.31          9.96
NaN
423            NaN          8.31          0.00          0.00
NaN
934            NaN          1.96         12.59          1.83
NaN
1187           NaN          0.00          0.00          0.00
NaN

      ic_others_7  ic_others_8  ic_others_9  total_rech_num_6  \
77            0.0         3.39          0.0                 4
364           0.0         0.00          0.0                 4
```

```
423           0.0         0.00          0.0                   4
934           0.0         0.00          0.0                   3
1187          0.0         0.00          0.0                   2

      total_rech_num_7  total_rech_num_8  total_rech_num_9
total_rech_amt_6  \
77                   5                 3                 3
0
364                 12                24                20
0
423                  4                 3                 3
252
934                  4                 9                 4
0
1187                20                24                 6
0

      total_rech_amt_7  total_rech_amt_8  total_rech_amt_9
max_rech_amt_6  \
77                1154               750                 0
0
364                970              1104              1214
0
423                591                 0               382
252
934               1302               150               108
0
1187               883              1160                 0
0

      max_rech_amt_7  max_rech_amt_8  max_rech_amt_9
last_day_rch_amt_6  \
77              1000             750               0
0
364              154             154             250
0
423              339               0             252
252
934              550             150              54
0
1187             150             250               0
0

      last_day_rch_amt_7  last_day_rch_amt_8  last_day_rch_amt_9
vol_2g_mb_6  \
77                     0                 750                   0
0.0
364                   50                  50                   0
0.0
423                    0                   0                   0
```

```
3.3
934                     0                   150                     0
0.0
1187                   30                     0                     0
0.0

      vol_2g_mb_7  vol_2g_mb_8  vol_2g_mb_9  vol_3g_mb_6  vol_3g_mb_7
\
77          96.48         0.00         0.00         0.00         0.00

364        565.78      2108.66         0.00         0.00         0.00

423         38.45         0.00         4.52       669.36       837.18

934          0.31        38.77        78.66         0.00      1045.79

1187         0.00         0.00         0.00         0.00         0.00


      vol_3g_mb_8  vol_3g_mb_9  monthly_2g_6  monthly_2g_7
monthly_2g_8  \
77           0.00         0.00             0             1
0
364          0.00         0.00             0             1
1
423          0.00       423.59             0             0
0
934        245.91       471.48             0             0
0
1187         0.00         0.00             0             0
0

      monthly_2g_9  sachet_2g_6  sachet_2g_7  sachet_2g_8  sachet_2g_9
\
77               0            0            0            0            0

364              0            0            0            2            0

423              0            0            0            0            0

934              0            0            0            0            0

1187             0            0            0            0            0


      monthly_3g_6  monthly_3g_7  monthly_3g_8  monthly_3g_9
sachet_3g_6  \
77               0             0             0             0
0
364              0             0             0             0
0
```

```
423                 1              1              0              1
0
934                 0              1              1              0
0
1187                0              0              0              0
0

      sachet_3g_7  sachet_3g_8  sachet_3g_9   aon  aug_vbc_3g
jul_vbc_3g  \
77              0            0            0  1894        0.00
0.00
364             0            1            0   424        0.00
0.00
423             0            0            0   945       73.55
266.94
934             0            2            1   490      188.83
215.00
1187            0            0            0   737        0.00
0.00

      jun_vbc_3g  sep_vbc_3g  avg_rech_amt_6_7
77          0.00        0.00             577.0
364         0.00        0.00             485.0
423        63.04        0.00             421.5
934         0.00       24.18             651.0
1187        0.00        0.00             441.5
```

```
# Deleting the records for which MOU for Jun(6) are null
df = df.drop(df_null_mou_6.index)

# Again cheking percent of missing values in columns
df_missing_columns =
(round(((df.isnull().sum()/len(df.index))*100),2).to_frame('null')).so
rt_values('null', ascending=False)
df_missing_columns
```

```
                  null
loc_ic_t2f_mou_7  0.12
isd_ic_mou_7      0.12
loc_og_t2f_mou_7  0.12
loc_og_t2c_mou_7  0.12
loc_og_mou_7      0.12
std_og_t2t_mou_7  0.12
std_og_t2f_mou_7  0.12
std_og_t2c_mou_7  0.12
std_og_mou_7      0.12
ic_others_7       0.12
isd_og_mou_7      0.12
spl_og_mou_7      0.12
loc_og_t2t_mou_7  0.12
```

```
og_others_7        0.12
spl_ic_mou_7       0.12
loc_ic_t2t_mou_7   0.12
std_ic_mou_7       0.12
loc_ic_t2m_mou_7   0.12
std_ic_t2o_mou_7   0.12
std_ic_t2f_mou_7   0.12
loc_ic_mou_7       0.12
std_ic_t2t_mou_7   0.12
loc_og_t2m_mou_7   0.12
std_og_t2m_mou_7   0.12
std_ic_t2m_mou_7   0.12
roam_ic_mou_7      0.12
onnet_mou_7        0.12
roam_og_mou_7      0.12
offnet_mou_7       0.12
isd_ic_mou_8       0.00
...                 ...
loc_ic_t2m_mou_8   0.00
loc_ic_t2f_mou_6   0.00
std_og_t2f_mou_6   0.00
loc_og_t2o_mou     0.00
loc_ic_t2f_mou_8   0.00
loc_ic_t2f_mou_9   0.00
loc_ic_mou_6       0.00
loc_ic_mou_8       0.00
loc_ic_mou_9       0.00
std_ic_t2t_mou_6   0.00
total_og_mou_7     0.00
total_og_mou_6     0.00
og_others_9        0.00
og_others_8        0.00
std_og_t2f_mou_8   0.00
std_og_t2f_mou_9   0.00
std_og_t2c_mou_6   0.00
std_og_t2c_mou_8   0.00
std_og_t2c_mou_9   0.00
std_og_mou_6       0.00
std_og_mou_8       0.00
std_og_mou_9       0.00
isd_og_mou_6       0.00
isd_og_mou_8       0.00
isd_og_mou_9       0.00
spl_og_mou_6       0.00
spl_og_mou_8       0.00
spl_og_mou_9       0.00
og_others_6        0.00
avg_rech_amt_6_7   0.00
```

```
[178 rows x 1 columns]
```

Looks like MOU for all the types of calls for the month of July (7) have missing values together for any particular record.

Lets check the records for the MOU for Jul(7), in which these coulmns have missing values together.

```
# Listing the columns of MOU Jul(7)
print(((df_missing_columns[df_missing_columns['null'] ==
0.12]).index).to_list())
```

```
['loc_ic_t2f_mou_7', 'isd_ic_mou_7', 'loc_og_t2f_mou_7',
'loc_og_t2c_mou_7', 'loc_og_mou_7', 'std_og_t2t_mou_7',
'std_og_t2f_mou_7', 'std_og_t2c_mou_7', 'std_og_mou_7', 'ic_others_7',
'isd_og_mou_7', 'spl_og_mou_7', 'loc_og_t2t_mou_7', 'og_others_7',
'spl_ic_mou_7', 'loc_ic_t2t_mou_7', 'std_ic_mou_7',
'loc_ic_t2m_mou_7', 'std_ic_t2o_mou_7', 'std_ic_t2f_mou_7',
'loc_ic_mou_7', 'std_ic_t2t_mou_7', 'loc_og_t2m_mou_7',
'std_og_t2m_mou_7', 'std_ic_t2m_mou_7', 'roam_ic_mou_7',
'onnet_mou_7', 'roam_og_mou_7', 'offnet_mou_7']
```

```
# Creating a dataframe with the condition, in which MOU for Jul(7) are
null
df_null_mou_7 = df[(df['loc_og_t2m_mou_7'].isnull()) &
(df['loc_ic_t2f_mou_7'].isnull()) & (df['roam_og_mou_7'].isnull()) &
(df['std_ic_t2m_mou_7'].isnull()) &
  (df['loc_og_t2t_mou_7'].isnull()) &
(df['std_ic_t2t_mou_7'].isnull()) & (df['loc_og_t2f_mou_7'].isnull())
& (df['loc_ic_mou_7'].isnull()) &
  (df['loc_og_t2c_mou_7'].isnull()) & (df['loc_og_mou_7'].isnull()) &
(df['std_og_t2t_mou_7'].isnull()) & (df['roam_ic_mou_7'].isnull()) &
  (df['loc_ic_t2m_mou_7'].isnull()) &
(df['std_og_t2m_mou_7'].isnull()) & (df['loc_ic_t2t_mou_7'].isnull())
& (df['std_og_t2f_mou_7'].isnull()) &
  (df['std_og_t2c_mou_7'].isnull()) & (df['og_others_7'].isnull()) &
(df['std_og_mou_7'].isnull()) & (df['spl_og_mou_7'].isnull()) &
  (df['std_ic_t2f_mou_7'].isnull()) & (df['isd_og_mou_7'].isnull()) &
(df['std_ic_mou_7'].isnull()) & (df['offnet_mou_7'].isnull()) &
  (df['isd_ic_mou_7'].isnull()) & (df['ic_others_7'].isnull()) &
(df['std_ic_t2o_mou_7'].isnull()) & (df['onnet_mou_7'].isnull()) &
  (df['spl_ic_mou_7'].isnull())]

df_null_mou_7.head()
```

```
       mobile_number  loc_og_t2o_mou  std_og_t2o_mou
loc_ic_t2o_mou  \
5616      7001238202             0.0             0.0             0.0
```

```
9451      7001477649             0.0             0.0             0.0

9955      7001658068             0.0             0.0             0.0

10724     7001391499             0.0             0.0             0.0

12107     7000131738             0.0             0.0             0.0


         arpu_6   arpu_7   arpu_8    arpu_9  onnet_mou_6  onnet_mou_7
\
5616    760.815  531.088  992.818  1144.676       324.91          NaN

9451   1129.566    0.000  128.252   802.648        11.89          NaN

9955    925.028  189.000  789.761   445.707        46.39          NaN

10724   894.818   85.000  207.040   363.314       117.21          NaN

12107  1803.475    0.000    0.600    25.243      1742.61          NaN


       onnet_mou_8  onnet_mou_9  offnet_mou_6  offnet_mou_7
offnet_mou_8  \
5616        386.13      1180.29        350.29           NaN
399.64
9451          1.46        33.89        259.18           NaN
26.21
9955         43.39        56.61        333.78           NaN
196.53
10724        97.01        35.43        119.79           NaN
12.79
12107         0.00         0.00        278.79           NaN
14.29

       offnet_mou_9  roam_ic_mou_6  roam_ic_mou_7  roam_ic_mou_8  \
5616         887.76         463.63            NaN         221.46
9451         241.18           9.98            NaN           1.73
9955         144.73           0.00            NaN           0.00
10724         92.04           0.00            NaN           0.00
12107          4.50           0.00            NaN           0.00

       roam_ic_mou_9  roam_og_mou_6  roam_og_mou_7  roam_og_mou_8  \
5616             0.0         505.71            NaN         175.93
9451             0.0           5.66            NaN           2.46
9955             0.0           0.00            NaN           0.00
10724            0.0           0.00            NaN           0.00
12107            0.0           0.00            NaN           0.00

       roam_og_mou_9  loc_og_t2t_mou_6  loc_og_t2t_mou_7
loc_og_t2t_mou_8  \
```

```
5616               0.0             145.91               NaN
243.43
9451               0.0               6.73               NaN
1.46
9955               0.0              46.39               NaN
43.39
10724              0.0             115.08               NaN
97.01
12107              0.0              96.08               NaN
0.00

       loc_og_t2t_mou_9  loc_og_t2m_mou_6  loc_og_t2m_mou_7
loc_og_t2m_mou_8  \
5616            1108.38              0.85               NaN
184.78
9451              20.84            171.46               NaN
20.54
9955              56.61            227.91               NaN
163.68
10724             34.98             86.39               NaN
6.59
12107              0.00             64.98               NaN
0.86

       loc_og_t2m_mou_9  loc_og_t2f_mou_6  loc_og_t2f_mou_7
loc_og_t2f_mou_8  \
5616             300.19              1.13               NaN
7.94
9451             148.88              0.00               NaN
0.00
9955             121.54            104.69               NaN
28.96
10724             55.44             17.18               NaN
6.19
12107              0.00              0.00               NaN
0.00

       loc_og_t2f_mou_9  loc_og_t2c_mou_6  loc_og_t2c_mou_7
loc_og_t2c_mou_8  \
5616              67.11              0.00               NaN
12.51
9451               0.00              0.00               NaN
0.00
9955              21.04              0.00               NaN
0.00
10724             28.08              0.00               NaN
0.00
12107              0.00             50.03               NaN
13.43
```

```
       loc_og_t2c_mou_9  loc_og_mou_6  loc_og_mou_7  loc_og_mou_8  \
5616              18.89        147.89           NaN        436.16   
9451               0.00        178.19           NaN         22.01   
9955               0.00        379.01           NaN        236.04   
10724              0.05        218.66           NaN        109.81   
12107              4.50        161.06           NaN          0.86   

       loc_og_mou_9  std_og_t2t_mou_6  std_og_t2t_mou_7  
std_og_t2t_mou_8  \
5616        1475.69              0.96               NaN  
17.06   
9451         169.73              5.16               NaN  
0.00   
9955         199.21              0.00               NaN  
0.00   
10724        118.51              2.13               NaN  
0.00   
12107          0.00           1646.53               NaN  
0.00   

       std_og_t2t_mou_9  std_og_t2m_mou_6  std_og_t2m_mou_7  
std_og_t2m_mou_8  \
5616              69.51             15.91               NaN  
144.04   
9451              13.05              0.00               NaN  
0.00   
9955               0.00              0.00               NaN  
0.00   
10724              0.45              2.43               NaN  
0.00   
12107              0.00            140.16               NaN  
0.00   

       std_og_t2m_mou_9  std_og_t2f_mou_6  std_og_t2f_mou_7  
std_og_t2f_mou_8  \
5616             490.61              0.00               NaN  
0.0   
9451               0.00              0.00               NaN  
0.0   
9955               1.26              1.16               NaN  
2.9   
10724              7.18              6.09               NaN  
0.0   
12107              0.00              1.26               NaN  
0.0   

       std_og_t2f_mou_9  std_og_t2c_mou_6  std_og_t2c_mou_7  
std_og_t2c_mou_8  \
5616              13.33               0.0               NaN  
0.0   
```

```
9451                0.00                0.0                NaN
0.0
9955                0.00                0.0                NaN
0.0
10724               1.28                0.0                NaN
0.0
12107               0.00                0.0                NaN
0.0

       std_og_t2c_mou_9  std_og_mou_6  std_og_mou_7  std_og_mou_8  \
5616                0.0         16.88           NaN        161.11
9451                0.0          5.16           NaN          0.00
9955                0.0          1.16           NaN          2.90
10724               0.0         10.66           NaN          0.00
12107               0.0       1787.96           NaN          0.00

       std_og_mou_9  isd_og_mou_6  isd_og_mou_7  isd_og_mou_8
isd_og_mou_9  \
5616         573.46          0.00           NaN          0.00
0.00
9451          13.05         74.91           NaN          4.74
92.29
9955           1.26         53.14           NaN         31.06
33.69
10724          8.91         16.86           NaN          6.21
2.18
12107          0.00          0.00           NaN          0.00
0.00

       spl_og_mou_6  spl_og_mou_7  spl_og_mou_8  spl_og_mou_9
og_others_6  \
5616           4.71           NaN         12.56         18.89
0.00
9451           7.13           NaN          0.00          1.08
0.00
9955           0.00           NaN          0.00          0.00
0.00
10724          0.00           NaN          0.00          0.05
0.00
12107         72.61           NaN         13.43          4.50
1.76

       og_others_7  og_others_8  og_others_9  total_og_mou_6
total_og_mou_7  \
5616           NaN          0.0          0.0          169.49
0.0
9451           NaN          0.0          0.0          265.41
0.0
9955           NaN          0.0          0.0          433.33
0.0
```

```
10724          NaN          0.0          0.0          246.19
0.0
12107          NaN          0.0          0.0         2023.41
0.0

       total_og_mou_8  total_og_mou_9  loc_ic_t2t_mou_6
loc_ic_t2t_mou_7  \
5616           609.84         2068.06             78.76
NaN
9451            26.76          276.16             17.24
NaN
9955           270.01          234.18             80.98
NaN
10724          116.03          129.66            887.04
NaN
12107           14.29            4.50             65.76
NaN

       loc_ic_t2t_mou_8  loc_ic_t2t_mou_9  loc_ic_t2m_mou_6
loc_ic_t2m_mou_7  \
5616             233.66            558.84              1.36
NaN
9451               0.60             36.69            130.09
NaN
9955              32.69            112.14            201.38
NaN
10724            200.51            408.66            104.18
NaN
12107              1.73              5.88             92.18
NaN

       loc_ic_t2m_mou_8  loc_ic_t2m_mou_9  loc_ic_t2f_mou_6
loc_ic_t2f_mou_7  \
5616              11.53             75.31              6.61
NaN
9451              16.54            110.19             25.46
NaN
9955             169.24            155.58             41.68
NaN
10724             22.24             76.39             16.74
NaN
12107              5.59              2.75              0.00
NaN

       loc_ic_t2f_mou_8  loc_ic_t2f_mou_9  loc_ic_mou_6  loc_ic_mou_7
\
5616               0.00             31.81         86.74           NaN

9451               8.76             40.24        172.81           NaN
```

```
9955             25.68              12.33        324.04            NaN

10724             1.61              28.18       1007.98            NaN

12107             0.00               0.00        157.94            NaN


       loc_ic_mou_8  loc_ic_mou_9  std_ic_t2t_mou_6  std_ic_t2t_mou_7
\
5616         245.19        665.98              0.00               NaN

9451          25.91        187.14              1.50               NaN

9955         227.63        280.06              0.00               NaN

10724        224.38        513.24              0.00               NaN

12107          7.33          8.63            103.66               NaN


       std_ic_t2t_mou_8  std_ic_t2t_mou_9  std_ic_t2m_mou_6
std_ic_t2m_mou_7  \
5616              12.13             42.39             21.76
NaN
9451               0.00              0.00              0.41
NaN
9955               0.00              0.00              0.98
NaN
10724              0.00              0.00              5.94
NaN
12107              0.00              0.00              3.01
NaN

       std_ic_t2m_mou_8  std_ic_t2m_mou_9  std_ic_t2f_mou_6
std_ic_t2f_mou_7  \
5616             110.99            263.98               0.0
NaN
9451               0.00             12.29               0.0
NaN
9955               2.13              2.58               0.0
NaN
10724              0.00              4.88               0.0
NaN
12107              0.00              0.00               0.0
NaN

       std_ic_t2f_mou_8  std_ic_t2f_mou_9  std_ic_t2o_mou_6
std_ic_t2o_mou_7  \
5616               0.00              6.43               0.0
NaN
```

```
9451                0.00                4.48                0.0
NaN
9955                0.23                0.00                0.0
NaN
10724              10.03                1.26                0.0
NaN
12107               0.00                0.00                0.0
NaN

       std_ic_t2o_mou_8  std_ic_t2o_mou_9  std_ic_mou_6  std_ic_mou_7
\
5616                0.0               0.0         21.76           NaN

9451                0.0               0.0          1.91           NaN

9955                0.0               0.0          0.98           NaN

10724               0.0               0.0          5.94           NaN

12107               0.0               0.0        106.68           NaN


       std_ic_mou_8  std_ic_mou_9  total_ic_mou_6  total_ic_mou_7  \
5616         123.13        312.81          189.81             0.0
9451           0.00         16.78          217.33             0.0
9955           2.36          2.58          332.33             0.0
10724         10.03          6.14         1140.54             0.0
12107          0.00          0.00          265.03             0.0

       total_ic_mou_8  total_ic_mou_9  spl_ic_mou_6  spl_ic_mou_7  \
5616           397.13         1020.16          0.00           NaN
9451            43.44          307.43          0.00           NaN
9955           506.94          526.54          0.00           NaN
10724          342.78          642.33          0.14           NaN
12107            7.33            8.63          0.00           NaN

       spl_ic_mou_8  spl_ic_mou_9  isd_ic_mou_6  isd_ic_mou_7
isd_ic_mou_8  \
5616           0.00          0.13         81.29           NaN
28.79
9451           0.00          0.00         42.59           NaN
17.53
9955           0.00          0.00          7.29           NaN
173.61
10724          0.08          0.09        126.13           NaN
106.53
12107          0.00          0.00          0.00           NaN
0.00

       isd_ic_mou_9  ic_others_6  ic_others_7  ic_others_8
```

```
ic_others_9  \
5616          41.23          0.00           NaN          0.00
0.00
9451         103.49          0.00           NaN          0.00
0.00
9955         229.44          0.00           NaN        103.33
14.45
10724        116.83          0.33           NaN          1.74
5.99
12107          0.00          0.40           NaN          0.00
0.00

       total_rech_num_6  total_rech_num_7  total_rech_num_8
total_rech_num_9  \
5616                  5                 7                 9
13
9451                 14                 4                 4
9
9955                  6                 1                 4
3
10724                 8                 3                 3
5
12107                17                 2                 1
2

       total_rech_amt_6  total_rech_amt_7  total_rech_amt_8
total_rech_amt_9  \
5616                776               780               904
1591
9451               1206                 0               223
991
9955               1385                 0               835
912
10724              1020                 0               360
480
12107              1990                 0                 0
30

       max_rech_amt_6  max_rech_amt_7  max_rech_amt_8  max_rech_amt_9
\
5616              250             330             200             289

9451              250               0             130             130

9955              350               0             300             479

10724             500               0             130             150

12107             250               0               0              30
```

```
       last_day_rch_amt_6  last_day_rch_amt_7  last_day_rch_amt_8  \
5616                  250                   0                 130
9451                  250                   0                 130
9955                  250                   0                 300
10724                 500                   0                 130
12107                 110                   0                   0

       last_day_rch_amt_9  vol_2g_mb_6  vol_2g_mb_7  vol_2g_mb_8
vol_2g_mb_9  \
5616                  250         0.00          0.0        11.26
83.32
9451                  130       321.86          0.0         0.00
431.85
9955                  479         0.00          0.0         0.00
0.00
10724                   0         0.00          0.0         0.00
0.00
12107                  30         0.00          0.0         0.00
0.00

       vol_3g_mb_6  vol_3g_mb_7  vol_3g_mb_8  vol_3g_mb_9
monthly_2g_6  \
5616           0.0          0.0        79.94        668.4
0
9451           0.0          0.0         0.00          0.0
1
9955           0.0          0.0         0.00          0.0
0
10724          0.0          0.0         0.00          0.0
0
12107          0.0          0.0         0.00          0.0
0

       monthly_2g_7  monthly_2g_8  monthly_2g_9  sachet_2g_6
sachet_2g_7  \
5616              0             1             1            0
0
9451              0             0             1            1
0
9955              0             0             0            0
0
10724             0             0             0            0
0
12107             0             0             0            0
0

       sachet_2g_8  sachet_2g_9  monthly_3g_6  monthly_3g_7
monthly_3g_8  \
5616             0            0             0            0
```

```
0
9451               0            2             0             0
0
9955               0            0             0             0
0
10724              0            0             0             0
0
12107              0            0             0             0
0

       monthly_3g_9  sachet_3g_6  sachet_3g_7  sachet_3g_8  
sachet_3g_9   aon  \
5616              0            0            0            0
0   576
9451              0            0            0            0
0   672
9955              0            0            0            0
0  3107
10724             0            0            0            0
0  2664
12107             0            0            0            0
0   219

       aug_vbc_3g  jul_vbc_3g  jun_vbc_3g  sep_vbc_3g  
avg_rech_amt_6_7
5616        63.38         0.0         0.0      163.39
778.0
9451         0.00         0.0         0.0        0.00
603.0
9955         0.00         0.0         0.0        0.00
692.5
10724        0.00         0.0         0.0        0.00
510.0
12107        0.00         0.0         0.0        0.00
995.0

# Deleting the records for which MOU for Jul(7) are null
df = df.drop(df_null_mou_7.index)

# Again cheking percent of missing values in columns
df_missing_columns = 
(round(((df.isnull().sum()/len(df.index))*100),2).to_frame('null')).so
rt_values('null', ascending=False)
df_missing_columns

                  null
mobile_number      0.0
total_rech_num_7   0.0
std_ic_mou_7       0.0
std_ic_mou_8       0.0
```

```
std_ic_mou_9       0.0
total_ic_mou_6     0.0
total_ic_mou_7     0.0
total_ic_mou_8     0.0
total_ic_mou_9     0.0
spl_ic_mou_6       0.0
spl_ic_mou_7       0.0
spl_ic_mou_8       0.0
spl_ic_mou_9       0.0
isd_ic_mou_6       0.0
isd_ic_mou_7       0.0
isd_ic_mou_8       0.0
isd_ic_mou_9       0.0
ic_others_6        0.0
ic_others_7        0.0
ic_others_8        0.0
ic_others_9        0.0
std_ic_mou_6       0.0
std_ic_t2o_mou_9   0.0
std_ic_t2o_mou_8   0.0
std_ic_t2t_mou_9   0.0
loc_ic_t2f_mou_9   0.0
loc_ic_mou_6       0.0
loc_ic_mou_7       0.0
loc_ic_mou_8       0.0
loc_ic_mou_9       0.0
...                ...
loc_ic_t2t_mou_6   0.0
loc_ic_t2t_mou_7   0.0
loc_ic_t2t_mou_8   0.0
loc_ic_t2t_mou_9   0.0
loc_ic_t2m_mou_6   0.0
loc_ic_t2m_mou_7   0.0
loc_ic_t2m_mou_8   0.0
spl_og_mou_6       0.0
isd_og_mou_8       0.0
std_og_t2t_mou_8   0.0
std_og_t2f_mou_9   0.0
std_og_t2t_mou_9   0.0
std_og_t2m_mou_6   0.0
std_og_t2m_mou_7   0.0
std_og_t2m_mou_8   0.0
std_og_t2m_mou_9   0.0
std_og_t2f_mou_6   0.0
std_og_t2f_mou_7   0.0
std_og_t2f_mou_8   0.0
std_og_t2c_mou_6   0.0
isd_og_mou_7       0.0
std_og_t2c_mou_7   0.0
```

```
std_og_t2c_mou_8    0.0
std_og_t2c_mou_9    0.0
std_og_mou_6        0.0
std_og_mou_7        0.0
std_og_mou_8        0.0
std_og_mou_9        0.0
isd_og_mou_6        0.0
avg_rech_amt_6_7    0.0

[178 rows x 1 columns]
```

We can see there are no more missing values in any columns.

```
df.shape

(27991, 178)

# Checking percentage of rows we have lost while handling the missing
values
round((1- (len(df.index)/30011)),2)

0.07
```

We can see that we have lost almost 7% records. But we have enough number of records to do our analysis.

Tag churners

Now tag the churned customers (churn=1, else 0) based on the fourth month as follows: Those who have not made any calls (either incoming or outgoing) AND have not used mobile internet even once in the churn phase.

```
df['churn'] = np.where((df['total_ic_mou_9']==0) &
(df['total_og_mou_9']==0) & (df['vol_2g_mb_9']==0) &
(df['vol_3g_mb_9']==0), 1, 0)

df.head()

    mobile_number  loc_og_t2o_mou  std_og_t2o_mou  loc_ic_t2o_mou
arpu_6  \
8      7001524846             0.0             0.0             0.0
378.721
13     7002191713             0.0             0.0             0.0
492.846
16     7000875565             0.0             0.0             0.0
430.975
17     7000187447             0.0             0.0             0.0
690.008
21     7002124215             0.0             0.0             0.0
514.453
```

```
     arpu_7   arpu_8   arpu_9  onnet_mou_6  onnet_mou_7  
onnet_mou_8  \
8   492.223  137.362  166.787       413.69       351.03        35.08   

13  205.671  593.260  322.732       501.76       108.39       534.24   

16  299.869  187.894  206.490        50.51        74.01        70.61   

17   18.980   25.499  257.583      1185.91         9.28         7.79   

21  597.753  637.760  578.596       102.41       132.11        85.14   


    onnet_mou_9  offnet_mou_6  offnet_mou_7  offnet_mou_8  
offnet_mou_9  \
8         33.46         94.66         80.63        136.48        
108.71   
13       244.81        413.31        119.28        482.46        
214.06   
16        31.34        296.29        229.74        162.76        
224.39   
17       558.51         61.64          0.00          5.54         
87.89   
21       161.63        757.93        896.68        983.39        
869.89   

    roam_ic_mou_6  roam_ic_mou_7  roam_ic_mou_8  roam_ic_mou_9  
roam_og_mou_6  \
8            0.00           0.00           0.00           0.00           
0.00   
13          23.53         144.24          72.11         136.78           
7.98   
16           0.00           2.83           0.00           0.00           
0.00   
17           0.00           4.76           4.81           0.00           
0.00   
21           0.00           0.00           0.00           0.00           
0.00   

    roam_og_mou_7  roam_og_mou_8  roam_og_mou_9  loc_og_t2t_mou_6  \
8            0.00           0.00           0.00            297.13   
13          35.26           1.44          12.78             49.63   
16          17.74           0.00           0.00             42.61   
17           8.46          13.34          17.98             38.99   
21           0.00           0.00           0.00              4.48   

    loc_og_t2t_mou_7  loc_og_t2t_mou_8  loc_og_t2t_mou_9  
loc_og_t2m_mou_6  \
8             217.59             12.49             26.13   
```

```
80.96
13            6.19            36.01             6.14
151.13
16           65.16            67.38            26.88
273.29
17            0.00             0.00            36.41
58.54
21            6.16            23.34            29.98
91.81

    loc_og_t2m_mou_7  loc_og_t2m_mou_8  loc_og_t2m_mou_9
loc_og_t2f_mou_6  \
8            70.58            50.54            34.58
0.00
13           47.28           294.46           108.24
4.54
16          145.99           128.28           201.49
0.00
17            0.00             0.00             9.38
0.00
21           87.93           104.81           107.54
0.75

    loc_og_t2f_mou_7  loc_og_t2f_mou_8  loc_og_t2f_mou_9
loc_og_t2c_mou_6  \
8             0.00             0.00             0.00
0.0
13            0.00            23.51             5.29
0.0
16            4.48            10.26             4.66
0.0
17            0.00             0.00             0.00
0.0
21            0.00             1.58             0.00
0.0

    loc_og_t2c_mou_7  loc_og_t2c_mou_8  loc_og_t2c_mou_9  loc_og_mou_6
\
8              0.0              7.15               0.0        378.09

13             0.0              0.49               0.0        205.31

16             0.0              0.00               0.0        315.91

17             0.0              0.00               0.0         97.54

21             0.0              0.00               0.0         97.04


    loc_og_mou_7  loc_og_mou_8  loc_og_mou_9  std_og_t2t_mou_6  \
```

```
8         288.18         63.04         60.71             116.56
13         53.48        353.99        119.69             446.41
16        215.64        205.93        233.04               7.89
17          0.00          0.00         45.79            1146.91
21         94.09        129.74        137.53              97.93

    std_og_t2t_mou_7  std_og_t2t_mou_8  std_og_t2t_mou_9
std_og_t2m_mou_6  \
8             133.43             22.58              7.33
13.69
13             85.98            498.23            230.38
255.36
16              2.58              3.23              4.46
22.99
17              0.81              0.00            504.11
1.55
21            125.94             61.79            131.64
665.36

    std_og_t2m_mou_7  std_og_t2m_mou_8  std_og_t2m_mou_9
std_og_t2f_mou_6  \
8              10.04             75.69             74.13
0.0
13             52.94            156.94             96.01
0.0
16             64.51             18.29             13.79
0.0
17              0.00              0.00             78.51
0.0
21            808.74            876.99            762.34
0.0

    std_og_t2f_mou_7  std_og_t2f_mou_8  std_og_t2f_mou_9
std_og_t2c_mou_6  \
8                0.0               0.0              0.00
0.0
13               0.0               0.0              0.00
0.0
16               0.0               0.0              4.43
0.0
17               0.0               0.0              0.00
0.0
21               0.0               0.0              0.00
0.0

    std_og_t2c_mou_7  std_og_t2c_mou_8  std_og_t2c_mou_9  std_og_mou_6
\
8                0.0               0.0               0.0        130.26

13               0.0               0.0               0.0        701.78
```

```
16                 0.0                 0.0                 0.0         30.89

17                 0.0                 0.0                 0.0       1148.46

21                 0.0                 0.0                 0.0        763.29


    std_og_mou_7  std_og_mou_8  std_og_mou_9  isd_og_mou_6
isd_og_mou_7  \
8         143.48         98.28         81.46           0.0
0.0
13        138.93        655.18        326.39           0.0
0.0
16         67.09         21.53         22.69           0.0
0.0
17          0.81          0.00        582.63           0.0
0.0
21        934.69        938.79        893.99           0.0
0.0

    isd_og_mou_8  isd_og_mou_9  spl_og_mou_6  spl_og_mou_7
spl_og_mou_8  \
8           0.00           0.0          0.00          0.00
10.23
13          1.29           0.0          0.00          0.00
4.78
16          0.00           0.0          0.00          3.26
5.91
17          0.00           0.0          2.58          0.00
0.00
21          0.00           0.0          0.00          0.00
0.00

    spl_og_mou_9  og_others_6  og_others_7  og_others_8
og_others_9  \
8           0.00         0.00          0.0          0.0          0.0

13          0.00         0.00          0.0          0.0          0.0

16          0.00         0.00          0.0          0.0          0.0

17          2.64         0.93          0.0          0.0          0.0

21          0.00         0.00          0.0          0.0          0.0


    total_og_mou_6  total_og_mou_7  total_og_mou_8  total_og_mou_9  \
8           508.36          431.66          171.56          142.18
13          907.09          192.41         1015.26          446.09
```

```
16          346.81          286.01          233.38          255.74
17         1249.53            0.81            0.00          631.08
21          860.34         1028.79         1068.54         1031.53

    loc_ic_t2t_mou_6  loc_ic_t2t_mou_7  loc_ic_t2t_mou_8
loc_ic_t2t_mou_9  \
8              23.84              9.84              0.31
4.03
13             67.88              7.58             52.58
24.98
16             41.33             71.44             28.89
50.23
17             34.54              0.00              0.00
40.91
21              2.48             10.19             19.54
17.99

    loc_ic_t2m_mou_6  loc_ic_t2m_mou_7  loc_ic_t2m_mou_8
loc_ic_t2m_mou_9  \
8              57.58             13.98             15.48
17.34
13            142.88             18.53            195.18
104.79
16            226.81            149.69            150.16
172.86
17             47.41              2.31              0.00
43.86
21            118.23             74.63            129.16
113.46

    loc_ic_t2f_mou_6  loc_ic_t2f_mou_7  loc_ic_t2f_mou_8
loc_ic_t2f_mou_9  \
8               0.00              0.00              0.00
0.00
13              4.81              0.00              7.49
8.51
16              8.71              8.68             32.71
65.21
17              0.00              0.00              0.00
0.71
21              4.61              2.84             10.39
8.41

    loc_ic_mou_6  loc_ic_mou_7  loc_ic_mou_8  loc_ic_mou_9
std_ic_t2t_mou_6  \
8          81.43         23.83         15.79         21.38
0.00
13        215.58         26.11        255.26        138.29
115.68
16        276.86        229.83        211.78        288.31
```

```
68.79
17         81.96          2.31          0.00         85.49
8.63
21        125.33         87.68        159.11        139.88
14.06

    std_ic_t2t_mou_7  std_ic_t2t_mou_8  std_ic_t2t_mou_9
std_ic_t2m_mou_6  \
8               0.58              0.10              0.00
22.43
13             38.29            154.58             62.39
308.13
16             78.64              6.33             16.66
18.68
17              0.00              0.00              0.00
1.28
21              5.98              0.18             16.74
67.69

    std_ic_t2m_mou_7  std_ic_t2m_mou_8  std_ic_t2m_mou_9
std_ic_t2f_mou_6  \
8               4.08              0.65             13.53
0.00
13             29.79            317.91            151.51
0.00
16             73.08             73.93             29.58
0.51
17              0.00              0.00              1.63
0.00
21             38.23            101.74             95.98
0.00

    std_ic_t2f_mou_7  std_ic_t2f_mou_8  std_ic_t2f_mou_9
std_ic_t2o_mou_6  \
8                0.0              0.00               0.0
0.0
13               0.0              1.91               0.0
0.0
16               0.0              2.18               0.0
0.0
17               0.0              0.00               0.0
0.0
21               0.0              0.00               0.0
0.0

    std_ic_t2o_mou_7  std_ic_t2o_mou_8  std_ic_t2o_mou_9  std_ic_mou_6
\
8                0.0               0.0               0.0         22.43

13               0.0               0.0               0.0        423.81
```

```
16                 0.0                 0.0                 0.0         87.99

17                 0.0                 0.0                 0.0          9.91

21                 0.0                 0.0                 0.0         81.76


    std_ic_mou_7  std_ic_mou_8  std_ic_mou_9  total_ic_mou_6  
total_ic_mou_7  \
8           4.66          0.75         13.53          103.86   
28.49   
13         68.09        474.41        213.91          968.61   
172.58   
16        151.73         82.44         46.24          364.86   
381.56   
17          0.00          0.00          1.63           91.88   
2.31   
21         44.21        101.93        112.73          207.09   
131.89   

    total_ic_mou_8  total_ic_mou_9  spl_ic_mou_6  spl_ic_mou_7  
spl_ic_mou_8  \
8            16.54           34.91          0.00           0.0   
0.0   
13         1144.53          631.86          0.45           0.0   
0.0   
16          294.46          334.56          0.00           0.0   
0.0   
17            0.00           87.13          0.00           0.0   
0.0   
21          261.04          252.61          0.00           0.0   
0.0   

    spl_ic_mou_9  isd_ic_mou_6  isd_ic_mou_7  isd_ic_mou_8  
isd_ic_mou_9  \
8            0.0          0.00          0.00          0.00   
0.00   
13           0.0        245.28         62.11        393.39   
259.33   
16           0.0          0.00          0.00          0.23   
0.00   
17           0.0          0.00          0.00          0.00   
0.00   
21           0.0          0.00          0.00          0.00   
0.00   

    ic_others_6  ic_others_7  ic_others_8  ic_others_9  
total_rech_num_6  \
8          0.00         0.00         0.00         0.00   
```

```
19
13        83.48        16.24        21.44        20.31
6
16         0.00         0.00         0.00         0.00
10
17         0.00         0.00         0.00         0.00
19
21         0.00         0.00         0.00         0.00
22

    total_rech_num_7  total_rech_num_8  total_rech_num_9
total_rech_amt_6  \
8                 21                14                15
437
13                 4                11                 7
507
16                 6                 2                 1
570
17                 2                 4                10
816
21                26                27                17
600

    total_rech_amt_7  total_rech_amt_8  total_rech_amt_9
max_rech_amt_6  \
8                601               120               186
90
13               253               717               353
110
16               348               160               220
110
17                 0                30               335
110
21               680               718               680
50

    max_rech_amt_7  max_rech_amt_8  max_rech_amt_9  last_day_rch_amt_6
\
8              154              30              36                  50

13             110             130             130                 110

16             110             130             220                 100

17               0              30             130                  30

21              50              50              50                  30


    last_day_rch_amt_7  last_day_rch_amt_8  last_day_rch_amt_9
```

```
vol_2g_mb_6  \
8                    0                   10                    0
0.0
13                  50                    0                    0
0.0
16                 100                  130                  220
0.0
17                   0                    0                    0
0.0
21                  20                   50                   30
0.0

    vol_2g_mb_7  vol_2g_mb_8  vol_2g_mb_9  vol_3g_mb_6  vol_3g_mb_7  \
8         356.0         0.03          0.0          0.0       750.95
13          0.0         0.02          0.0          0.0         0.00
16          0.0         0.00          0.0          0.0         0.00
17          0.0         0.00          0.0          0.0         0.00
21          0.0         0.00          0.0          0.0         0.00

    vol_3g_mb_8  vol_3g_mb_9  monthly_2g_6  monthly_2g_7  monthly_2g_8
\
8         11.94          0.0             0             1             0

13         0.00          0.0             0             0             0

16         0.00          0.0             0             0             0

17         0.00          0.0             0             0             0

21         0.00          0.0             0             0             0


    monthly_2g_9  sachet_2g_6  sachet_2g_7  sachet_2g_8
sachet_2g_9  \
8              0            0            1            3            0

13             0            0            0            3            0

16             0            0            0            0            0

17             0            0            0            0            0

21             0            0            0            0            0


    monthly_3g_6  monthly_3g_7  monthly_3g_8  monthly_3g_9
sachet_3g_6  \
8              0             0             0             0
0
13             0             0             0             0
0
```

```
16              0             0             0             0
0
17              0             0             0             0
0
21              0             0             0             0
0

    sachet_3g_7  sachet_3g_8  sachet_3g_9   aon  aug_vbc_3g
jul_vbc_3g  \
8             0            0            0   315       21.03
910.65
13            0            0            0  2607        0.00
0.00
16            0            0            0   511        0.00
2.45
17            0            0            0   667        0.00
0.00
21            0            0            0   720        0.00
0.00

    jun_vbc_3g  sep_vbc_3g  avg_rech_amt_6_7  churn
8       122.16         0.0             519.0      0
13        0.00         0.0             380.0      0
16       21.89         0.0             459.0      0
17        0.00         0.0             408.0      0
21        0.00         0.0             640.0      0
```

Deleting all the attributes corresponding to the churn phase

```
# List the columns for churn month(9)
col_9 = [col for col in df.columns.to_list() if '_9' in col]
print(col_9)

['arpu_9', 'onnet_mou_9', 'offnet_mou_9', 'roam_ic_mou_9',
'roam_og_mou_9', 'loc_og_t2t_mou_9', 'loc_og_t2m_mou_9',
'loc_og_t2f_mou_9', 'loc_og_t2c_mou_9', 'loc_og_mou_9',
'std_og_t2t_mou_9', 'std_og_t2m_mou_9', 'std_og_t2f_mou_9',
'std_og_t2c_mou_9', 'std_og_mou_9', 'isd_og_mou_9', 'spl_og_mou_9',
'og_others_9', 'total_og_mou_9', 'loc_ic_t2t_mou_9',
'loc_ic_t2m_mou_9', 'loc_ic_t2f_mou_9', 'loc_ic_mou_9',
'std_ic_t2t_mou_9', 'std_ic_t2m_mou_9', 'std_ic_t2f_mou_9',
'std_ic_t2o_mou_9', 'std_ic_mou_9', 'total_ic_mou_9', 'spl_ic_mou_9',
'isd_ic_mou_9', 'ic_others_9', 'total_rech_num_9', 'total_rech_amt_9',
'max_rech_amt_9', 'last_day_rch_amt_9', 'vol_2g_mb_9', 'vol_3g_mb_9',
'monthly_2g_9', 'sachet_2g_9', 'monthly_3g_9', 'sachet_3g_9']

# Deleting the churn month columns
df = df.drop(col_9, axis=1)
```

```
# Dropping sep_vbc_3g column
df = df.drop('sep_vbc_3g', axis=1)
```

Checking churn percentage

```
round(100*(df['churn'].mean()),2)

3.39
```

There is very little percentage of churn rate. We will take care of the class imbalance later.

Outliers treatment

In the filtered dataset except mobile_number and churn columns all the columns are numeric types. Hence, converting mobile_number and churn datatype to object.

```
df['mobile_number'] = df['mobile_number'].astype(object)
df['churn'] = df['churn'].astype(object)

df.info()

<class 'pandas.core.frame.DataFrame'>
Int64Index: 27991 entries, 8 to 99997
Columns: 136 entries, mobile_number to churn
dtypes: float64(109), int64(25), object(2)
memory usage: 29.3+ MB

# List only the numeric columns
numeric_cols = df.select_dtypes(exclude=['object']).columns
print(numeric_cols)

Index(['loc_og_t2o_mou', 'std_og_t2o_mou', 'loc_ic_t2o_mou', 'arpu_6',
       'arpu_7', 'arpu_8', 'onnet_mou_6', 'onnet_mou_7',
'onnet_mou_8',
       'offnet_mou_6',
       ...
       'monthly_3g_7', 'monthly_3g_8', 'sachet_3g_6', 'sachet_3g_7',
       'sachet_3g_8', 'aon', 'aug_vbc_3g', 'jul_vbc_3g', 'jun_vbc_3g',
       'avg_rech_amt_6_7'],
      dtype='object', length=134)

# Removing outliers below 10th and above 90th percentile
for col in numeric_cols:
    q1 = df[col].quantile(0.10)
    q3 = df[col].quantile(0.90)
    iqr = q3-q1
    range_low  = q1-1.5*iqr
    range_high = q3+1.5*iqr
    # Assigning the filtered dataset into data
    data = df.loc[(df[col] > range_low) & (df[col] < range_high)]
```

```
data.shape
```

```
(27705, 136)
```

Derive new features

```
# List the columns of total mou, rech_num and rech_amt
[total for total in data.columns.to_list() if 'total' in total]
```

```
['total_og_mou_6',
 'total_og_mou_7',
 'total_og_mou_8',
 'total_ic_mou_6',
 'total_ic_mou_7',
 'total_ic_mou_8',
 'total_rech_num_6',
 'total_rech_num_7',
 'total_rech_num_8',
 'total_rech_amt_6',
 'total_rech_amt_7',
 'total_rech_amt_8']
```

Deriving new column `decrease_mou_action`

This column indicates whether the minutes of usage of the customer has decreased in the action phase than the good phase.

```
# Total mou at good phase incoming and outgoing
data['total_mou_good'] = (data['total_og_mou_6'] +
data['total_ic_mou_6'])

# Avg. mou at action phase
# We are taking average because there are two months(7 and 8) in
action phase
data['avg_mou_action'] = (data['total_og_mou_7'] +
data['total_og_mou_8'] + data['total_ic_mou_7'] +
data['total_ic_mou_8'])/2

# Difference avg_mou_good and avg_mou_action
data['diff_mou'] = data['avg_mou_action'] - data['total_mou_good']

# Checking whether the mou has decreased in action phase
data['decrease_mou_action'] = np.where((data['diff_mou'] < 0), 1, 0)

data.head()
```

```
   mobile_number  loc_og_t2o_mou  std_og_t2o_mou  loc_ic_t2o_mou
arpu_6  \
8     7001524846             0.0             0.0             0.0
378.721
```

```
13    7002191713             0.0             0.0             0.0
492.846
16    7000875565             0.0             0.0             0.0
430.975
17    7000187447             0.0             0.0             0.0
690.008
21    7002124215             0.0             0.0             0.0
514.453

     arpu_7   arpu_8  onnet_mou_6  onnet_mou_7  onnet_mou_8
offnet_mou_6  \
8   492.223  137.362       413.69       351.03        35.08
94.66
13  205.671  593.260       501.76       108.39       534.24
413.31
16  299.869  187.894        50.51        74.01        70.61
296.29
17   18.980   25.499      1185.91         9.28         7.79
61.64
21  597.753  637.760       102.41       132.11        85.14
757.93

    offnet_mou_7  offnet_mou_8  roam_ic_mou_6  roam_ic_mou_7
roam_ic_mou_8  \
8          80.63        136.48           0.00           0.00
0.00
13        119.28        482.46          23.53         144.24
72.11
16        229.74        162.76           0.00           2.83
0.00
17          0.00          5.54           0.00           4.76
4.81
21        896.68        983.39           0.00           0.00
0.00

    roam_og_mou_6  roam_og_mou_7  roam_og_mou_8  loc_og_t2t_mou_6  \
8            0.00           0.00           0.00            297.13
13           7.98          35.26           1.44             49.63
16           0.00          17.74           0.00             42.61
17           0.00           8.46          13.34             38.99
21           0.00           0.00           0.00              4.48

    loc_og_t2t_mou_7  loc_og_t2t_mou_8  loc_og_t2m_mou_6
loc_og_t2m_mou_7  \
8             217.59             12.49             80.96
70.58
13              6.19             36.01            151.13
47.28
16             65.16             67.38            273.29
145.99
```

```
17              0.00              0.00             58.54
0.00
21              6.16             23.34             91.81
87.93

    loc_og_t2m_mou_8  loc_og_t2f_mou_6  loc_og_t2f_mou_7
loc_og_t2f_mou_8  \
8              50.54              0.00              0.00
0.00
13            294.46              4.54              0.00
23.51
16            128.28              0.00              4.48
10.26
17              0.00              0.00              0.00
0.00
21            104.81              0.75              0.00
1.58

    loc_og_t2c_mou_6  loc_og_t2c_mou_7  loc_og_t2c_mou_8  loc_og_mou_6
\
8                0.0               0.0              7.15        378.09

13               0.0               0.0              0.49        205.31

16               0.0               0.0              0.00        315.91

17               0.0               0.0              0.00         97.54

21               0.0               0.0              0.00         97.04


    loc_og_mou_7  loc_og_mou_8  std_og_t2t_mou_6  std_og_t2t_mou_7  \
8         288.18         63.04            116.56            133.43
13         53.48        353.99            446.41             85.98
16        215.64        205.93              7.89              2.58
17          0.00          0.00           1146.91              0.81
21         94.09        129.74             97.93            125.94

    std_og_t2t_mou_8  std_og_t2m_mou_6  std_og_t2m_mou_7
std_og_t2m_mou_8  \
8              22.58             13.69             10.04
75.69
13            498.23            255.36             52.94
156.94
16              3.23             22.99             64.51
18.29
17              0.00              1.55              0.00
0.00
21             61.79            665.36            808.74
876.99
```

```
    std_og_t2f_mou_6  std_og_t2f_mou_7  std_og_t2f_mou_8  
std_og_t2c_mou_6  \
8                0.0               0.0               0.0  
0.0   
13               0.0               0.0               0.0  
0.0   
16               0.0               0.0               0.0  
0.0   
17               0.0               0.0               0.0  
0.0   
21               0.0               0.0               0.0  
0.0   

    std_og_t2c_mou_7  std_og_t2c_mou_8  std_og_mou_6  std_og_mou_7  \
8                0.0               0.0        130.26        143.48   
13               0.0               0.0        701.78        138.93   
16               0.0               0.0         30.89         67.09   
17               0.0               0.0       1148.46          0.81   
21               0.0               0.0        763.29        934.69   

    std_og_mou_8  isd_og_mou_6  isd_og_mou_7  isd_og_mou_8  
spl_og_mou_6  \
8          98.28           0.0           0.0          0.00  
0.00   
13        655.18           0.0           0.0          1.29  
0.00   
16         21.53           0.0           0.0          0.00  
0.00   
17          0.00           0.0           0.0          0.00  
2.58   
21        938.79           0.0           0.0          0.00  
0.00   

    spl_og_mou_7  spl_og_mou_8  og_others_6  og_others_7  og_others_8  
\
8           0.00         10.23         0.00          0.0          0.0   

13          0.00          4.78         0.00          0.0          0.0   

16          3.26          5.91         0.00          0.0          0.0   

17          0.00          0.00         0.93          0.0          0.0   

21          0.00          0.00         0.00          0.0          0.0   


    total_og_mou_6  total_og_mou_7  total_og_mou_8  
loc_ic_t2t_mou_6  \
8           508.36          431.66          171.56             23.84   
```

```
13          907.09          192.41          1015.26                  67.88

16          346.81          286.01           233.38                  41.33

17         1249.53            0.81             0.00                  34.54

21          860.34         1028.79          1068.54                   2.48


    loc_ic_t2t_mou_7  loc_ic_t2t_mou_8  loc_ic_t2m_mou_6  
loc_ic_t2m_mou_7  \
8               9.84              0.31             57.58   
13.98   
13              7.58             52.58            142.88   
18.53   
16             71.44             28.89            226.81   
149.69   
17              0.00              0.00             47.41   
2.31   
21             10.19             19.54            118.23   
74.63   

    loc_ic_t2m_mou_8  loc_ic_t2f_mou_6  loc_ic_t2f_mou_7  
loc_ic_t2f_mou_8  \
8              15.48              0.00              0.00   
0.00   
13            195.18              4.81              0.00   
7.49   
16            150.16              8.71              8.68   
32.71   
17              0.00              0.00              0.00   
0.00   
21            129.16              4.61              2.84   
10.39   

    loc_ic_mou_6  loc_ic_mou_7  loc_ic_mou_8  std_ic_t2t_mou_6  \
8          81.43         23.83         15.79              0.00   
13        215.58         26.11        255.26            115.68   
16        276.86        229.83        211.78             68.79   
17         81.96          2.31          0.00              8.63   
21        125.33         87.68        159.11             14.06   

    std_ic_t2t_mou_7  std_ic_t2t_mou_8  std_ic_t2m_mou_6  
std_ic_t2m_mou_7  \
8               0.58              0.10             22.43   
4.08   
13             38.29            154.58            308.13   
29.79   
16             78.64              6.33             18.68   
```

```
73.08
17               0.00                0.00                1.28
0.00
21               5.98                0.18               67.69
38.23

    std_ic_t2m_mou_8  std_ic_t2f_mou_6  std_ic_t2f_mou_7
std_ic_t2f_mou_8  \
8                0.65                0.00                 0.0
0.00
13             317.91                0.00                 0.0
1.91
16              73.93                0.51                 0.0
2.18
17               0.00                0.00                 0.0
0.00
21             101.74                0.00                 0.0
0.00

    std_ic_t2o_mou_6  std_ic_t2o_mou_7  std_ic_t2o_mou_8  std_ic_mou_6
\
8                 0.0                 0.0                 0.0         22.43

13                0.0                 0.0                 0.0        423.81

16                0.0                 0.0                 0.0         87.99

17                0.0                 0.0                 0.0          9.91

21                0.0                 0.0                 0.0         81.76


    std_ic_mou_7  std_ic_mou_8  total_ic_mou_6  total_ic_mou_7  \
8           4.66          0.75          103.86           28.49
13         68.09        474.41          968.61          172.58
16        151.73         82.44          364.86          381.56
17          0.00          0.00           91.88            2.31
21         44.21        101.93          207.09          131.89

    total_ic_mou_8  spl_ic_mou_6  spl_ic_mou_7  spl_ic_mou_8
isd_ic_mou_6  \
8            16.54          0.00           0.0           0.0
0.00
13         1144.53          0.45           0.0           0.0
245.28
16          294.46          0.00           0.0           0.0
0.00
17            0.00          0.00           0.0           0.0
0.00
21          261.04          0.00           0.0           0.0
```

```
0.00

    isd_ic_mou_7  isd_ic_mou_8  ic_others_6  ic_others_7  ic_others_8
\
8           0.00          0.00         0.00         0.00         0.00

13         62.11        393.39        83.48        16.24        21.44

16          0.00          0.23         0.00         0.00         0.00

17          0.00          0.00         0.00         0.00         0.00

21          0.00          0.00         0.00         0.00         0.00


    total_rech_num_6  total_rech_num_7  total_rech_num_8
total_rech_amt_6  \
8                 19                21                14
437
13                 6                 4                11
507
16                10                 6                 2
570
17                19                 2                 4
816
21                22                26                27
600

    total_rech_amt_7  total_rech_amt_8  max_rech_amt_6  max_rech_amt_7
\
8                601               120              90             154

13               253               717             110             110

16               348               160             110             110

17                 0                30             110               0

21               680               718              50              50


    max_rech_amt_8  last_day_rch_amt_6  last_day_rch_amt_7  \
8               30                  50                   0
13             130                 110                  50
16             130                 100                 100
17              30                  30                   0
21              50                  30                  20

    last_day_rch_amt_8  vol_2g_mb_6  vol_2g_mb_7  vol_2g_mb_8
vol_3g_mb_6  \
8                   10          0.0        356.0         0.03
```

```
0.0
13                   0          0.0          0.0         0.02
0.0
16                 130          0.0          0.0         0.00
0.0
17                   0          0.0          0.0         0.00
0.0
21                  50          0.0          0.0         0.00
0.0

    vol_3g_mb_7  vol_3g_mb_8  monthly_2g_6  monthly_2g_7  monthly_2g_8
\
8        750.95        11.94             0             1             0

13         0.00         0.00             0             0             0

16         0.00         0.00             0             0             0

17         0.00         0.00             0             0             0

21         0.00         0.00             0             0             0


    sachet_2g_6  sachet_2g_7  sachet_2g_8  monthly_3g_6  monthly_3g_7
\
8             0            1            3             0             0

13            0            0            3             0             0

16            0            0            0             0             0

17            0            0            0             0             0

21            0            0            0             0             0


    monthly_3g_8  sachet_3g_6  sachet_3g_7  sachet_3g_8   aon
aug_vbc_3g  \
8              0            0            0            0   315
21.03
13             0            0            0            0  2607
0.00
16             0            0            0            0   511
0.00
17             0            0            0            0   667
0.00
21             0            0            0            0   720
0.00

    jul_vbc_3g  jun_vbc_3g  avg_rech_amt_6_7 churn  total_mou_good  \
8       910.65      122.16             519.0     0          612.22
```

```
13        0.00        0.00                380.0     0          1875.70
16        2.45       21.89                459.0     0           711.67
17        0.00        0.00                408.0     0          1341.41
21        0.00        0.00                640.0     0          1067.43

    avg_mou_action   diff_mou  decrease_mou_action
8          324.125   -288.095                    1
13        1262.390   -613.310                    1
16         597.705   -113.965                    1
17           1.560 -1339.850                    1
21        1245.130    177.700                    0
```

Deriving new column `decrease_rech_num_action`

This column indicates whether the number of recharge of the customer has decreased in the action phase than the good phase.

```
# Avg rech number at action phase
data['avg_rech_num_action'] = (data['total_rech_num_7'] +
data['total_rech_num_8'])/2

# Difference total_rech_num_6 and avg_rech_action
data['diff_rech_num'] = data['avg_rech_num_action'] -
data['total_rech_num_6']

# Checking if rech_num has decreased in action phase
data['decrease_rech_num_action'] = np.where((data['diff_rech_num'] <
0), 1, 0)

data.head()

   mobile_number  loc_og_t2o_mou  std_og_t2o_mou  loc_ic_t2o_mou
arpu_6  \
8     7001524846             0.0             0.0             0.0
378.721
13    7002191713             0.0             0.0             0.0
492.846
16    7000875565             0.0             0.0             0.0
430.975
17    7000187447             0.0             0.0             0.0
690.008
21    7002124215             0.0             0.0             0.0
514.453

     arpu_7   arpu_8  onnet_mou_6  onnet_mou_7  onnet_mou_8
offnet_mou_6  \
8   492.223  137.362       413.69       351.03        35.08
94.66
13  205.671  593.260       501.76       108.39       534.24
413.31
```

```
16  299.869  187.894        50.51        74.01        70.61
296.29
17   18.980   25.499      1185.91         9.28         7.79
61.64
21  597.753  637.760       102.41       132.11        85.14
757.93

    offnet_mou_7  offnet_mou_8  roam_ic_mou_6  roam_ic_mou_7
roam_ic_mou_8  \
8          80.63        136.48           0.00           0.00
0.00
13        119.28        482.46          23.53         144.24
72.11
16        229.74        162.76           0.00           2.83
0.00
17          0.00          5.54           0.00           4.76
4.81
21        896.68        983.39           0.00           0.00
0.00

    roam_og_mou_6  roam_og_mou_7  roam_og_mou_8  loc_og_t2t_mou_6  \
8            0.00           0.00           0.00            297.13
13           7.98          35.26           1.44             49.63
16           0.00          17.74           0.00             42.61
17           0.00           8.46          13.34             38.99
21           0.00           0.00           0.00              4.48

    loc_og_t2t_mou_7  loc_og_t2t_mou_8  loc_og_t2m_mou_6
loc_og_t2m_mou_7  \
8             217.59             12.49             80.96
70.58
13              6.19             36.01            151.13
47.28
16             65.16             67.38            273.29
145.99
17              0.00              0.00             58.54
0.00
21              6.16             23.34             91.81
87.93

    loc_og_t2m_mou_8  loc_og_t2f_mou_6  loc_og_t2f_mou_7
loc_og_t2f_mou_8  \
8              50.54              0.00              0.00
0.00
13            294.46              4.54              0.00
23.51
16            128.28              0.00              4.48
10.26
17              0.00              0.00              0.00
0.00
```

```
21            104.81              0.75              0.00
1.58

    loc_og_t2c_mou_6  loc_og_t2c_mou_7  loc_og_t2c_mou_8  loc_og_mou_6
\
8                0.0               0.0              7.15        378.09

13               0.0               0.0              0.49        205.31

16               0.0               0.0              0.00        315.91

17               0.0               0.0              0.00         97.54

21               0.0               0.0              0.00         97.04


    loc_og_mou_7  loc_og_mou_8  std_og_t2t_mou_6  std_og_t2t_mou_7  \
8         288.18         63.04            116.56            133.43
13         53.48        353.99            446.41             85.98
16        215.64        205.93              7.89              2.58
17          0.00          0.00           1146.91              0.81
21         94.09        129.74             97.93            125.94

    std_og_t2t_mou_8  std_og_t2m_mou_6  std_og_t2m_mou_7
std_og_t2m_mou_8  \
8              22.58             13.69             10.04
75.69
13            498.23            255.36             52.94
156.94
16              3.23             22.99             64.51
18.29
17              0.00              1.55              0.00
0.00
21             61.79            665.36            808.74
876.99

    std_og_t2f_mou_6  std_og_t2f_mou_7  std_og_t2f_mou_8
std_og_t2c_mou_6  \
8                0.0               0.0               0.0
0.0
13               0.0               0.0               0.0
0.0
16               0.0               0.0               0.0
0.0
17               0.0               0.0               0.0
0.0
21               0.0               0.0               0.0
0.0

    std_og_t2c_mou_7  std_og_t2c_mou_8  std_og_mou_6  std_og_mou_7  \
```

```
8                 0.0                 0.0       130.26       143.48
13                0.0                 0.0       701.78       138.93
16                0.0                 0.0        30.89        67.09
17                0.0                 0.0      1148.46         0.81
21                0.0                 0.0       763.29       934.69

    std_og_mou_8  isd_og_mou_6  isd_og_mou_7  isd_og_mou_8
spl_og_mou_6  \
8          98.28           0.0           0.0          0.00
0.00
13        655.18           0.0           0.0          1.29
0.00
16         21.53           0.0           0.0          0.00
0.00
17          0.00           0.0           0.0          0.00
2.58
21        938.79           0.0           0.0          0.00
0.00

    spl_og_mou_7  spl_og_mou_8  og_others_6  og_others_7  og_others_8
\
8           0.00         10.23         0.00          0.0          0.0

13          0.00          4.78         0.00          0.0          0.0

16          3.26          5.91         0.00          0.0          0.0

17          0.00          0.00         0.93          0.0          0.0

21          0.00          0.00         0.00          0.0          0.0


    total_og_mou_6  total_og_mou_7  total_og_mou_8
loc_ic_t2t_mou_6  \
8           508.36          431.66          171.56             23.84

13          907.09          192.41         1015.26             67.88

16          346.81          286.01          233.38             41.33

17         1249.53            0.81            0.00             34.54

21          860.34         1028.79         1068.54              2.48


    loc_ic_t2t_mou_7  loc_ic_t2t_mou_8  loc_ic_t2m_mou_6
loc_ic_t2m_mou_7  \
8               9.84              0.31             57.58
13.98
13              7.58             52.58            142.88
18.53
```

```
16          71.44           28.89          226.81
149.69
17           0.00            0.00           47.41
2.31
21          10.19           19.54          118.23
74.63

    loc_ic_t2m_mou_8  loc_ic_t2f_mou_6  loc_ic_t2f_mou_7
loc_ic_t2f_mou_8  \
8              15.48             0.00             0.00
0.00
13            195.18             4.81             0.00
7.49
16            150.16             8.71             8.68
32.71
17              0.00             0.00             0.00
0.00
21            129.16             4.61             2.84
10.39

    loc_ic_mou_6  loc_ic_mou_7  loc_ic_mou_8  std_ic_t2t_mou_6  \
8          81.43         23.83         15.79              0.00
13        215.58         26.11        255.26            115.68
16        276.86        229.83        211.78             68.79
17         81.96          2.31          0.00              8.63
21        125.33         87.68        159.11             14.06

    std_ic_t2t_mou_7  std_ic_t2t_mou_8  std_ic_t2m_mou_6
std_ic_t2m_mou_7  \
8               0.58             0.10            22.43
4.08
13             38.29           154.58           308.13
29.79
16             78.64             6.33            18.68
73.08
17              0.00             0.00             1.28
0.00
21              5.98             0.18            67.69
38.23

    std_ic_t2m_mou_8  std_ic_t2f_mou_6  std_ic_t2f_mou_7
std_ic_t2f_mou_8  \
8               0.65             0.00              0.0
0.00
13            317.91             0.00              0.0
1.91
16             73.93             0.51              0.0
2.18
17              0.00             0.00              0.0
0.00
```

```
21           101.74              0.00               0.0
0.00

    std_ic_t2o_mou_6  std_ic_t2o_mou_7  std_ic_t2o_mou_8  std_ic_mou_6
\
8                0.0               0.0               0.0         22.43

13               0.0               0.0               0.0        423.81

16               0.0               0.0               0.0         87.99

17               0.0               0.0               0.0          9.91

21               0.0               0.0               0.0         81.76


    std_ic_mou_7  std_ic_mou_8  total_ic_mou_6  total_ic_mou_7  \
8           4.66          0.75          103.86           28.49
13         68.09        474.41          968.61          172.58
16        151.73         82.44          364.86          381.56
17          0.00          0.00           91.88            2.31
21         44.21        101.93          207.09          131.89

    total_ic_mou_8  spl_ic_mou_6  spl_ic_mou_7  spl_ic_mou_8
isd_ic_mou_6  \
8            16.54          0.00           0.0           0.0
0.00
13         1144.53          0.45           0.0           0.0
245.28
16          294.46          0.00           0.0           0.0
0.00
17            0.00          0.00           0.0           0.0
0.00
21          261.04          0.00           0.0           0.0
0.00

    isd_ic_mou_7  isd_ic_mou_8  ic_others_6  ic_others_7  ic_others_8
\
8           0.00          0.00         0.00         0.00         0.00

13         62.11        393.39        83.48        16.24        21.44

16          0.00          0.23         0.00         0.00         0.00

17          0.00          0.00         0.00         0.00         0.00

21          0.00          0.00         0.00         0.00         0.00


    total_rech_num_6  total_rech_num_7  total_rech_num_8
total_rech_amt_6  \
```

```
8                  19                 21                 14
437
13                  6                  4                 11
507
16                 10                  6                  2
570
17                 19                  2                  4
816
21                 22                 26                 27
600

    total_rech_amt_7  total_rech_amt_8  max_rech_amt_6  max_rech_amt_7
\
8                601               120              90             154

13               253               717             110             110

16               348               160             110             110

17                 0                30             110               0

21               680               718              50              50


    max_rech_amt_8  last_day_rch_amt_6  last_day_rch_amt_7  \
8               30                  50                   0
13             130                 110                  50
16             130                 100                 100
17              30                  30                   0
21              50                  30                  20

    last_day_rch_amt_8  vol_2g_mb_6  vol_2g_mb_7  vol_2g_mb_8
vol_3g_mb_6  \
8                   10          0.0        356.0         0.03
0.0
13                   0          0.0          0.0         0.02
0.0
16                 130          0.0          0.0         0.00
0.0
17                   0          0.0          0.0         0.00
0.0
21                  50          0.0          0.0         0.00
0.0

    vol_3g_mb_7  vol_3g_mb_8  monthly_2g_6  monthly_2g_7  monthly_2g_8
\
8        750.95        11.94             0             1             0

13         0.00         0.00             0             0             0
```

```
16        0.00        0.00              0              0              0

17        0.00        0.00              0              0              0

21        0.00        0.00              0              0              0


    sachet_2g_6  sachet_2g_7  sachet_2g_8  monthly_3g_6  monthly_3g_7
\
8             0            1            3             0             0

13            0            0            3             0             0

16            0            0            0             0             0

17            0            0            0             0             0

21            0            0            0             0             0


    monthly_3g_8  sachet_3g_6  sachet_3g_7  sachet_3g_8   aon
aug_vbc_3g  \
8              0            0            0            0   315
21.03
13             0            0            0            0  2607
0.00
16             0            0            0            0   511
0.00
17             0            0            0            0   667
0.00
21             0            0            0            0   720
0.00

    jul_vbc_3g  jun_vbc_3g  avg_rech_amt_6_7 churn  total_mou_good  \
8       910.65      122.16             519.0     0          612.22
13        0.00        0.00             380.0     0         1875.70
16        2.45       21.89             459.0     0          711.67
17        0.00        0.00             408.0     0         1341.41
21        0.00        0.00             640.0     0         1067.43

    avg_mou_action  diff_mou  decrease_mou_action  avg_rech_num_action
\
8          324.125  -288.095                    1                 17.5

13        1262.390  -613.310                    1                  7.5

16         597.705  -113.965                    1                  4.0

17           1.560 -1339.850                    1                  3.0

21        1245.130   177.700                    0                 26.5
```

```
    diff_rech_num  decrease_rech_num_action
8            -1.5                         1
13            1.5                         0
16           -6.0                         1
17          -16.0                         1
21            4.5                         0
```

Deriving new column `decrease_rech_amt_action`

This column indicates whether the amount of recharge of the customer has decreased in the action phase than the good phase.

```
# Avg rech_amt in action phase
data['avg_rech_amt_action'] = (data['total_rech_amt_7'] +
data['total_rech_amt_8'])/2

# Difference of action phase rech amt and good phase rech amt
data['diff_rech_amt'] = data['avg_rech_amt_action'] -
data['total_rech_amt_6']

# Checking if rech_amt has decreased in action phase
data['decrease_rech_amt_action'] = np.where((data['diff_rech_amt'] <
0), 1, 0)

data.head()
```

```
   mobile_number  loc_og_t2o_mou  std_og_t2o_mou  loc_ic_t2o_mou
arpu_6  \
8     7001524846             0.0             0.0             0.0
378.721
13    7002191713             0.0             0.0             0.0
492.846
16    7000875565             0.0             0.0             0.0
430.975
17    7000187447             0.0             0.0             0.0
690.008
21    7002124215             0.0             0.0             0.0
514.453

     arpu_7   arpu_8  onnet_mou_6  onnet_mou_7  onnet_mou_8
offnet_mou_6  \
8   492.223  137.362       413.69       351.03        35.08
94.66
13  205.671  593.260       501.76       108.39       534.24
413.31
16  299.869  187.894        50.51        74.01        70.61
296.29
17   18.980   25.499      1185.91         9.28         7.79
```

```
61.64
21  597.753  637.760       102.41       132.11        85.14
757.93

    offnet_mou_7  offnet_mou_8  roam_ic_mou_6  roam_ic_mou_7
roam_ic_mou_8  \
8          80.63        136.48           0.00           0.00
0.00
13        119.28        482.46          23.53         144.24
72.11
16        229.74        162.76           0.00           2.83
0.00
17          0.00          5.54           0.00           4.76
4.81
21        896.68        983.39           0.00           0.00
0.00

    roam_og_mou_6  roam_og_mou_7  roam_og_mou_8  loc_og_t2t_mou_6  \
8            0.00           0.00           0.00            297.13
13           7.98          35.26           1.44             49.63
16           0.00          17.74           0.00             42.61
17           0.00           8.46          13.34             38.99
21           0.00           0.00           0.00              4.48

    loc_og_t2t_mou_7  loc_og_t2t_mou_8  loc_og_t2m_mou_6
loc_og_t2m_mou_7  \
8             217.59             12.49             80.96
70.58
13              6.19             36.01            151.13
47.28
16             65.16             67.38            273.29
145.99
17              0.00              0.00             58.54
0.00
21              6.16             23.34             91.81
87.93

    loc_og_t2m_mou_8  loc_og_t2f_mou_6  loc_og_t2f_mou_7
loc_og_t2f_mou_8  \
8              50.54              0.00              0.00
0.00
13            294.46              4.54              0.00
23.51
16            128.28              0.00              4.48
10.26
17              0.00              0.00              0.00
0.00
21            104.81              0.75              0.00
1.58
```

```
    loc_og_t2c_mou_6  loc_og_t2c_mou_7  loc_og_t2c_mou_8  loc_og_mou_6
\
8                0.0               0.0              7.15        378.09

13               0.0               0.0              0.49        205.31

16               0.0               0.0              0.00        315.91

17               0.0               0.0              0.00         97.54

21               0.0               0.0              0.00         97.04


    loc_og_mou_7  loc_og_mou_8  std_og_t2t_mou_6  std_og_t2t_mou_7  \
8         288.18         63.04            116.56            133.43
13         53.48        353.99            446.41             85.98
16        215.64        205.93              7.89              2.58
17          0.00          0.00           1146.91              0.81
21         94.09        129.74             97.93            125.94

    std_og_t2t_mou_8  std_og_t2m_mou_6  std_og_t2m_mou_7
std_og_t2m_mou_8  \
8              22.58             13.69             10.04
75.69
13            498.23            255.36             52.94
156.94
16              3.23             22.99             64.51
18.29
17              0.00              1.55              0.00
0.00
21             61.79            665.36            808.74
876.99

    std_og_t2f_mou_6  std_og_t2f_mou_7  std_og_t2f_mou_8
std_og_t2c_mou_6  \
8                0.0               0.0               0.0
0.0
13               0.0               0.0               0.0
0.0
16               0.0               0.0               0.0
0.0
17               0.0               0.0               0.0
0.0
21               0.0               0.0               0.0
0.0

    std_og_t2c_mou_7  std_og_t2c_mou_8  std_og_mou_6  std_og_mou_7  \
8                0.0               0.0        130.26        143.48
13               0.0               0.0        701.78        138.93
16               0.0               0.0         30.89         67.09
```

```
17                0.0                 0.0       1148.46          0.81
21                0.0                 0.0        763.29        934.69

    std_og_mou_8  isd_og_mou_6  isd_og_mou_7  isd_og_mou_8
spl_og_mou_6  \
8          98.28           0.0           0.0          0.00
0.00
13        655.18           0.0           0.0          1.29
0.00
16         21.53           0.0           0.0          0.00
0.00
17          0.00           0.0           0.0          0.00
2.58
21        938.79           0.0           0.0          0.00
0.00

    spl_og_mou_7  spl_og_mou_8  og_others_6  og_others_7  og_others_8
\
8           0.00         10.23         0.00          0.0          0.0

13          0.00          4.78         0.00          0.0          0.0

16          3.26          5.91         0.00          0.0          0.0

17          0.00          0.00         0.93          0.0          0.0

21          0.00          0.00         0.00          0.0          0.0


    total_og_mou_6  total_og_mou_7  total_og_mou_8
loc_ic_t2t_mou_6  \
8           508.36          431.66          171.56             23.84

13          907.09          192.41         1015.26             67.88

16          346.81          286.01          233.38             41.33

17         1249.53            0.81            0.00             34.54

21          860.34         1028.79         1068.54              2.48


    loc_ic_t2t_mou_7  loc_ic_t2t_mou_8  loc_ic_t2m_mou_6
loc_ic_t2m_mou_7  \
8               9.84              0.31             57.58
13.98
13              7.58             52.58            142.88
18.53
16             71.44             28.89            226.81
149.69
17              0.00              0.00             47.41
```

```
2.31
21            10.19             19.54            118.23
74.63

    loc_ic_t2m_mou_8  loc_ic_t2f_mou_6  loc_ic_t2f_mou_7
loc_ic_t2f_mou_8  \
8              15.48              0.00              0.00
0.00
13            195.18              4.81              0.00
7.49
16            150.16              8.71              8.68
32.71
17              0.00              0.00              0.00
0.00
21            129.16              4.61              2.84
10.39

    loc_ic_mou_6  loc_ic_mou_7  loc_ic_mou_8  std_ic_t2t_mou_6  \
8          81.43         23.83         15.79              0.00
13        215.58         26.11        255.26            115.68
16        276.86        229.83        211.78             68.79
17         81.96          2.31          0.00              8.63
21        125.33         87.68        159.11             14.06

    std_ic_t2t_mou_7  std_ic_t2t_mou_8  std_ic_t2m_mou_6
std_ic_t2m_mou_7  \
8               0.58              0.10             22.43
4.08
13             38.29            154.58            308.13
29.79
16             78.64              6.33             18.68
73.08
17              0.00              0.00              1.28
0.00
21              5.98              0.18             67.69
38.23

    std_ic_t2m_mou_8  std_ic_t2f_mou_6  std_ic_t2f_mou_7
std_ic_t2f_mou_8  \
8               0.65              0.00               0.0
0.00
13            317.91              0.00               0.0
1.91
16             73.93              0.51               0.0
2.18
17              0.00              0.00               0.0
0.00
21            101.74              0.00               0.0
0.00
```

```
    std_ic_t2o_mou_6  std_ic_t2o_mou_7  std_ic_t2o_mou_8  std_ic_mou_6
\
8                0.0               0.0               0.0         22.43

13               0.0               0.0               0.0        423.81

16               0.0               0.0               0.0         87.99

17               0.0               0.0               0.0          9.91

21               0.0               0.0               0.0         81.76


    std_ic_mou_7  std_ic_mou_8  total_ic_mou_6  total_ic_mou_7  \
8           4.66          0.75          103.86           28.49
13         68.09        474.41          968.61          172.58
16        151.73         82.44          364.86          381.56
17          0.00          0.00           91.88            2.31
21         44.21        101.93          207.09          131.89

    total_ic_mou_8  spl_ic_mou_6  spl_ic_mou_7  spl_ic_mou_8
isd_ic_mou_6  \
8            16.54          0.00           0.0           0.0
0.00
13         1144.53          0.45           0.0           0.0
245.28
16          294.46          0.00           0.0           0.0
0.00
17            0.00          0.00           0.0           0.0
0.00
21          261.04          0.00           0.0           0.0
0.00

    isd_ic_mou_7  isd_ic_mou_8  ic_others_6  ic_others_7  ic_others_8
\
8           0.00          0.00         0.00         0.00         0.00

13         62.11        393.39        83.48        16.24        21.44

16          0.00          0.23         0.00         0.00         0.00

17          0.00          0.00         0.00         0.00         0.00

21          0.00          0.00         0.00         0.00         0.00


    total_rech_num_6  total_rech_num_7  total_rech_num_8
total_rech_amt_6  \
8                 19                21                14
437
13                 6                 4                11
```

```
507
16                10                  6                  2
570
17                19                  2                  4
816
21                22                 26                 27
600

    total_rech_amt_7  total_rech_amt_8  max_rech_amt_6  max_rech_amt_7
\
8                601               120              90             154

13               253               717             110             110

16               348               160             110             110

17                 0                30             110               0

21               680               718              50              50


    max_rech_amt_8  last_day_rch_amt_6  last_day_rch_amt_7  \
8               30                  50                   0
13             130                 110                  50
16             130                 100                 100
17              30                  30                   0
21              50                  30                  20

    last_day_rch_amt_8  vol_2g_mb_6  vol_2g_mb_7  vol_2g_mb_8
vol_3g_mb_6  \
8                   10          0.0        356.0         0.03
0.0
13                   0          0.0          0.0         0.02
0.0
16                 130          0.0          0.0         0.00
0.0
17                   0          0.0          0.0         0.00
0.0
21                  50          0.0          0.0         0.00
0.0

    vol_3g_mb_7  vol_3g_mb_8  monthly_2g_6  monthly_2g_7  monthly_2g_8
\
8        750.95        11.94             0             1             0

13         0.00         0.00             0             0             0

16         0.00         0.00             0             0             0

17         0.00         0.00             0             0             0
```

```
21         0.00         0.00             0             0             0


    sachet_2g_6  sachet_2g_7  sachet_2g_8  monthly_3g_6  monthly_3g_7
\
8             0            1            3             0             0

13            0            0            3             0             0

16            0            0            0             0             0

17            0            0            0             0             0

21            0            0            0             0             0


    monthly_3g_8  sachet_3g_6  sachet_3g_7  sachet_3g_8   aon
aug_vbc_3g  \
8              0            0            0            0   315
21.03
13             0            0            0            0  2607
0.00
16             0            0            0            0   511
0.00
17             0            0            0            0   667
0.00
21             0            0            0            0   720
0.00

    jul_vbc_3g  jun_vbc_3g  avg_rech_amt_6_7 churn  total_mou_good  \
8       910.65      122.16             519.0     0          612.22
13        0.00        0.00             380.0     0         1875.70
16        2.45       21.89             459.0     0          711.67
17        0.00        0.00             408.0     0         1341.41
21        0.00        0.00             640.0     0         1067.43

    avg_mou_action  diff_mou  decrease_mou_action  avg_rech_num_action
\
8          324.125  -288.095                    1                 17.5

13        1262.390  -613.310                    1                  7.5

16         597.705  -113.965                    1                  4.0

17           1.560 -1339.850                    1                  3.0

21        1245.130   177.700                    0                 26.5


    diff_rech_num  decrease_rech_num_action  avg_rech_amt_action  \
```

```
8             -1.5                        1                360.5
13             1.5                        0                485.0
16            -6.0                        1                254.0
17           -16.0                        1                 15.0
21             4.5                        0                699.0

    diff_rech_amt  decrease_rech_amt_action
8           -76.5                         1
13          -22.0                         1
16         -316.0                         1
17         -801.0                         1
21           99.0                         0
```

Deriving new column `decrease_arpu_action`

This column indicates whether the average revenue per customer has decreased in the action phase than the good phase.

```
# ARUP in action phase
data['avg_arpu_action'] = (data['arpu_7'] + data['arpu_8'])/2

# Difference of good and action phase ARPU
data['diff_arpu'] = data['avg_arpu_action'] - data['arpu_6']

# Checking whether the arpu has decreased on the action month
data['decrease_arpu_action'] = np.where(data['diff_arpu'] < 0, 1, 0)

data.head()
```

```
   mobile_number  loc_og_t2o_mou  std_og_t2o_mou  loc_ic_t2o_mou
arpu_6  \
8     7001524846             0.0             0.0             0.0
378.721
13    7002191713             0.0             0.0             0.0
492.846
16    7000875565             0.0             0.0             0.0
430.975
17    7000187447             0.0             0.0             0.0
690.008
21    7002124215             0.0             0.0             0.0
514.453

     arpu_7   arpu_8  onnet_mou_6  onnet_mou_7  onnet_mou_8
offnet_mou_6  \
8   492.223  137.362       413.69       351.03        35.08
94.66
13  205.671  593.260       501.76       108.39       534.24
413.31
16  299.869  187.894        50.51        74.01        70.61
296.29
```

```
17   18.980   25.499      1185.91         9.28         7.79
61.64
21  597.753  637.760       102.41       132.11        85.14
757.93

    offnet_mou_7  offnet_mou_8  roam_ic_mou_6  roam_ic_mou_7
roam_ic_mou_8  \
8          80.63        136.48           0.00           0.00
0.00
13        119.28        482.46          23.53         144.24
72.11
16        229.74        162.76           0.00           2.83
0.00
17          0.00          5.54           0.00           4.76
4.81
21        896.68        983.39           0.00           0.00
0.00

    roam_og_mou_6  roam_og_mou_7  roam_og_mou_8  loc_og_t2t_mou_6  \
8            0.00           0.00           0.00            297.13
13           7.98          35.26           1.44             49.63
16           0.00          17.74           0.00             42.61
17           0.00           8.46          13.34             38.99
21           0.00           0.00           0.00              4.48

    loc_og_t2t_mou_7  loc_og_t2t_mou_8  loc_og_t2m_mou_6
loc_og_t2m_mou_7  \
8             217.59             12.49             80.96
70.58
13              6.19             36.01            151.13
47.28
16             65.16             67.38            273.29
145.99
17              0.00              0.00             58.54
0.00
21              6.16             23.34             91.81
87.93

    loc_og_t2m_mou_8  loc_og_t2f_mou_6  loc_og_t2f_mou_7
loc_og_t2f_mou_8  \
8              50.54              0.00              0.00
0.00
13            294.46              4.54              0.00
23.51
16            128.28              0.00              4.48
10.26
17              0.00              0.00              0.00
0.00
21            104.81              0.75              0.00
1.58
```

```
    loc_og_t2c_mou_6  loc_og_t2c_mou_7  loc_og_t2c_mou_8  loc_og_mou_6
\
8                0.0               0.0              7.15        378.09

13               0.0               0.0              0.49        205.31

16               0.0               0.0              0.00        315.91

17               0.0               0.0              0.00         97.54

21               0.0               0.0              0.00         97.04


    loc_og_mou_7  loc_og_mou_8  std_og_t2t_mou_6  std_og_t2t_mou_7  \
8         288.18         63.04            116.56            133.43
13         53.48        353.99            446.41             85.98
16        215.64        205.93              7.89              2.58
17          0.00          0.00           1146.91              0.81
21         94.09        129.74             97.93            125.94

    std_og_t2t_mou_8  std_og_t2m_mou_6  std_og_t2m_mou_7
std_og_t2m_mou_8  \
8              22.58             13.69             10.04
75.69
13            498.23            255.36             52.94
156.94
16              3.23             22.99             64.51
18.29
17              0.00              1.55              0.00
0.00
21             61.79            665.36            808.74
876.99

    std_og_t2f_mou_6  std_og_t2f_mou_7  std_og_t2f_mou_8
std_og_t2c_mou_6  \
8                0.0               0.0               0.0
0.0
13               0.0               0.0               0.0
0.0
16               0.0               0.0               0.0
0.0
17               0.0               0.0               0.0
0.0
21               0.0               0.0               0.0
0.0

    std_og_t2c_mou_7  std_og_t2c_mou_8  std_og_mou_6  std_og_mou_7  \
8                0.0               0.0        130.26        143.48
13               0.0               0.0        701.78        138.93
```

```
16              0.0              0.0        30.89        67.09
17              0.0              0.0      1148.46         0.81
21              0.0              0.0       763.29       934.69

    std_og_mou_8  isd_og_mou_6  isd_og_mou_7  isd_og_mou_8
spl_og_mou_6  \
8          98.28           0.0           0.0          0.00
0.00
13        655.18           0.0           0.0          1.29
0.00
16         21.53           0.0           0.0          0.00
0.00
17          0.00           0.0           0.0          0.00
2.58
21        938.79           0.0           0.0          0.00
0.00

    spl_og_mou_7  spl_og_mou_8  og_others_6  og_others_7  og_others_8
\
8           0.00         10.23         0.00          0.0          0.0

13          0.00          4.78         0.00          0.0          0.0

16          3.26          5.91         0.00          0.0          0.0

17          0.00          0.00         0.93          0.0          0.0

21          0.00          0.00         0.00          0.0          0.0


    total_og_mou_6  total_og_mou_7  total_og_mou_8
loc_ic_t2t_mou_6  \
8           508.36          431.66          171.56               23.84

13          907.09          192.41         1015.26               67.88

16          346.81          286.01          233.38               41.33

17         1249.53            0.81            0.00               34.54

21          860.34         1028.79         1068.54                2.48


    loc_ic_t2t_mou_7  loc_ic_t2t_mou_8  loc_ic_t2m_mou_6
loc_ic_t2m_mou_7  \
8               9.84              0.31             57.58
13.98
13              7.58             52.58            142.88
18.53
16             71.44             28.89            226.81
149.69
```

```
17             0.00              0.00             47.41
2.31
21            10.19             19.54            118.23
74.63

    loc_ic_t2m_mou_8  loc_ic_t2f_mou_6  loc_ic_t2f_mou_7
loc_ic_t2f_mou_8  \
8              15.48              0.00              0.00
0.00
13            195.18              4.81              0.00
7.49
16            150.16              8.71              8.68
32.71
17              0.00              0.00              0.00
0.00
21            129.16              4.61              2.84
10.39

    loc_ic_mou_6  loc_ic_mou_7  loc_ic_mou_8  std_ic_t2t_mou_6  \
8          81.43         23.83         15.79              0.00
13        215.58         26.11        255.26            115.68
16        276.86        229.83        211.78             68.79
17         81.96          2.31          0.00              8.63
21        125.33         87.68        159.11             14.06

    std_ic_t2t_mou_7  std_ic_t2t_mou_8  std_ic_t2m_mou_6
std_ic_t2m_mou_7  \
8               0.58              0.10             22.43
4.08
13             38.29            154.58            308.13
29.79
16             78.64              6.33             18.68
73.08
17              0.00              0.00              1.28
0.00
21              5.98              0.18             67.69
38.23

    std_ic_t2m_mou_8  std_ic_t2f_mou_6  std_ic_t2f_mou_7
std_ic_t2f_mou_8  \
8               0.65              0.00               0.0
0.00
13            317.91              0.00               0.0
1.91
16             73.93              0.51               0.0
2.18
17              0.00              0.00               0.0
0.00
21            101.74              0.00               0.0
0.00
```

```
    std_ic_t2o_mou_6  std_ic_t2o_mou_7  std_ic_t2o_mou_8  std_ic_mou_6
\
8                0.0               0.0               0.0         22.43

13               0.0               0.0               0.0        423.81

16               0.0               0.0               0.0         87.99

17               0.0               0.0               0.0          9.91

21               0.0               0.0               0.0         81.76


    std_ic_mou_7  std_ic_mou_8  total_ic_mou_6  total_ic_mou_7  \
8           4.66          0.75          103.86           28.49
13         68.09        474.41          968.61          172.58
16        151.73         82.44          364.86          381.56
17          0.00          0.00           91.88            2.31
21         44.21        101.93          207.09          131.89

    total_ic_mou_8  spl_ic_mou_6  spl_ic_mou_7  spl_ic_mou_8
isd_ic_mou_6  \
8            16.54          0.00           0.0           0.0
0.00
13         1144.53          0.45           0.0           0.0
245.28
16          294.46          0.00           0.0           0.0
0.00
17            0.00          0.00           0.0           0.0
0.00
21          261.04          0.00           0.0           0.0
0.00

    isd_ic_mou_7  isd_ic_mou_8  ic_others_6  ic_others_7  ic_others_8
\
8           0.00          0.00         0.00         0.00         0.00

13         62.11        393.39        83.48        16.24        21.44

16          0.00          0.23         0.00         0.00         0.00

17          0.00          0.00         0.00         0.00         0.00

21          0.00          0.00         0.00         0.00         0.00


    total_rech_num_6  total_rech_num_7  total_rech_num_8
total_rech_amt_6  \
8                 19                21                14
437
```

```
13                 6                 4                 11
507
16                10                 6                  2
570
17                19                 2                  4
816
21                22                26                 27
600

    total_rech_amt_7  total_rech_amt_8  max_rech_amt_6  max_rech_amt_7
\
8                601               120              90             154

13               253               717             110             110

16               348               160             110             110

17                 0                30             110               0

21               680               718              50              50


    max_rech_amt_8  last_day_rch_amt_6  last_day_rch_amt_7  \
8               30                  50                   0
13             130                 110                  50
16             130                 100                 100
17              30                  30                   0
21              50                  30                  20

    last_day_rch_amt_8  vol_2g_mb_6  vol_2g_mb_7  vol_2g_mb_8
vol_3g_mb_6  \
8                   10          0.0        356.0         0.03
0.0
13                   0          0.0          0.0         0.02
0.0
16                 130          0.0          0.0         0.00
0.0
17                   0          0.0          0.0         0.00
0.0
21                  50          0.0          0.0         0.00
0.0

    vol_3g_mb_7  vol_3g_mb_8  monthly_2g_6  monthly_2g_7  monthly_2g_8
\
8        750.95        11.94             0             1             0

13         0.00         0.00             0             0             0

16         0.00         0.00             0             0             0
```

```
17         0.00         0.00              0              0              0

21         0.00         0.00              0              0              0


    sachet_2g_6  sachet_2g_7  sachet_2g_8  monthly_3g_6  monthly_3g_7  
\
8             0            1            3             0             0

13            0            0            3             0             0

16            0            0            0             0             0

17            0            0            0             0             0

21            0            0            0             0             0


    monthly_3g_8  sachet_3g_6  sachet_3g_7  sachet_3g_8   aon  
aug_vbc_3g  \
8              0            0            0            0   315  
21.03
13             0            0            0            0  2607  
0.00
16             0            0            0            0   511  
0.00
17             0            0            0            0   667  
0.00
21             0            0            0            0   720  
0.00

    jul_vbc_3g  jun_vbc_3g  avg_rech_amt_6_7 churn  total_mou_good  \
8       910.65      122.16             519.0     0          612.22  
13        0.00        0.00             380.0     0         1875.70  
16        2.45       21.89             459.0     0          711.67  
17        0.00        0.00             408.0     0         1341.41  
21        0.00        0.00             640.0     0         1067.43  

    avg_mou_action  diff_mou  decrease_mou_action  avg_rech_num_action  
\
8          324.125  -288.095                    1                 17.5

13        1262.390  -613.310                    1                  7.5

16         597.705  -113.965                    1                  4.0

17           1.560 -1339.850                    1                  3.0

21        1245.130   177.700                    0                 26.5
```

```
    diff_rech_num  decrease_rech_num_action  avg_rech_amt_action  \
8            -1.5                         1                360.5
13            1.5                         0                485.0
16           -6.0                         1                254.0
17          -16.0                         1                 15.0
21            4.5                         0                699.0

    diff_rech_amt  decrease_rech_amt_action  avg_arpu_action
diff_arpu  \
8           -76.5                         1         314.7925    -
63.9285
13          -22.0                         1         399.4655    -
93.3805
16         -316.0                         1         243.8815   -
187.0935
17         -801.0                         1          22.2395   -
667.7685
21           99.0                         0         617.7565
103.3035

    decrease_arpu_action
8                      1
13                     1
16                     1
17                     1
21                     0
```

Deriving new column `decrease_vbc_action`

This column indicates whether the volume based cost of the customer has decreased in the action phase than the good phase.

```
# VBC in action phase
data['avg_vbc_3g_action'] = (data['jul_vbc_3g'] +
data['aug_vbc_3g'])/2

# Difference of good and action phase VBC
data['diff_vbc'] = data['avg_vbc_3g_action'] - data['jun_vbc_3g']

# Checking whether the VBC has decreased on the action month
data['decrease_vbc_action'] = np.where(data['diff_vbc'] < 0 , 1, 0)

data.head()
```

```
   mobile_number  loc_og_t2o_mou  std_og_t2o_mou  loc_ic_t2o_mou
arpu_6  \
8     7001524846             0.0             0.0             0.0
378.721
13    7002191713             0.0             0.0             0.0
492.846
```

```
16    7000875565             0.0             0.0             0.0
430.975
17    7000187447             0.0             0.0             0.0
690.008
21    7002124215             0.0             0.0             0.0
514.453

     arpu_7   arpu_8  onnet_mou_6  onnet_mou_7  onnet_mou_8
offnet_mou_6  \
8   492.223  137.362       413.69       351.03        35.08
94.66
13  205.671  593.260       501.76       108.39       534.24
413.31
16  299.869  187.894        50.51        74.01        70.61
296.29
17   18.980   25.499      1185.91         9.28         7.79
61.64
21  597.753  637.760       102.41       132.11        85.14
757.93

    offnet_mou_7  offnet_mou_8  roam_ic_mou_6  roam_ic_mou_7
roam_ic_mou_8  \
8          80.63        136.48           0.00           0.00
0.00
13        119.28        482.46          23.53         144.24
72.11
16        229.74        162.76           0.00           2.83
0.00
17          0.00          5.54           0.00           4.76
4.81
21        896.68        983.39           0.00           0.00
0.00

    roam_og_mou_6  roam_og_mou_7  roam_og_mou_8  loc_og_t2t_mou_6  \
8            0.00           0.00           0.00            297.13
13           7.98          35.26           1.44             49.63
16           0.00          17.74           0.00             42.61
17           0.00           8.46          13.34             38.99
21           0.00           0.00           0.00              4.48

    loc_og_t2t_mou_7  loc_og_t2t_mou_8  loc_og_t2m_mou_6
loc_og_t2m_mou_7  \
8             217.59             12.49             80.96
70.58
13              6.19             36.01            151.13
47.28
16             65.16             67.38            273.29
145.99
17              0.00              0.00             58.54
0.00
```

```
21              6.16             23.34             91.81
87.93

    loc_og_t2m_mou_8  loc_og_t2f_mou_6  loc_og_t2f_mou_7
loc_og_t2f_mou_8  \
8              50.54              0.00              0.00
0.00
13            294.46              4.54              0.00
23.51
16            128.28              0.00              4.48
10.26
17              0.00              0.00              0.00
0.00
21            104.81              0.75              0.00
1.58

    loc_og_t2c_mou_6  loc_og_t2c_mou_7  loc_og_t2c_mou_8  loc_og_mou_6
\
8                0.0               0.0              7.15        378.09

13               0.0               0.0              0.49        205.31

16               0.0               0.0              0.00        315.91

17               0.0               0.0              0.00         97.54

21               0.0               0.0              0.00         97.04


    loc_og_mou_7  loc_og_mou_8  std_og_t2t_mou_6  std_og_t2t_mou_7  \
8         288.18         63.04            116.56            133.43
13         53.48        353.99            446.41             85.98
16        215.64        205.93              7.89              2.58
17          0.00          0.00           1146.91              0.81
21         94.09        129.74             97.93            125.94

    std_og_t2t_mou_8  std_og_t2m_mou_6  std_og_t2m_mou_7
std_og_t2m_mou_8  \
8              22.58             13.69             10.04
75.69
13            498.23            255.36             52.94
156.94
16              3.23             22.99             64.51
18.29
17              0.00              1.55              0.00
0.00
21             61.79            665.36            808.74
876.99

    std_og_t2f_mou_6  std_og_t2f_mou_7  std_og_t2f_mou_8
```

```
std_og_t2c_mou_6  \
8                0.0               0.0               0.0
0.0
13               0.0               0.0               0.0
0.0
16               0.0               0.0               0.0
0.0
17               0.0               0.0               0.0
0.0
21               0.0               0.0               0.0
0.0

    std_og_t2c_mou_7  std_og_t2c_mou_8  std_og_mou_6  std_og_mou_7  \
8                0.0               0.0        130.26        143.48
13               0.0               0.0        701.78        138.93
16               0.0               0.0         30.89         67.09
17               0.0               0.0       1148.46          0.81
21               0.0               0.0        763.29        934.69

    std_og_mou_8  isd_og_mou_6  isd_og_mou_7  isd_og_mou_8
spl_og_mou_6  \
8          98.28           0.0           0.0          0.00
0.00
13        655.18           0.0           0.0          1.29
0.00
16         21.53           0.0           0.0          0.00
0.00
17          0.00           0.0           0.0          0.00
2.58
21        938.79           0.0           0.0          0.00
0.00

    spl_og_mou_7  spl_og_mou_8  og_others_6  og_others_7  og_others_8
\
8           0.00         10.23         0.00          0.0          0.0

13          0.00          4.78         0.00          0.0          0.0

16          3.26          5.91         0.00          0.0          0.0

17          0.00          0.00         0.93          0.0          0.0

21          0.00          0.00         0.00          0.0          0.0


    total_og_mou_6  total_og_mou_7  total_og_mou_8
loc_ic_t2t_mou_6  \
8           508.36          431.66          171.56             23.84

13          907.09          192.41         1015.26             67.88
```

```
16          346.81          286.01          233.38             41.33
17         1249.53            0.81            0.00             34.54
21          860.34         1028.79         1068.54              2.48

    loc_ic_t2t_mou_7  loc_ic_t2t_mou_8  loc_ic_t2m_mou_6
loc_ic_t2m_mou_7  \
8               9.84              0.31             57.58
13.98
13              7.58             52.58            142.88
18.53
16             71.44             28.89            226.81
149.69
17              0.00              0.00             47.41
2.31
21             10.19             19.54            118.23
74.63

    loc_ic_t2m_mou_8  loc_ic_t2f_mou_6  loc_ic_t2f_mou_7
loc_ic_t2f_mou_8  \
8              15.48              0.00              0.00
0.00
13            195.18              4.81              0.00
7.49
16            150.16              8.71              8.68
32.71
17              0.00              0.00              0.00
0.00
21            129.16              4.61              2.84
10.39

    loc_ic_mou_6  loc_ic_mou_7  loc_ic_mou_8  std_ic_t2t_mou_6  \
8          81.43         23.83         15.79              0.00
13        215.58         26.11        255.26            115.68
16        276.86        229.83        211.78             68.79
17         81.96          2.31          0.00              8.63
21        125.33         87.68        159.11             14.06

    std_ic_t2t_mou_7  std_ic_t2t_mou_8  std_ic_t2m_mou_6
std_ic_t2m_mou_7  \
8               0.58              0.10             22.43
4.08
13             38.29            154.58            308.13
29.79
16             78.64              6.33             18.68
73.08
17              0.00              0.00              1.28
```

```
0.00
21              5.98              0.18             67.69
38.23

    std_ic_t2m_mou_8  std_ic_t2f_mou_6  std_ic_t2f_mou_7
std_ic_t2f_mou_8  \
8               0.65              0.00               0.0
0.00
13            317.91              0.00               0.0
1.91
16             73.93              0.51               0.0
2.18
17              0.00              0.00               0.0
0.00
21            101.74              0.00               0.0
0.00

    std_ic_t2o_mou_6  std_ic_t2o_mou_7  std_ic_t2o_mou_8  std_ic_mou_6
\
8                0.0               0.0               0.0         22.43

13               0.0               0.0               0.0        423.81

16               0.0               0.0               0.0         87.99

17               0.0               0.0               0.0          9.91

21               0.0               0.0               0.0         81.76


    std_ic_mou_7  std_ic_mou_8  total_ic_mou_6  total_ic_mou_7  \
8           4.66          0.75          103.86           28.49
13         68.09        474.41          968.61          172.58
16        151.73         82.44          364.86          381.56
17          0.00          0.00           91.88            2.31
21         44.21        101.93          207.09          131.89

    total_ic_mou_8  spl_ic_mou_6  spl_ic_mou_7  spl_ic_mou_8
isd_ic_mou_6  \
8            16.54          0.00           0.0           0.0
0.00
13         1144.53          0.45           0.0           0.0
245.28
16          294.46          0.00           0.0           0.0
0.00
17            0.00          0.00           0.0           0.0
0.00
21          261.04          0.00           0.0           0.0
0.00
```

```
    isd_ic_mou_7  isd_ic_mou_8  ic_others_6  ic_others_7  ic_others_8
\
8           0.00          0.00         0.00         0.00         0.00

13         62.11        393.39        83.48        16.24        21.44

16          0.00          0.23         0.00         0.00         0.00

17          0.00          0.00         0.00         0.00         0.00

21          0.00          0.00         0.00         0.00         0.00


    total_rech_num_6  total_rech_num_7  total_rech_num_8
total_rech_amt_6  \
8                 19                21                14
437
13                 6                 4                11
507
16                10                 6                 2
570
17                19                 2                 4
816
21                22                26                27
600

    total_rech_amt_7  total_rech_amt_8  max_rech_amt_6  max_rech_amt_7
\
8                601               120              90             154

13               253               717             110             110

16               348               160             110             110

17                 0                30             110               0

21               680               718              50              50


    max_rech_amt_8  last_day_rch_amt_6  last_day_rch_amt_7  \
8               30                  50                   0
13             130                 110                  50
16             130                 100                 100
17              30                  30                   0
21              50                  30                  20

    last_day_rch_amt_8  vol_2g_mb_6  vol_2g_mb_7  vol_2g_mb_8
vol_3g_mb_6  \
8                   10          0.0        356.0         0.03
0.0
13                   0          0.0          0.0         0.02
```

```
0.0
16                 130          0.0          0.0         0.00
0.0
17                   0          0.0          0.0         0.00
0.0
21                  50          0.0          0.0         0.00
0.0

    vol_3g_mb_7  vol_3g_mb_8  monthly_2g_6  monthly_2g_7  monthly_2g_8
\
8        750.95        11.94             0             1             0

13         0.00         0.00             0             0             0

16         0.00         0.00             0             0             0

17         0.00         0.00             0             0             0

21         0.00         0.00             0             0             0


    sachet_2g_6  sachet_2g_7  sachet_2g_8  monthly_3g_6  monthly_3g_7
\
8             0            1            3             0             0

13            0            0            3             0             0

16            0            0            0             0             0

17            0            0            0             0             0

21            0            0            0             0             0


    monthly_3g_8  sachet_3g_6  sachet_3g_7  sachet_3g_8   aon
aug_vbc_3g  \
8              0            0            0            0   315
21.03
13             0            0            0            0  2607
0.00
16             0            0            0            0   511
0.00
17             0            0            0            0   667
0.00
21             0            0            0            0   720
0.00

    jul_vbc_3g  jun_vbc_3g  avg_rech_amt_6_7 churn  total_mou_good  \
8       910.65      122.16             519.0     0          612.22
13        0.00        0.00             380.0     0         1875.70
16        2.45       21.89             459.0     0          711.67
```

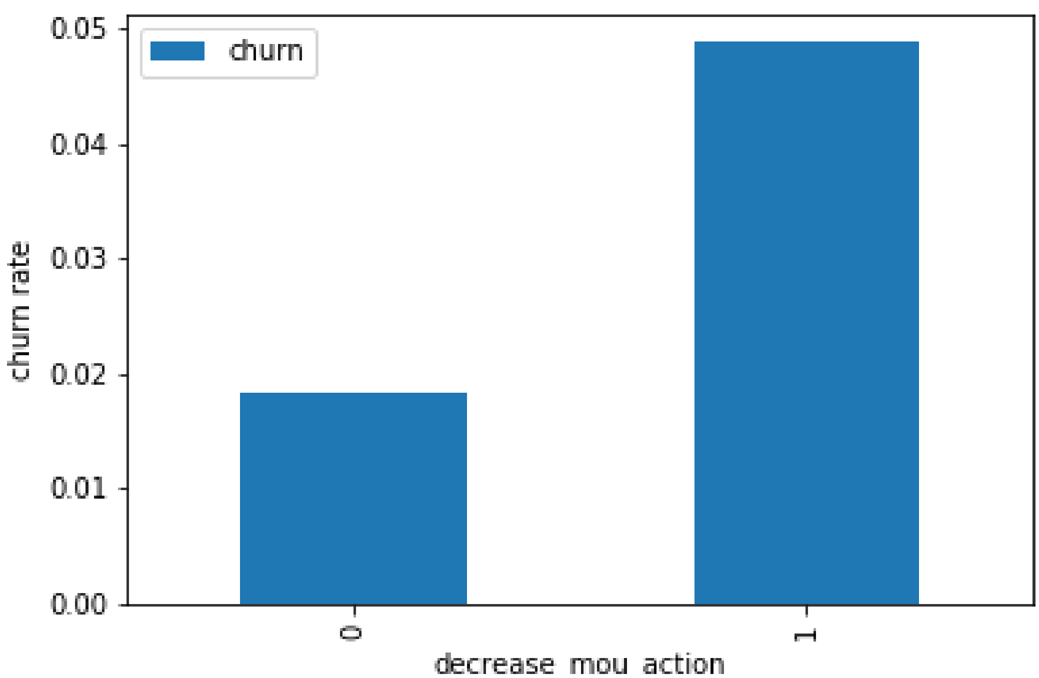
```
17        0.00        0.00              408.0     0         1341.41
21        0.00        0.00              640.0     0         1067.43

    avg_mou_action  diff_mou  decrease_mou_action  avg_rech_num_action
\
8          324.125  -288.095                    1                 17.5

13        1262.390  -613.310                    1                  7.5

16         597.705  -113.965                    1                  4.0

17           1.560 -1339.850                    1                  3.0

21        1245.130   177.700                    0                 26.5


    diff_rech_num  decrease_rech_num_action  avg_rech_amt_action  \
8            -1.5                         1                360.5
13            1.5                         0                485.0
16           -6.0                         1                254.0
17          -16.0                         1                 15.0
21            4.5                         0                699.0

    diff_rech_amt  decrease_rech_amt_action  avg_arpu_action
diff_arpu  \
8           -76.5                         1         314.7925   -
63.9285
13          -22.0                         1         399.4655   -
93.3805
16         -316.0                         1         243.8815  -
187.0935
17         -801.0                         1          22.2395  -
667.7685
21           99.0                         0         617.7565
103.3035

    decrease_arpu_action  avg_vbc_3g_action  diff_vbc
decrease_vbc_action
8                      1            465.840   343.680
0
13                     1              0.000     0.000
0
16                     1              1.225   -20.665
1
17                     1              0.000     0.000
0
21                     0              0.000     0.000
0
```

EDA

Univariate analysis

Churn rate on the basis whether the customer decreased her/his MOU in action month

```
# Converting churn column to int in order to do aggfunc in the pivot
table
data['churn'] = data['churn'].astype('int64')

data.pivot_table(values='churn', index='decrease_mou_action',
aggfunc='mean').plot.bar()
plt.ylabel('churn rate')
plt.show()
```

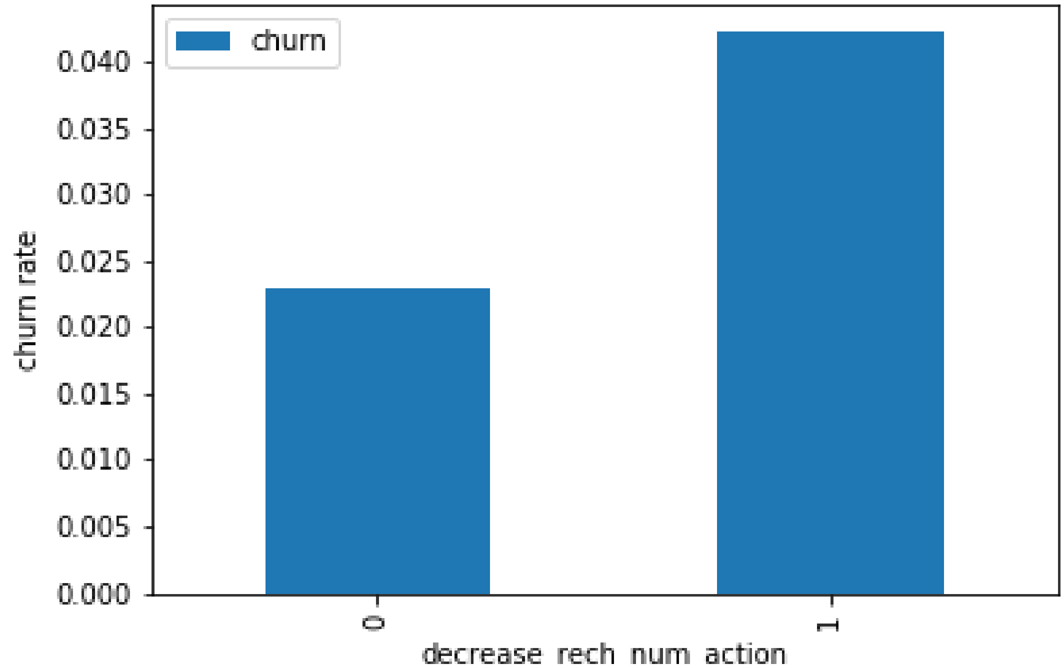


Analysis

We can see that the churn rate is more for the customers, whose minutes of usage(mou) decreased in the action phase than the good phase.

Churn rate on the basis whether the customer decreased her/his number of recharge in action month

```
data.pivot_table(values='churn', index='decrease_rech_num_action',
aggfunc='mean').plot.bar()
plt.ylabel('churn rate')
plt.show()
```

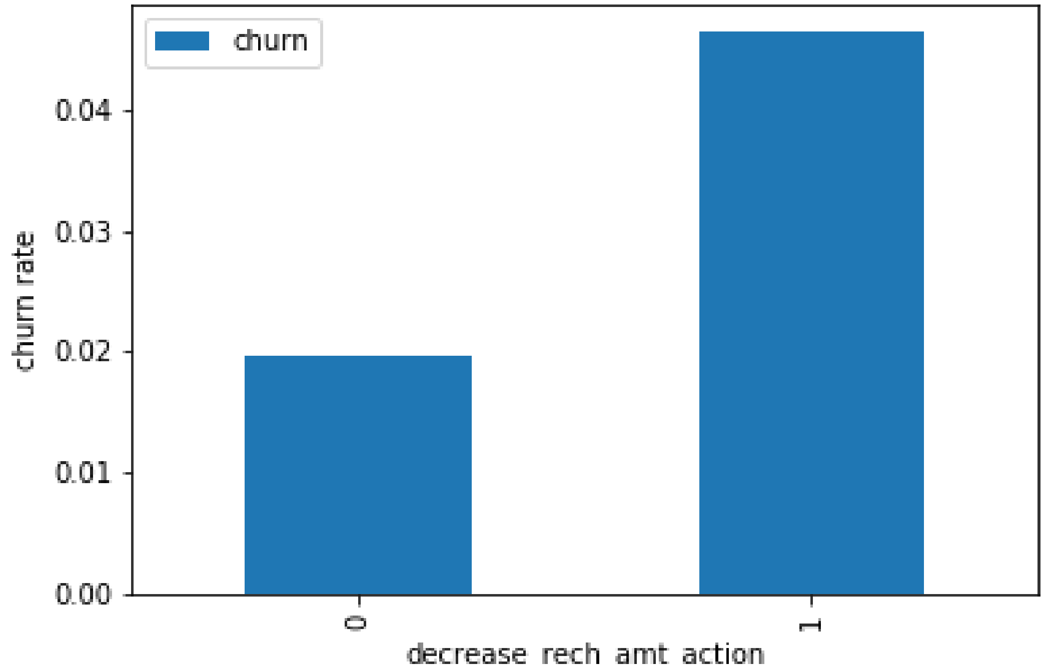


Analysis

As expected, the churn rate is more for the customers, whose number of recharge in the action phase is lesser than the number in good phase.

Churn rate on the basis whether the customer decreased her/his amount of recharge in action month

```
data.pivot_table(values='churn', index='decrease_rech_amt_action',
aggfunc='mean').plot.bar()
plt.ylabel('churn rate')
plt.show()
```

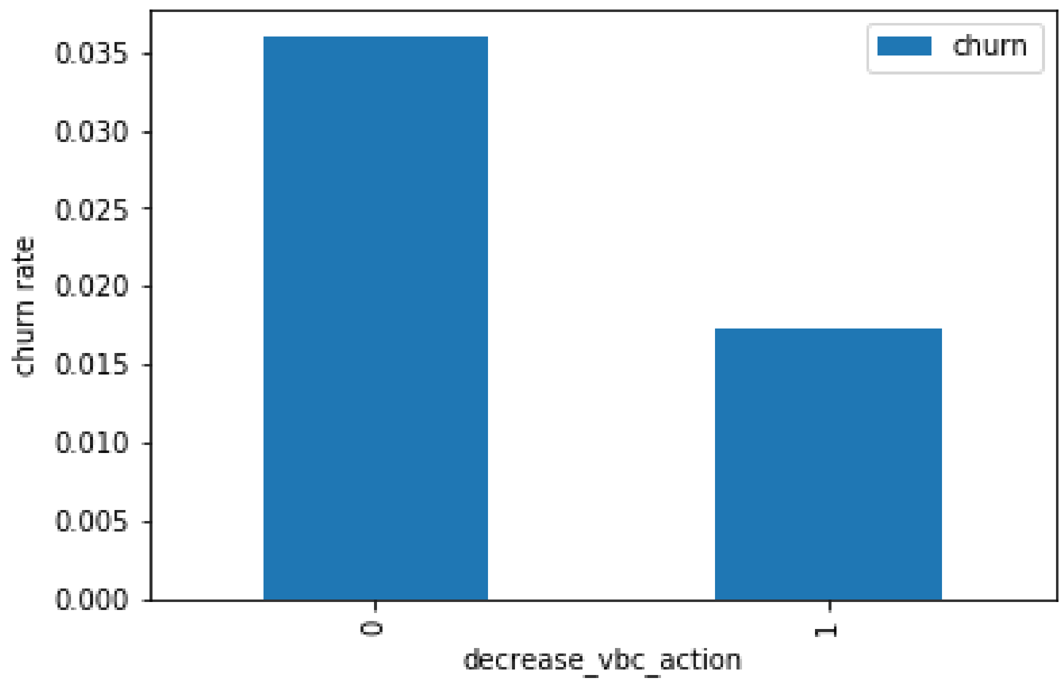


Analysis

Here also we see the same behaviour. The churn rate is more for the customers, whose amount of recharge in the action phase is lesser than the amount in good phase.

Churn rate on the basis whether the customer decreased her/his volume based cost in action month

```
data.pivot_table(values='churn', index='decrease_vbc_action',
aggfunc='mean').plot.bar()
plt.ylabel('churn rate')
plt.show()
```

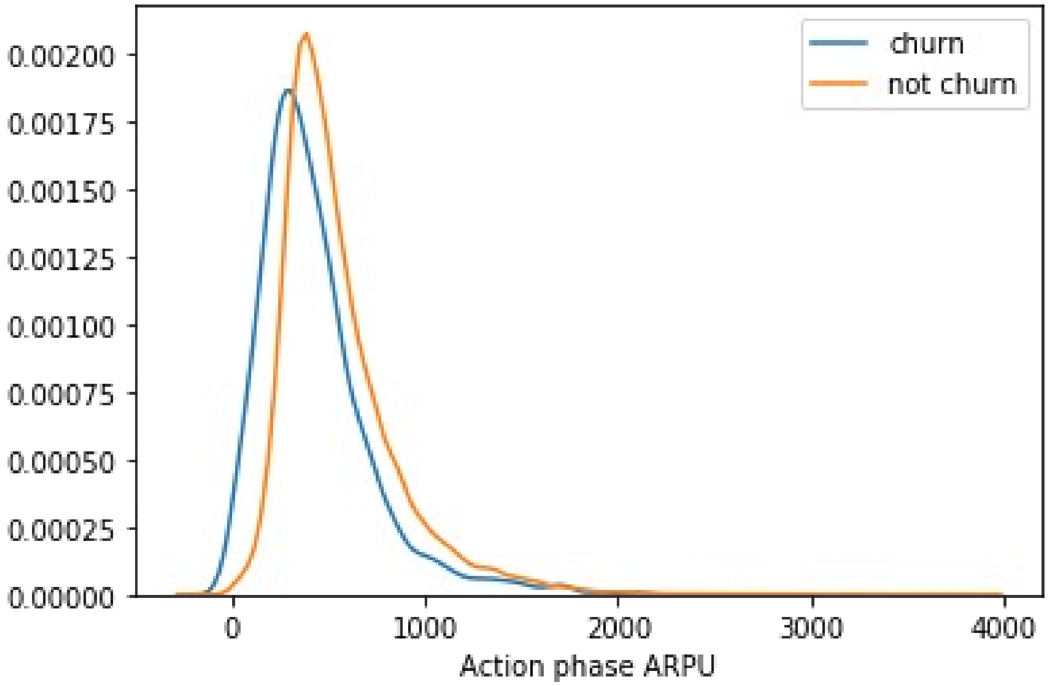


Analysis

Here we see the expected result. The churn rate is more for the customers, whose volume based cost in action month is increased. That means the customers do not do the monthly recharge more when they are in the action phase.

Analysis of the average revenue per customer (churn and not churn) in the action phase

```
# Creating churn dataframe
data_churn = data[data['churn'] == 1]
# Creating not churn dataframe
data_non_churn = data[data['churn'] == 0]

# Distribution plot
ax =
sns.distplot(data_churn['avg_arpu_action'],label='churn',hist=False)
ax = sns.distplot(data_non_churn['avg_arpu_action'],label='not
churn',hist=False)
ax.set(xlabel='Action phase ARPU')

[Text(0.5, 0, 'Action phase ARPU')]
```

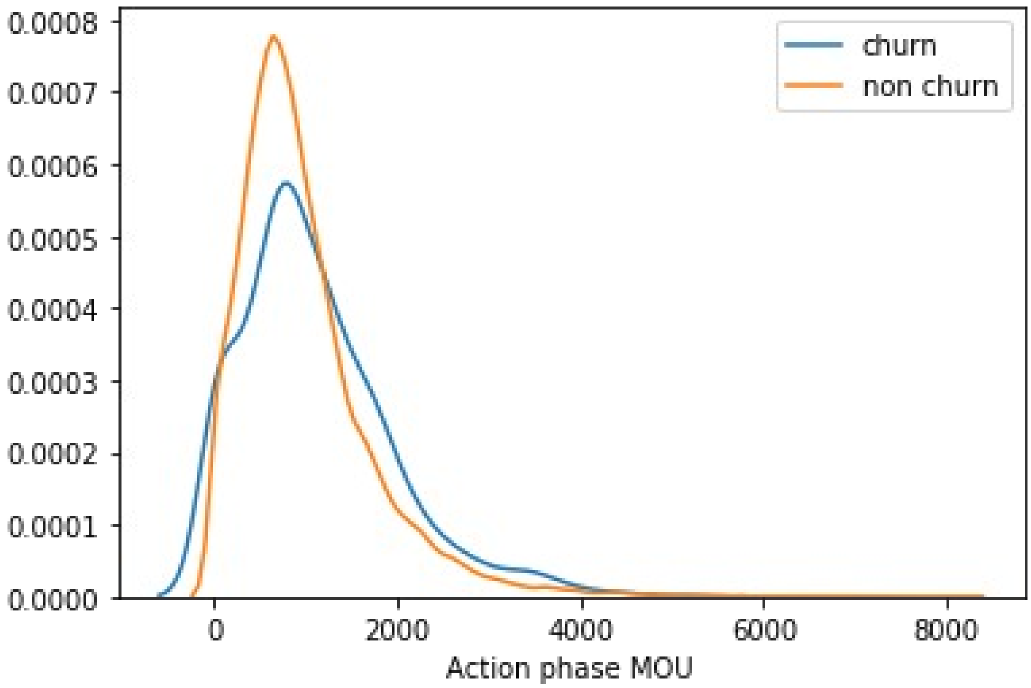


Average revenue per user (ARPU) for the churned customers is mostly densed on the 0 to 900. The higher ARPU customers are less likely to be churned.

ARPU for the not churned customers is mostly densed on the 0 to 1000.

Analysis of the minutes of usage MOU (churn and not churn) in the action phase

```
# Distribution plot
ax =
sns.distplot(data_churn['total_mou_good'],label='churn',hist=False)
ax = sns.distplot(data_non_churn['total_mou_good'],label='non
churn',hist=False)
ax.set(xlabel='Action phase MOU')

[Text(0.5, 0, 'Action phase MOU')]
```

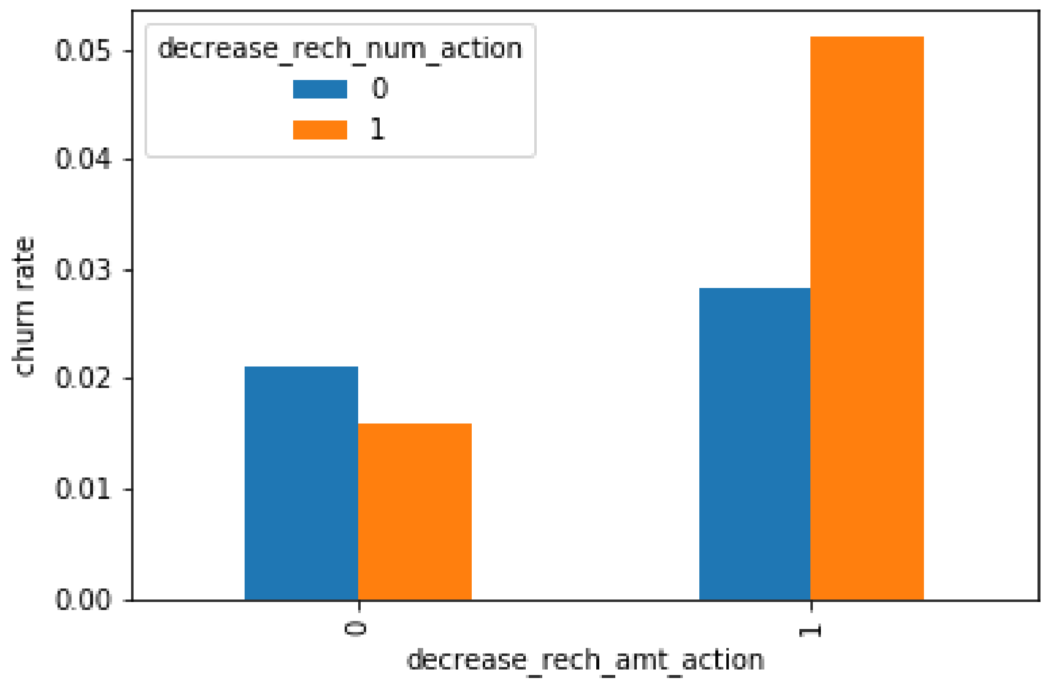


Minutes of usage(MOU) of the churn customers is mostly populated on the 0 to 2500 range. Higher the MOU, lesser the churn probability.

Bivariate analysis

Analysis of churn rate by the decreasing recharge amount and number of recharge in the action phase

```
data.pivot_table(values='churn', index='decrease_rech_amt_action',
columns='decrease_rech_num_action', aggfunc='mean').plot.bar()
plt.ylabel('churn rate')
plt.show()
```

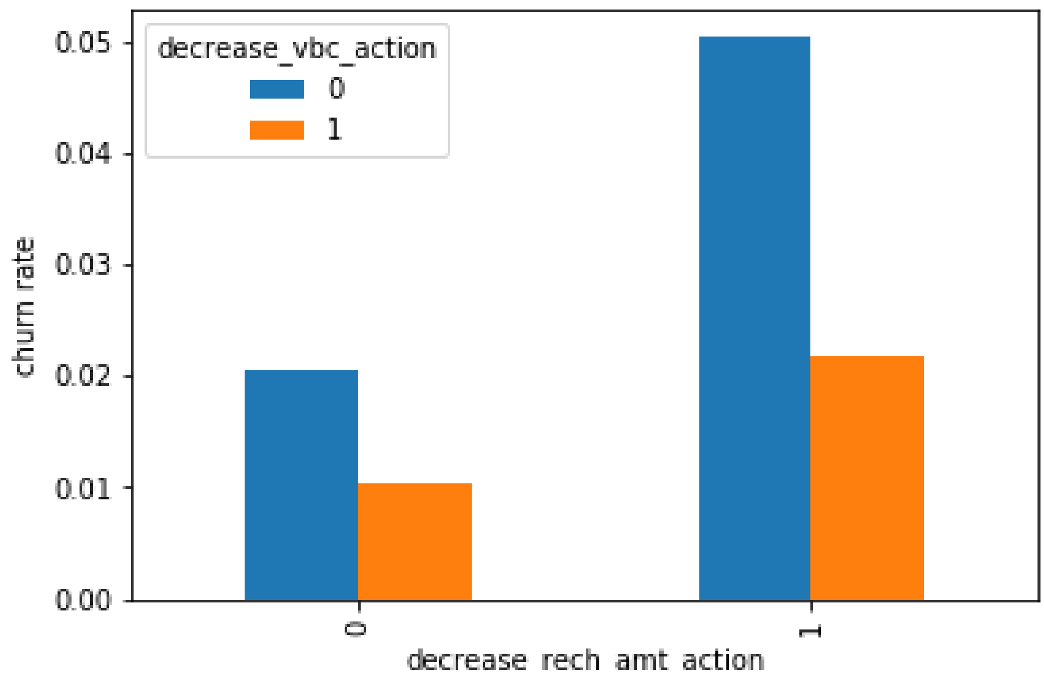


Analysis

We can see from the above plot, that the churn rate is more for the customers, whose recharge amount as well as number of recharge have decreased in the action phase than the good phase.

Analysis of churn rate by the decreasing recharge amount and volume based cost in the action phase

```
data.pivot_table(values='churn', index='decrease_rech_amt_action',
columns='decrease_vbc_action', aggfunc='mean').plot.bar()
plt.ylabel('churn rate')
plt.show()
```

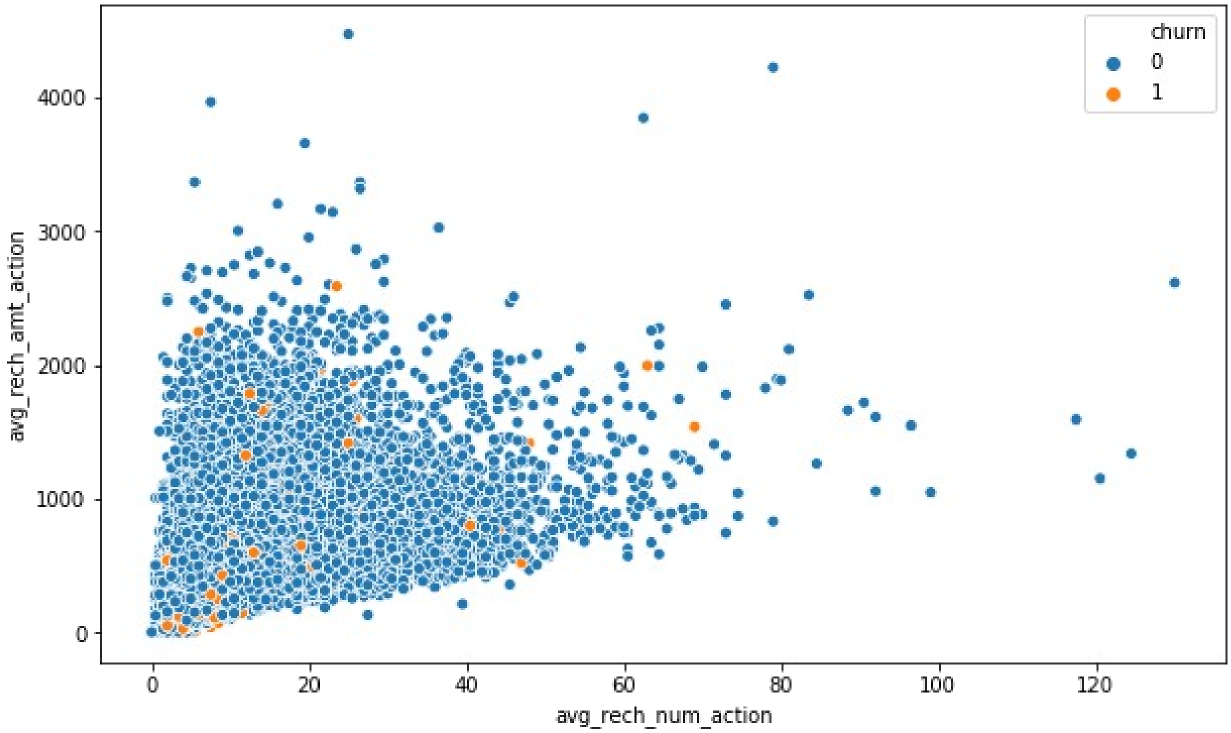


Analysis

Here, also we can see that the churn rate is more for the customers, whose recharge amount is decreased along with the volume based cost is increased in the action month.

Analysis of recharge amount and number of recharge in action month

```
plt.figure(figsize=(10,6))
ax = sns.scatterplot('avg_rech_num_action','avg_rech_amt_action',
hue='churn', data=data)
```



Analysis

We can see from the above pattern that the recharge number and the recharge amount are mostly propotional. More the number of recharge, more the amount of the recharge.

Dropping few derived columns, which are not required in further analysis

```
data =
data.drop(['total_mou_good','avg_mou_action','diff_mou','avg_rech_num_action','diff_rech_num','avg_rech_amt_action',

'diff_rech_amt','avg_arpu_action','diff_arpu','avg_vbc_3g_action','diff_vbc','avg_rech_amt_6_7'], axis=1)
```

Train-Test Split

```
# Import library
from sklearn.model_selection import train_test_split

# Putting feature variables into X
X = data.drop(['mobile_number','churn'], axis=1)

# Putting target variable to y
y = data['churn']

# Splitting data into train and test set 80:20
X_train, X_test, y_train, y_test = train_test_split(X, y,
train_size=0.8, test_size=0.2, random_state=100)
```

Dealing with data imbalance

We are creating synthetic samples by doing upsampling using SMOTE(Synthetic Minority Oversampling Technique).

```
# Imporing SMOTE
from imblearn.over_sampling import SMOTE

# Instantiate SMOTE
sm = SMOTE(random_state=27)

# Fittign SMOTE to the train set
X_train, y_train = sm.fit_sample(X_train, y_train)
```

Feature Scaling

```
# Standardization method
from sklearn.preprocessing import StandardScaler

# Instantiate the Scaler
scaler = StandardScaler()

# List of the numeric columns
cols_scale = X_train.columns.to_list()
# Removing the derived binary columns
cols_scale.remove('decrease_mou_action')
cols_scale.remove('decrease_rech_num_action')
cols_scale.remove('decrease_rech_amt_action')
cols_scale.remove('decrease_arpu_action')
cols_scale.remove('decrease_vbc_action')

# Fit the data into scaler and transform
X_train[cols_scale] = scaler.fit_transform(X_train[cols_scale])

X_train.head()
```

```
   loc_og_t2o_mou  std_og_t2o_mou  loc_ic_t2o_mou    arpu_6    arpu_7
\
0             0.0             0.0             0.0  0.140777 -0.522792

1             0.0             0.0             0.0 -1.427243  4.428047

2             0.0             0.0             0.0 -0.222751  0.543206

3             0.0             0.0             0.0 -0.911173  0.842273

4             0.0             0.0             0.0  0.271356  0.247684


     arpu_8  onnet_mou_6  onnet_mou_7  onnet_mou_8  offnet_mou_6  \
0 -0.276289     0.106540    -0.662084    -0.465777     -0.211202
```

```
1  3.254270    -0.658491    -0.236590    -0.004450     -0.776075
2  0.809117    -0.601239    -0.599206    -0.331043     -0.363395
3  0.731302    -0.702232    -0.650471    -0.458464     -0.789784
4  1.256421    -0.356392    -0.180394     0.114727      0.899204

   offnet_mou_7  offnet_mou_8  roam_ic_mou_6  roam_ic_mou_7
roam_ic_mou_8  \
0     -0.636415      0.317224      -0.254996      -0.001208       -
0.235211
1      2.523985      2.732154      -0.254996      -0.253231       -
0.304660
2     -0.495976     -0.028236      -0.254996      -0.253231       -
0.304660
3     -0.654483     -0.519047      -0.254996      -0.253231       -
0.304660
4      0.904465      1.255807      -0.231882      -0.253231       -
0.304660

   roam_og_mou_6  roam_og_mou_7  roam_og_mou_8  loc_og_t2t_mou_6  \
0      -0.300833      -0.374857      -0.412810         -0.263308
1      -0.300833      -0.374857      -0.431026         -0.201396
2      -0.300833      -0.374857      -0.431026          0.077694
3      -0.300833      -0.374857      -0.431026         -0.192289
4      -0.202644      -0.374857      -0.431026          0.128384

   loc_og_t2t_mou_7  loc_og_t2t_mou_8  loc_og_t2m_mou_6
loc_og_t2m_mou_7  \
0         -0.311548         -0.251411          0.485770         -
0.190660
1          0.270791          0.198344         -0.529474
1.106670
2         -0.095916          0.228431          0.605362
0.258376
3         -0.181513         -0.064925         -0.371787         -
0.205099
4          0.784682          1.062326          1.423002
0.996094

   loc_og_t2m_mou_8  loc_og_t2f_mou_6  loc_og_t2f_mou_7
loc_og_t2f_mou_8  \
0         -0.399182         -0.256866         -0.267401         -
0.244832
1          0.288951         -0.276320         -0.267401         -
0.244832
2          0.908270          1.475098          0.451689         -
0.131562
3         -0.251524         -0.157090          0.216496         -
0.244832
4          1.845573          0.780430          1.055332
0.519904
```

```
   loc_og_t2c_mou_6  loc_og_t2c_mou_7  loc_og_t2c_mou_8  loc_og_mou_6
\
0         -0.191587         -0.267368         -0.244432      0.129144

1         -0.191587         -0.267368         -0.244432     -0.477059

2         -0.191587         -0.267368         -0.244432      0.512549

3          1.002136          2.438345          2.557369     -0.364845

4          1.811266         -0.267368          0.843143      1.025297


   loc_og_mou_7  loc_og_mou_8  std_og_t2t_mou_6  std_og_t2t_mou_7  \
0     -0.335468     -0.418749          0.254982         -0.528622
1      0.843930      0.290569         -0.570615         -0.320253
2      0.121104      0.710496         -0.618738         -0.551860
3     -0.233086     -0.212616         -0.619956         -0.570510
4      1.183543      1.843624         -0.414192         -0.474892

   std_og_t2t_mou_8  std_og_t2m_mou_6  std_og_t2m_mou_7
std_og_t2m_mou_8  \
0         -0.338018         -0.342394         -0.504282
0.650664
1         -0.041333         -0.512504          2.294191
3.087483
2         -0.420186         -0.617043         -0.571393         -
0.416795
3         -0.420186         -0.621707         -0.578677         -
0.406309
4         -0.327001          0.357250          0.585026
0.555984

   std_og_t2f_mou_6  std_og_t2f_mou_7  std_og_t2f_mou_8
std_og_t2c_mou_6  \
0         -0.143576         -0.139257         -0.119299
0.0
1         -0.143576         -0.139257         -0.119299
0.0
2         -0.143576         -0.139257         -0.067469
0.0
3         -0.143576         -0.139257         -0.119299
0.0
4         -0.143576         -0.139257         -0.119299
0.0

   std_og_t2c_mou_7  std_og_t2c_mou_8  std_og_mou_6  std_og_mou_7  \
0               0.0               0.0     -0.048161     -0.731560
1               0.0               0.0     -0.771902      1.368343
```

```
2               0.0                 0.0     -0.878705     -0.794939
3               0.0                 0.0     -0.882786     -0.813361
4               0.0                 0.0     -0.062970      0.066271

   std_og_mou_8  isd_og_mou_6  isd_og_mou_7  isd_og_mou_8
spl_og_mou_6  \
0      0.214243     -0.080803     -0.092449     -0.061631     -
0.347585
1      2.063999     -0.080803     -0.092449     -0.061631     -
0.347585
2     -0.563412     -0.080803     -0.031701     -0.061631     -
0.347585
3     -0.557142     -0.080803     -0.092449     -0.061631
0.299948
4      0.157380     -0.080803     -0.092449      0.132387
0.906003

   spl_og_mou_7  spl_og_mou_8  og_others_6  og_others_7
og_others_8  \
0     -0.363159     -0.017165    -0.346191    -0.015583    -0.013735

1     -0.363159     -0.290355    -0.346191    -0.015583    -0.013735

2     -0.203140      0.151727    -0.346191    -0.015583    -0.013735

3      0.639325      0.743145    -0.244436    -0.015583    -0.013735

4     -0.251495      0.107282    -0.346191    -0.015583    -0.013735


   total_og_mou_6  total_og_mou_7  total_og_mou_8  loc_ic_t2t_mou_6  \
0       -0.000389       -0.860412       -0.011382         -0.203981
1       -0.970285        1.670188        1.938953         -0.410762
2       -0.637091       -0.716013       -0.155609         -0.073331
3       -1.012362       -0.864684       -0.569774         -0.262725
4        0.411184        0.572929        1.014123         -0.238919

   loc_ic_t2t_mou_7  loc_ic_t2t_mou_8  loc_ic_t2m_mou_6
loc_ic_t2m_mou_7  \
0         -0.266718         -0.242771         -0.380593         -
0.272733
1          0.193158          0.156537         -0.481723
0.744741
2         -0.082299          0.189717          0.211940
0.166326
3         -0.287643         -0.150724          0.157353
0.540086
4          0.483606          0.750395         -0.281606
0.384609
```

```
   loc_ic_t2m_mou_8  loc_ic_t2f_mou_6  loc_ic_t2f_mou_7
loc_ic_t2f_mou_8  \
0         -0.437571         -0.290528         -0.270877         -
0.150060
1          0.256589         -0.290528         -0.270877         -
0.257696
2          0.542595          0.223523         -0.117519
0.167136
3         -0.095861         -0.290528         -0.268736         -
0.250781
4          0.578588          0.220005          0.304016
0.113318

   loc_ic_mou_6  loc_ic_mou_7  loc_ic_mou_8  std_ic_t2t_mou_6  \
0     -0.409101     -0.363983     -0.440411         -0.175106
1     -0.583307      0.570197      0.219470         -0.215496
2      0.142990      0.054813      0.490068         -0.215496
3     -0.061177      0.184367     -0.172152         -0.215496
4     -0.286414      0.556564      0.777995         -0.215496

   std_ic_t2t_mou_7  std_ic_t2t_mou_8  std_ic_t2m_mou_6
std_ic_t2m_mou_7  \
0         -0.159825          0.078711         -0.164347
0.367474
1         -0.200464         -0.112725         -0.355157
0.100763
2         -0.200464         -0.187265         -0.361304         -
0.256979
3         -0.200464         -0.187265         -0.361304         -
0.343715
4         -0.200464          0.108490         -0.066471
1.099027

   std_ic_t2m_mou_8  std_ic_t2f_mou_6  std_ic_t2f_mou_7
std_ic_t2f_mou_8  \
0         -0.117454         -0.135479         -0.137327         -
0.110642
1         -0.034777         -0.135479         -0.137327         -
0.110642
2         -0.217027         -0.135479         -0.137327         -
0.109904
3         -0.229338         -0.135479         -0.137327         -
0.110642
4          0.087246          0.078665         -0.072592
0.078362

   std_ic_t2o_mou_6  std_ic_t2o_mou_7  std_ic_t2o_mou_8  std_ic_mou_6
\
0               0.0               0.0               0.0     -0.234904
```

```
1                0.0                0.0                0.0     -0.386264

2                0.0                0.0                0.0     -0.390310

3                0.0                0.0                0.0     -0.390310

4                0.0                0.0                0.0     -0.171917


   std_ic_mou_7  std_ic_mou_8  total_ic_mou_6  total_ic_mou_7
total_ic_mou_8  \
0      0.121332     -0.064154       -0.475564       -0.287010        -
0.420829
1     -0.078694     -0.096335       -0.688082        0.417278
0.125859
2     -0.312284     -0.272135       -0.073424       -0.106086
0.290685
3     -0.368919     -0.281605       -0.248992       -0.029566        -
0.273184
4      0.581141      0.130311       -0.108798        2.215081
2.220000

   spl_ic_mou_6  spl_ic_mou_7  spl_ic_mou_8  isd_ic_mou_6
isd_ic_mou_7  \
0     -0.366516     -0.089786     -0.192624     -0.151655     -
0.153778
1     -0.366516     -0.089786     -0.192624     -0.151655     -
0.153778
2     -0.366516     -0.089786     -0.192624     -0.132791     -
0.099984
3     -0.366516      0.968997     -0.192624     -0.151655     -
0.153778
4     -0.366516     -0.089786     -0.192624      1.103151
4.262216

   isd_ic_mou_8  ic_others_6  ic_others_7  ic_others_8
total_rech_num_6  \
0     -0.126576    -0.099745    -0.121704    -0.081491
0.192736
1     -0.126576    -0.099745    -0.121704    -0.081491          -
0.738325
2     -0.126576    -0.099745    -0.121704    -0.081491          -
0.738325
3     -0.126576    -0.099745    -0.121704    -0.081491          -
0.272794
4      4.608310     0.746998    26.877658    25.149134          -
0.738325

   total_rech_num_7  total_rech_num_8  total_rech_amt_6
total_rech_amt_7  \
```

```
0         -0.444988         0.305289         0.044172         -
0.726027
1          4.142873         2.933529        -1.364090
4.102682
2         -0.327351        -0.195328        -0.110493
0.728436
3          0.378474         0.555597        -0.946224
0.693869
4         -0.209713         0.555597        -0.368267
0.175368

   total_rech_amt_8  max_rech_amt_6  max_rech_amt_7  max_rech_amt_8  \
0         -0.235478        0.054992        0.023937        0.029739
1          3.350107       -0.748908       -0.386255       -0.054702
2          0.772451        0.039532        0.023937        0.198621
3          0.803137        0.054992        0.768359        0.966264
4          1.225665       -0.207821       -0.158371        0.029739

   last_day_rch_amt_6  last_day_rch_amt_7  last_day_rch_amt_8
vol_2g_mb_6  \
0            0.601511           -0.811577           -0.626096    -
0.094017
1           -0.405085           -0.350629           -0.066907    -
0.245535
2            0.272431            0.386888            0.565618    -
0.077862
3           -0.598662           -0.535008           -0.351085    -
0.059437
4            0.272431            0.386888            0.565618    -
0.245535

   vol_2g_mb_7  vol_2g_mb_8  vol_3g_mb_6  vol_3g_mb_7  vol_3g_mb_8  \
0     0.696113     1.750783     0.510634     1.202971    -0.241652
1    -0.235847    -0.207939    -0.262491    -0.274601    -0.249913
2    -0.034247     0.104903     0.950720     1.994409     1.671342
3    -0.040569    -0.027155     2.610032     5.767468     4.000137
4    -0.235847    -0.207939    -0.262491    -0.274601    -0.249913

   monthly_2g_6  monthly_2g_7  monthly_2g_8  sachet_2g_6  sachet_2g_7
\
0      3.236849      3.104207     -0.232664     4.023237     2.358097

1     -0.246650     -0.251375     -0.232664    -0.255793    -0.269796

2     -0.246650      3.104207     -0.232664     0.457379     1.044151

3      3.236849     -0.251375     -0.232664    -0.255793    -0.269796

4     -0.246650     -0.251375     -0.232664    -0.255793    -0.269796
```

```
   sachet_2g_8  monthly_3g_6  monthly_3g_7  monthly_3g_8  sachet_3g_6
\
0     2.447476     -0.224183     -0.221779     -0.216364     -0.141182

1    -0.268245     -0.224183     -0.221779     -0.216364     -0.141182

2     1.089616     -0.224183     -0.221779     -0.216364      1.315163

3    -0.268245      2.171393      9.083717      4.618685     -0.141182

4    -0.268245     -0.224183     -0.221779     -0.216364     -0.141182


   sachet_3g_7  sachet_3g_8       aon  aug_vbc_3g  jul_vbc_3g
jun_vbc_3g  \
0    -0.136208    -0.113882 -0.361238   -0.236209   -0.265392
0.110582
1    -0.136208    -0.113882 -0.790173   -0.255884   -0.265392   -
0.259366
2     2.575301     2.526725  1.571302    3.307334    2.691063
1.700218
3    -0.136208    -0.113882 -0.951024   -0.255884   -0.265392   -
0.259366
4    -0.136208    -0.113882 -0.519757   -0.255884   -0.265392   -
0.259366

   decrease_mou_action  decrease_rech_num_action
decrease_rech_amt_action  \
0                    1                         1
1
1                    0                         0
0
2                    1                         0
0
3                    0                         0
0
4                    0                         0
0

   decrease_arpu_action  decrease_vbc_action
0                     1                    1
1                     0                    0
2                     0                    0
3                     0                    0
4                     0                    0
```

Scaling the test set

We don't fit scaler on the test set. We only transform the test set.

```python
# Transform the test set
X_test[cols_scale] = scaler.transform(X_test[cols_scale])
X_test.head()
```

```
       loc_og_t2o_mou  std_og_t2o_mou  loc_ic_t2o_mou    arpu_6
arpu_7  \
5704              0.0             0.0             0.0  0.244310 -
0.268832
64892             0.0             0.0             0.0  0.048359 -
0.779609
39613             0.0             0.0             0.0  0.545470
0.184388
93118             0.0             0.0             0.0  0.641508
0.816632
81235             0.0             0.0             0.0  3.878627
0.911619

         arpu_8  onnet_mou_6  onnet_mou_7  onnet_mou_8
offnet_mou_6  \
5704   1.005890    -0.725286    -0.690223    -0.476634      0.483540

64892 -0.157969    -0.734066    -0.698072    -0.502219     -0.358555

39613  1.403349    -0.537110    -0.521615    -0.206890      0.694901

93118 -0.211023    -0.058843     0.029897    -0.155872     -0.148197

81235  2.745295     4.117829     1.452446     2.809582     -0.002634


       offnet_mou_7  offnet_mou_8  roam_ic_mou_6  roam_ic_mou_7  \
5704       0.307300      2.323745      -0.077655      -0.253231
64892     -0.577717     -0.256061       0.022864      -0.253231
39613      0.435043      1.465067      -0.254996      -0.253231
93118     -0.143451     -0.410827      -0.254996      -0.253231
81235     -0.290323      0.029332      -0.254996      -0.253231

       roam_ic_mou_8  roam_og_mou_6  roam_og_mou_7  roam_og_mou_8  \
5704       -0.304660       0.215992      -0.374857      -0.431026
64892      -0.304660      -0.120122      -0.374857      -0.431026
39613      -0.304660      -0.300833      -0.374857      -0.431026
93118      -0.304660      -0.300833      -0.374857      -0.431026
81235      -0.003778      -0.300833      -0.374857       1.456232

       loc_og_t2t_mou_6  loc_og_t2t_mou_7  loc_og_t2t_mou_8
loc_og_t2m_mou_6  \
5704          -0.278217         -0.282623         -0.106758
0.028192
64892         -0.278380         -0.302589         -0.174571         -
0.300150
```

```
39613          0.254268          0.146234          0.514266
2.795255
93118          0.871759          1.002772          0.222587
0.871444
81235          2.888120          0.289221          1.362336
0.767176

       loc_og_t2m_mou_7  loc_og_t2m_mou_8  loc_og_t2f_mou_6
loc_og_t2f_mou_7  \
5704           0.006336          0.034141         -0.087435          -
0.267401
64892         -0.204014         -0.295881         -0.261886          -
0.267401
39613          2.186811          3.743713          0.011714          -
0.076422
93118          0.713384         -0.116066          1.669630
1.311405
81235          0.540001          0.742988          0.005438          -
0.267401

       loc_og_t2f_mou_8  loc_og_t2c_mou_6  loc_og_t2c_mou_7
loc_og_t2c_mou_8  \
5704          -0.244832          0.037799         -0.267368          -
0.244432
64892         -0.244832         -0.191587         -0.267368          -
0.244432
39613          1.174644         -0.191587         -0.267368          -
0.244432
93118          0.642996         -0.191587         -0.267368          -
0.244432
81235         -0.244832         -0.191587         -0.267368          -
0.244432

       loc_og_mou_6  loc_og_mou_7  loc_og_mou_8  std_og_t2t_mou_6  \
5704      -0.161248     -0.195270     -0.055078         -0.610819
64892     -0.379084     -0.337876     -0.306653         -0.619956
39613      1.932970      1.438327      2.763270         -0.619956
93118      1.189608      1.165755      0.093205         -0.358067
81235      2.297311      0.506959      1.278083          3.237049

       std_og_t2t_mou_7  std_og_t2t_mou_8  std_og_t2m_mou_6
std_og_t2m_mou_7  \
5704          -0.570510         -0.420186          0.346789
0.369671
64892         -0.570510         -0.415897         -0.231854          -
0.437192
39613         -0.570510         -0.420186         -0.394991          -
0.343132
93118         -0.342850         -0.221957         -0.507976          -
0.406765
```

```
81235          1.462701          2.078469          -0.263825          -
0.435005

       std_og_t2m_mou_8  std_og_t2f_mou_6  std_og_t2f_mou_7
std_og_t2f_mou_8  \
5704           2.702104         -0.143576         -0.139257          -
0.119299
64892         -0.040526         -0.143576         -0.139257          -
0.104326
39613         -0.177784          1.244575         -0.139257          -
0.119299
93118         -0.346116         -0.143576         -0.139257          -
0.119299
81235         -0.400887         -0.143576         -0.139257          -
0.119299

       std_og_t2c_mou_6  std_og_t2c_mou_7  std_og_t2c_mou_8
std_og_mou_6  \
5704                0.0               0.0               0.0     -
0.214836
64892               0.0               0.0               0.0     -
0.616620
39613               0.0               0.0               0.0     -
0.708089
93118               0.0               0.0               0.0     -
0.612400
81235               0.0               0.0               0.0
2.200139

       std_og_mou_7  std_og_mou_8  isd_og_mou_6  isd_og_mou_7
isd_og_mou_8  \
5704      -0.152215      1.550482     -0.080803     -0.092449     -
0.061631
64892     -0.714724     -0.306010     -0.080803     -0.092449     -
0.061631
39613     -0.649149     -0.402193     -0.080803     -0.092449     -
0.061631
93118     -0.530795     -0.384371     -0.080803     -0.092449     -
0.061631
81235      0.739892      1.109859     -0.080803     -0.092449     -
0.061631

       spl_og_mou_6  spl_og_mou_7  spl_og_mou_8  og_others_6
og_others_7  \
5704       1.055196      0.774917      0.757960     0.315218    -
0.015583
64892     -0.327156     -0.363159     -0.290355    -0.346191    -
0.015583
39613     -0.347585     -0.363159     -0.290355    -0.346191    -
0.015583
```

```
93118     -0.278869     -0.293867     -0.231687    -0.025662    -
0.015583
81235      0.049230     -0.363159     -0.290355    -0.346191    -
0.015583

       og_others_8  total_og_mou_6  total_og_mou_7  total_og_mou_8  \
5704     -0.013735       -0.254350       -0.209855        1.354152
64892    -0.013735       -0.775847       -0.845314       -0.422452
39613    -0.013735        0.155438       -0.005238        0.943279
93118    -0.013735       -0.077192       -0.008896       -0.300672
81235    -0.013735        3.147976        0.919824        1.568307

       loc_ic_t2t_mou_6  loc_ic_t2t_mou_7  loc_ic_t2t_mou_8
loc_ic_t2m_mou_6  \
5704          -0.356975         -0.095026          0.281846
0.089162
64892         -0.107944         -0.347607         -0.187444
0.377903
39613          0.075275         -0.307553         -0.130965         -
0.113096
93118          2.234897          1.680142          1.178931
0.874402
81235          0.238993          0.429108          0.113725
1.182362

       loc_ic_t2m_mou_7  loc_ic_t2m_mou_8  loc_ic_t2f_mou_6
loc_ic_t2f_mou_7  \
5704          -0.112790          0.515971         -0.290528         -
0.270877
64892          0.199498          0.240935         -0.275866         -
0.257495
39613         -0.328115          0.017490         -0.104613         -
0.247057
93118          0.796818          0.524427         -0.043033
0.080535
81235          0.691388          0.502602         -0.182615         -
0.060511

       loc_ic_t2f_mou_8  loc_ic_mou_6  loc_ic_mou_7  loc_ic_mou_8  \
5704          -0.194257     -0.156095     -0.166424      0.468259
64892         -0.235146      0.172870     -0.078726      0.045944
39613         -0.125105     -0.056143     -0.419352     -0.067426
93118          0.274772      1.723994      1.417516      0.968096
81235         -0.257696      0.923322      0.685320      0.369639

       std_ic_t2t_mou_6  std_ic_t2t_mou_7  std_ic_t2t_mou_8
std_ic_t2m_mou_6  \
5704          -0.215496         -0.200464         -0.187265
0.113370
64892         -0.215496         -0.152024          0.151031
```

```
2.985768
39613          -0.215496         -0.200464         -0.187265         -
0.190865
93118          -0.141573         -0.121450         -0.104402         -
0.219794
81235           3.676291          2.238646          4.587345         -
0.261982

       std_ic_t2m_mou_7  std_ic_t2m_mou_8  std_ic_t2f_mou_6
std_ic_t2f_mou_7  \
5704           -0.185210         -0.166335         -0.135479         -
0.137327
64892           2.167834          2.203886          0.947838
2.883004
39613          -0.281392         -0.252874          0.271115         -
0.137327
93118          -0.280534         -0.238753         -0.135479         -
0.137327
81235          -0.280902         -0.232114         -0.135479         -
0.137327

       std_ic_t2f_mou_8  std_ic_t2o_mou_6  std_ic_t2o_mou_7
std_ic_t2o_mou_8  \
5704           -0.110642               0.0               0.0
0.0
64892           1.082447               0.0               0.0
0.0
39613          -0.110642               0.0               0.0
0.0
93118          -0.110642               0.0               0.0
0.0
81235          -0.110642               0.0               0.0
0.0

       std_ic_mou_6  std_ic_mou_7  std_ic_mou_8  total_ic_mou_6  \
5704      -0.077912     -0.265421     -0.233610       -0.194148
64892      1.935296      1.671948      1.888954        1.033317
39613     -0.231969     -0.328225     -0.299535       -0.176324
93118     -0.250056     -0.277357     -0.247586        1.336498
81235      2.151705      1.225035      2.089855        1.680641

       total_ic_mou_7  total_ic_mou_8  spl_ic_mou_6  spl_ic_mou_7  \
5704        -0.204469        0.286255     -0.366516     -0.089786
64892        0.758037        0.716003     -0.366516     -0.089786
39613       -0.522456       -0.189128     -0.366516     -0.089786
93118        1.048813        0.704124     -0.366516     -0.089786
81235        1.061830        1.050754     -0.366516     -0.089786

       spl_ic_mou_8  isd_ic_mou_6  isd_ic_mou_7  isd_ic_mou_8
ic_others_6  \
```

```
5704      -0.192624     -0.151655      0.285066     -0.126576    -
0.099745
64892     -0.192624      0.312051     -0.021464     -0.126576    -
0.050008
39613     -0.192624     -0.151655     -0.153778     -0.126576    -
0.099745
93118     -0.192624     -0.047189     -0.153778     -0.126576    -
0.099745
81235     -0.192624     -0.151655     -0.153778     -0.126576    -
0.099745

       ic_others_7  ic_others_8  total_rech_num_6  total_rech_num_7  \
5704     -0.121704    -0.081491         -0.156412          0.260837
64892     4.574367     0.366640         -0.040029         -0.680263
39613    -0.121704    -0.011433         -0.738325         -1.033175
93118    -0.121704    -0.081491         -0.738325          0.025562
81235    -0.121704    -0.081491          1.472945          0.025562

       total_rech_num_8  total_rech_amt_6  total_rech_amt_7
total_rech_amt_8  \
5704           1.306523          0.087587         -0.236774
0.817300
64892          0.054980          0.060452         -0.688801          -
0.051360
39613         -0.695945          0.421336         -0.518626
1.256352
93118         -0.445637          1.126824          0.638030          -
0.511656
81235          0.555597          3.764262          0.688551
3.201396

       max_rech_amt_6  max_rech_amt_7  max_rech_amt_8
last_day_rch_amt_6  \
5704         0.054992       -0.173563        0.029739
0.175643
64892        0.054992        0.358167        0.551737            -
0.598662
39613        2.412584        2.340760        2.555285
3.553548
93118        1.183544        0.753166        0.950911
1.530677
81235        0.812513        0.008745        1.718554
0.175643

       last_day_rch_amt_7  last_day_rch_amt_8  vol_2g_mb_6
vol_2g_mb_7  \
5704             0.368450           -0.351085     3.313695
2.175444
64892           -0.350629           -0.626096     3.855666
6.784445
```

```
39613          3.419926          3.040717    -0.245535    -
0.235847
93118          1.493164         -0.626096    -0.245535    -
0.235847
81235         -0.350629          1.207310     5.471850
2.782323

       vol_2g_mb_8  vol_3g_mb_6  vol_3g_mb_7  vol_3g_mb_8
monthly_2g_6  \
5704     -0.098306    -0.262491    -0.063995     0.506232
3.236849
64892     4.402555     1.716008     0.276844     0.288491
6.720348
39613    -0.207939    -0.262491    -0.274601    -0.249913     -
0.246650
93118    -0.207939    -0.262491    -0.274601    -0.249913     -
0.246650
81235     1.989567    -0.262491    -0.274601    -0.249913     -
0.246650

       monthly_2g_7  monthly_2g_8  sachet_2g_6  sachet_2g_7
sachet_2g_8  \
5704      -0.251375     -0.232664     0.457379     2.358097
2.447476
64892      3.104207      3.421905    -0.255793    -0.269796
2.447476
39613     -0.251375     -0.232664    -0.255793    -0.269796    -
0.268245
93118     -0.251375     -0.232664    -0.255793    -0.269796    -
0.268245
81235     -0.251375     -0.232664     1.883722     1.044151
0.410685

       monthly_3g_6  monthly_3g_7  monthly_3g_8  sachet_3g_6
sachet_3g_7  \
5704      -0.224183     -0.221779     -0.216364     1.315163
1.219546
64892     -0.224183     -0.221779     -0.216364    -0.141182    -
0.136208
39613     -0.224183     -0.221779     -0.216364    -0.141182    -
0.136208
93118     -0.224183     -0.221779     -0.216364    -0.141182    -
0.136208
81235      2.171393     -0.221779      2.201160     2.771508
2.575301

       sachet_3g_8       aon  aug_vbc_3g  jul_vbc_3g  jun_vbc_3g  \
5704      2.526725  0.225051    0.018023    0.194794   -0.259366
64892    -0.113882  0.622516    2.423668    2.357564    5.861151
39613    -0.113882  2.966507   -0.255884   -0.265392   -0.259366
```

```
93118    -0.113882  1.742643   -0.255884   -0.265392   -0.259366
81235     1.206422 -0.244679   -0.255884   -0.265392   -0.259366

       decrease_mou_action  decrease_rech_num_action  \
5704                     0                         0
64892                    1                         1
39613                    1                         1
93118                    1                         0
81235                    1                         1

       decrease_rech_amt_action  decrease_arpu_action
decrease_vbc_action
5704                          1                     1
0
64892                         1                     1
1
39613                         1                     0
0
93118                         1                     1
0
81235                         1                     1
0
```

Model with PCA

```
#Import PCA
from sklearn.decomposition import PCA

# Instantiate PCA
pca = PCA(random_state=42)

# Fit train set on PCA
pca.fit(X_train)

PCA(copy=True, iterated_power='auto', n_components=None,
random_state=42,
    svd_solver='auto', tol=0.0, whiten=False)

# Principal components
pca.components_

array([[-7.50315936e-20,  4.16333634e-17,  1.11022302e-16, ...,
        -2.59799614e-02, -2.57740516e-02,  1.40032998e-02],
       [-1.61507486e-19, -5.55111512e-17,  0.00000000e+00, ...,
        -1.16737642e-02, -9.94022864e-03, -1.42598315e-02],
       [ 1.91332162e-19, -2.77555756e-17,  0.00000000e+00, ...,
        -4.18532955e-02, -4.28357226e-02,  2.46812846e-02],
       ...,
       [-0.00000000e+00, -3.78694731e-02, -3.56427844e-02, ...,
```

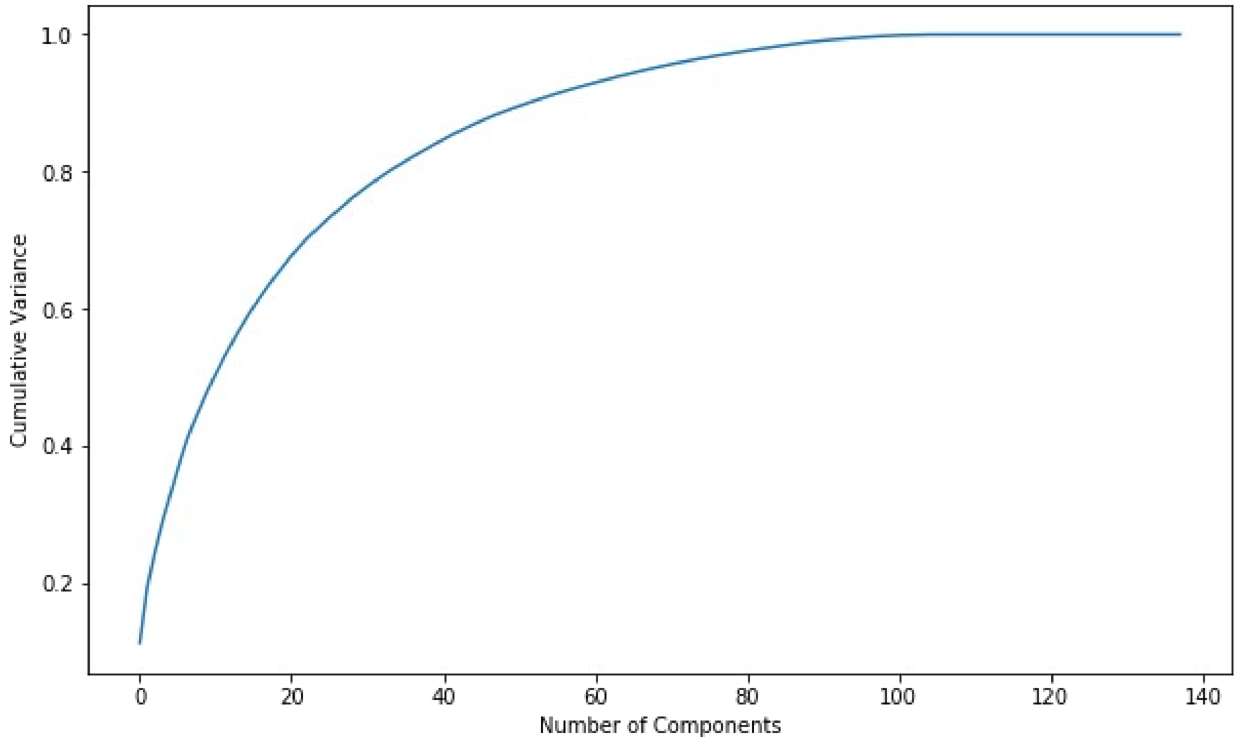
```
         1.23056947e-16, -4.06575815e-17, -0.00000000e+00],
       [ 0.00000000e+00,  2.32804774e-01,  3.95374959e-02, ...,
         6.41847686e-17,  3.12250226e-17,  8.32667268e-17],
       [ 9.99999199e-01, -3.85782335e-04,  1.19512948e-03, ...,
         1.35525272e-20,  3.11708125e-19, -1.99086624e-17]])
```

```
# Cumuliative varinace of the PCs
variance_cumu = np.cumsum(pca.explained_variance_ratio_)
print(variance_cumu)
```

```
[0.11213256 0.19426234 0.24575583 0.28953571 0.32841891 0.36623473
 0.40173361 0.43144425 0.45702167 0.48194328 0.50480575 0.52673812
 0.54724457 0.5670202  0.58530008 0.60304258 0.6190213  0.63473458
 0.64927873 0.66341423 0.67712828 0.69025011 0.7020618  0.71278516
 0.72309435 0.73290234 0.74255604 0.75209676 0.76151565 0.77010093
 0.77861315 0.7866115  0.79429496 0.80173555 0.80878909 0.81538157
 0.82193734 0.8283476  0.83472622 0.84089758 0.84687761 0.85280024
 0.85840083 0.86374029 0.86901646 0.87418749 0.87891437 0.88341796
 0.887723   0.89186057 0.89588256 0.89966074 0.90339384 0.90704071
 0.91060084 0.91411689 0.91752343 0.92076319 0.92395413 0.92705111
 0.93001239 0.93296077 0.93580029 0.93862291 0.94138851 0.9441162
 0.94678675 0.94937767 0.95188405 0.95433786 0.95665036 0.95893735
 0.96116409 0.96323063 0.96526039 0.967203   0.96912626 0.97100138
 0.97284931 0.9746657  0.97639261 0.97806622 0.97972617 0.98133794
 0.98290963 0.98446566 0.98601222 0.98753485 0.98877905 0.98998795
 0.99114751 0.99224606 0.99321228 0.99407803 0.9949224  0.99573799
 0.99652652 0.99717502 0.99776401 0.99831985 0.99880793 0.99912289
 0.99942656 0.99969174 0.99985313 0.99994737 0.99998103 0.99999839
 0.99999963 0.99999989 1.         1.         1.         1.
 1.         1.         1.         1.         1.         1.
 1.         1.         1.         1.         1.         1.
 1.         1.         1.         1.         1.         1.
 1.         1.         1.         1.         1.         1.        ]
```

```
# Plotting scree plot
fig = plt.figure(figsize = (10,6))
plt.plot(variance_cumu)
plt.xlabel('Number of Components')
plt.ylabel('Cumulative Variance')
```

```
Text(0, 0.5, 'Cumulative Variance')
```



We can see that `60 components` explain amost more than 90% variance of the data. So, we will perform PCA with 60 components.

Performing PCA with 60 components

```
# Importing incremental PCA
from sklearn.decomposition import IncrementalPCA

# Instantiate PCA with 60 components
pca_final = IncrementalPCA(n_components=60)

# Fit and transform the X_train
X_train_pca = pca_final.fit_transform(X_train)
```

Applying transformation on the test set

We are only doing Transform in the test set not the Fit-Transform. Because the Fitting is already done on the train set. So, we just have to do the transformation with the already fitted data on the train set.

```
X_test_pca = pca_final.transform(X_test)
```

Emphasize Sensitivity/Recall than Accuracy

We are more focused on higher Sensitivity/Recall score than the accuracy.

Beacuse we need to care more about churn cases than the not churn cases. The main goal is to reatin the customers, who have the possiblity to churn. There should not be a problem, if we consider few not churn customers as churn customers and provide them some incentives for retaining them. Hence, the sensitivity score is more important here.

Logistic regression with PCA

```
# Importing scikit logistic regression module
from sklearn.linear_model import LogisticRegression

# Impoting metrics
from sklearn import metrics
from sklearn.metrics import confusion_matrix
```

Tuning hyperparameter C

C is the the inverse of regularization strength in Logistic Regression. Higher values of C correspond to less regularization.

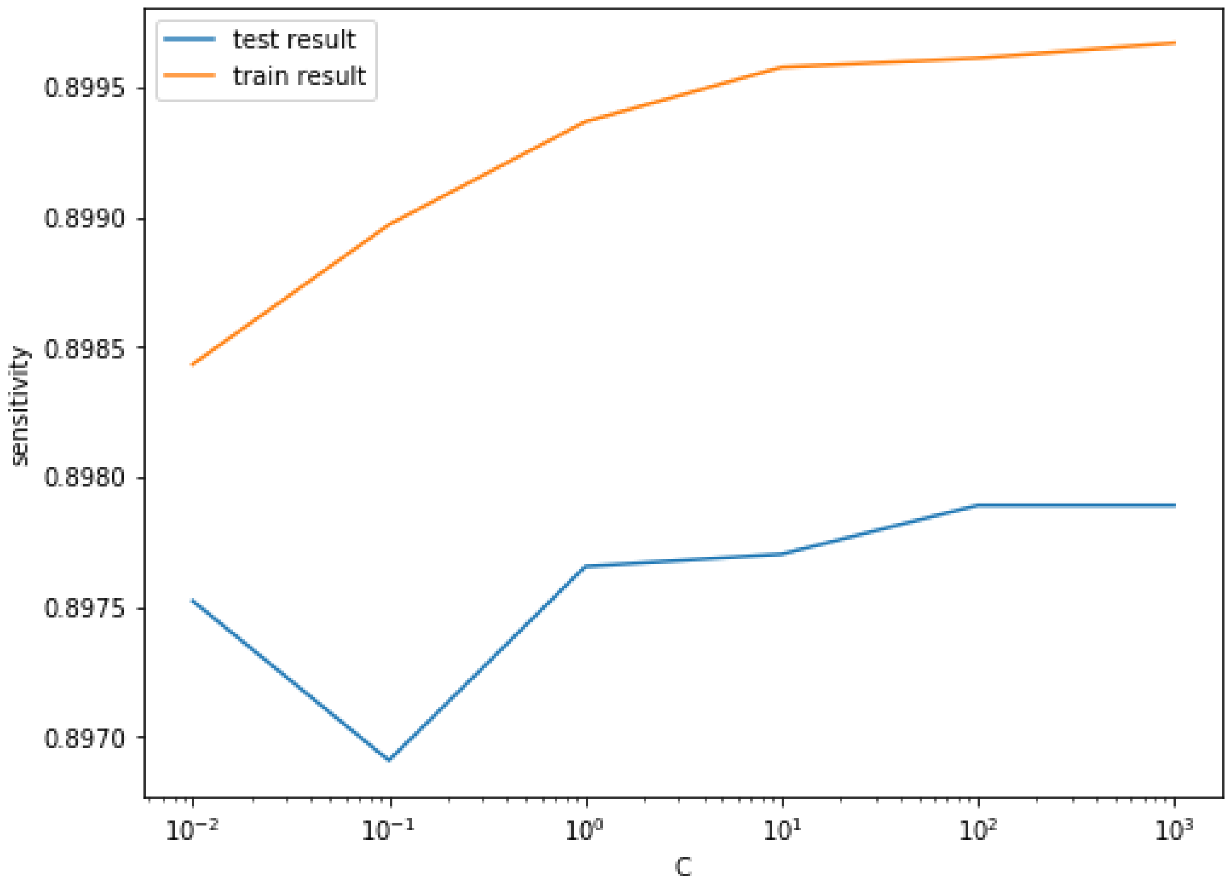
```
# Importing libraries for cross validation
from sklearn.model_selection import KFold
from sklearn.model_selection import cross_val_score
from sklearn.model_selection import GridSearchCV

# Creating KFold object with 5 splits
folds = KFold(n_splits=5, shuffle=True, random_state=4)

# Specify params
params = {"C": [0.01, 0.1, 1, 10, 100, 1000]}

# Specifing score as recall as we are more focused on acheiving the 
higher sensitivity than the accuracy
model_cv = GridSearchCV(estimator = LogisticRegression(),
                        param_grid = params,
                        scoring= 'recall',
                        cv = folds,
                        verbose = 1,
                        return_train_score=True)

# Fit the model
model_cv.fit(X_train_pca, y_train)

Fitting 5 folds for each of 6 candidates, totalling 30 fits

[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1 
concurrent workers.
[Parallel(n_jobs=1)]: Done  30 out of  30 | elapsed:   21.6s finished

GridSearchCV(cv=KFold(n_splits=5, random_state=4, shuffle=True),
             error_score=nan,
             estimator=LogisticRegression(C=1.0, class_weight=None, 
dual=False,
                                          fit_intercept=True,
```

```
                                                  intercept_scaling=1,
l1_ratio=None,
                                                  max_iter=100,
multi_class='auto',
                                                  n_jobs=None, penalty='l2',
                                                  random_state=None,
solver='lbfgs',
                                                  tol=0.0001, verbose=0,
                                                  warm_start=False),
             iid='deprecated', n_jobs=None,
             param_grid={'C': [0.01, 0.1, 1, 10, 100, 1000]},
             pre_dispatch='2*n_jobs', refit=True,
return_train_score=True,
             scoring='recall', verbose=1)
```

```
# results of grid search CV
cv_results = pd.DataFrame(model_cv.cv_results_)
cv_results
```

```
   mean_fit_time  std_fit_time  mean_score_time  std_score_time
param_C  \
0       0.478627      0.060932         0.007600    1.200167e-03
0.01
1       0.731842      0.021868         0.006801    3.999949e-04
0.1
2       0.743043      0.008100         0.007000    6.325605e-04
1
3       0.754643      0.024106         0.007200    1.469782e-03
10
4       0.720841      0.015716         0.007000    1.784161e-07
100
5       0.719441      0.008778         0.006600    4.899208e-04
1000

        params  split0_test_score  split1_test_score
split2_test_score  \
0  {'C': 0.01}           0.900071           0.897759
0.895814
1   {'C': 0.1}           0.898177           0.896359
0.894651
2     {'C': 1}           0.898650           0.898693
0.895581
3    {'C': 10}           0.898887           0.898459
0.896744
4   {'C': 100}           0.899597           0.898226
0.896977
5  {'C': 1000}           0.899597           0.898226
0.896977

   split3_test_score  split4_test_score  mean_test_score
```

```
std_test_score  \
0           0.906425           0.887552         0.897524
0.006134
1           0.905959           0.889403         0.896910
0.005390
2           0.905028           0.890329         0.897656
0.004783
3           0.904562           0.889866         0.897704
0.004719
4           0.904330           0.890329         0.897892
0.004528
5           0.904330           0.890329         0.897892
0.004528

   rank_test_score  split0_train_score  split1_train_score  \
0                5            0.901116            0.898256
1                6            0.901174            0.898431
2                4            0.901988            0.898606
3                3            0.902511            0.898956
4                1            0.902628            0.898722
5                1            0.902628            0.898839

   split2_train_score  split3_train_score  split4_train_score  \
0            0.899387            0.895440            0.897971
1            0.899270            0.896725            0.899257
2            0.898861            0.898184            0.899199
3            0.898394            0.898476            0.899550
4            0.898569            0.898593            0.899550
5            0.898686            0.898593            0.899608

   mean_train_score  std_train_score
0          0.898434         0.001861
1          0.898971         0.001440
2          0.899368         0.001351
3          0.899577         0.001524
4          0.899612         0.001550
5          0.899671         0.001521

# plot of C versus train and validation scores

plt.figure(figsize=(8, 6))
plt.plot(cv_results['param_C'], cv_results['mean_test_score'])
plt.plot(cv_results['param_C'], cv_results['mean_train_score'])
plt.xlabel('C')
plt.ylabel('sensitivity')
plt.legend(['test result', 'train result'], loc='upper left')
plt.xscale('log')
```




```
# Best score with best C
best_score = model_cv.best_score_
best_C = model_cv.best_params_['C']

print(" The highest test sensitivity is {0} at C =
{1}".format(best_score, best_C))

 The highest test sensitivity is 0.8978916608693863 at C = 100
```

Logistic regression with optimal C

```
# Instantiate the model with best C
logistic_pca = LogisticRegression(C=best_C)

# Fit the model on the train set
log_pca_model = logistic_pca.fit(X_train_pca, y_train)
```

Prediction on the train set

```
# Predictions on the train set
y_train_pred = log_pca_model.predict(X_train_pca)
```

```
# Confusion matrix
confusion = metrics.confusion_matrix(y_train, y_train_pred)
print(confusion)
```

```
[[17908  3517]
 [ 2154 19271]]
```

```
TP = confusion[1,1] # true positive
TN = confusion[0,0] # true negatives
FP = confusion[0,1] # false positives
FN = confusion[1,0] # false negatives

# Accuracy
print("Accuracy:-",metrics.accuracy_score(y_train, y_train_pred))

# Sensitivity
print("Sensitivity:-",TP / float(TP+FN))

# Specificity
print("Specificity:-", TN / float(TN+FP))
```

```
Accuracy:- 0.8676546091015169
Sensitivity:- 0.899463243873979
Specificity:- 0.8358459743290548
```

Prediction on the test set

```
# Prediction on the test set
y_test_pred = log_pca_model.predict(X_test_pca)

# Confusion matrix
confusion = metrics.confusion_matrix(y_test, y_test_pred)
print(confusion)
```

```
[[4452  896]
 [  36  157]]
```

```
TP = confusion[1,1] # true positive
TN = confusion[0,0] # true negatives
FP = confusion[0,1] # false positives
FN = confusion[1,0] # false negatives

# Accuracy
print("Accuracy:-",metrics.accuracy_score(y_test, y_test_pred))

# Sensitivity
print("Sensitivity:-",TP / float(TP+FN))

# Specificity
print("Specificity:-", TN / float(TN+FP))
```

```
Accuracy:- 0.8317993142032124
Sensitivity:- 0.8134715025906736
Specificity:- 0.8324607329842932
```

Model summary

- Train set
  - Accuracy = 0.86
  - Sensitivity = 0.89
  - Specificity = 0.83
- Test set
  - Accuracy = 0.83
  - Sensitivity = 0.81
  - Specificity = 0.83

Overall, the model is performing well in the test set, what it had learnt from the train set.

Support Vector Machine(SVM) with PCA

```
# Importing SVC
from sklearn.svm import SVC
```

Hyperparameter tuning

C:- Regularization parameter.

gamma:- Handles non linear classifications.

```
# specify range of hyperparameters

hyper_params = [ {'gamma': [1e-2, 1e-3, 1e-4],
                     'C': [1, 10, 100, 1000]}]


# specify model with RBF kernel
model = SVC(kernel="rbf")

# set up GridSearchCV()
model_cv = GridSearchCV(estimator = model,
                        param_grid = hyper_params,
                        scoring= 'accuracy',
                        cv = 3,
                        verbose = 1,
                        return_train_score=True)

# fit the model
model_cv.fit(X_train_pca, y_train)
```

```
Fitting 3 folds for each of 12 candidates, totalling 36 fits
```

```
[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1
concurrent workers.
[Parallel(n_jobs=1)]: Done  36 out of  36 | elapsed: 95.4min finished

GridSearchCV(cv=3, error_score=nan,
             estimator=SVC(C=1.0, break_ties=False, cache_size=200,
                           class_weight=None, coef0=0.0,
                           decision_function_shape='ovr', degree=3,
                           gamma='scale', kernel='rbf', max_iter=-1,
                           probability=False, random_state=None,
shrinking=True,
                           tol=0.001, verbose=False),
             iid='deprecated', n_jobs=None,
             param_grid=[{'C': [1, 10, 100, 1000],
                          'gamma': [0.01, 0.001, 0.0001]}],
             pre_dispatch='2*n_jobs', refit=True,
return_train_score=True,
             scoring='accuracy', verbose=1)

# cv results
cv_results = pd.DataFrame(model_cv.cv_results_)
cv_results

    mean_fit_time  std_fit_time  mean_score_time  std_score_time
param_C  \
0       42.032071      0.126973        12.777397        0.027355
1
1       53.846413      0.407173        17.470999        0.045588
1
2       67.914884      0.491901        22.857974        0.176785
1
3       39.426255      0.483549         8.479152        0.292587
10
4       47.964410      0.411481        14.921520        0.169904
10
5       57.650298      0.850001        19.027755        0.122431
10
6       57.674299      6.235520       670.884914      941.456985
100
7       56.490898      0.578504        11.192307        0.035219
100
8       54.180099      0.697826        16.342601        0.187994
100
9       93.312670      2.057615         3.813552        0.053278
1000
10     127.868314      3.560431         8.287141        0.121411
1000
11      79.973241      1.123954        14.635170        0.255735
1000
```

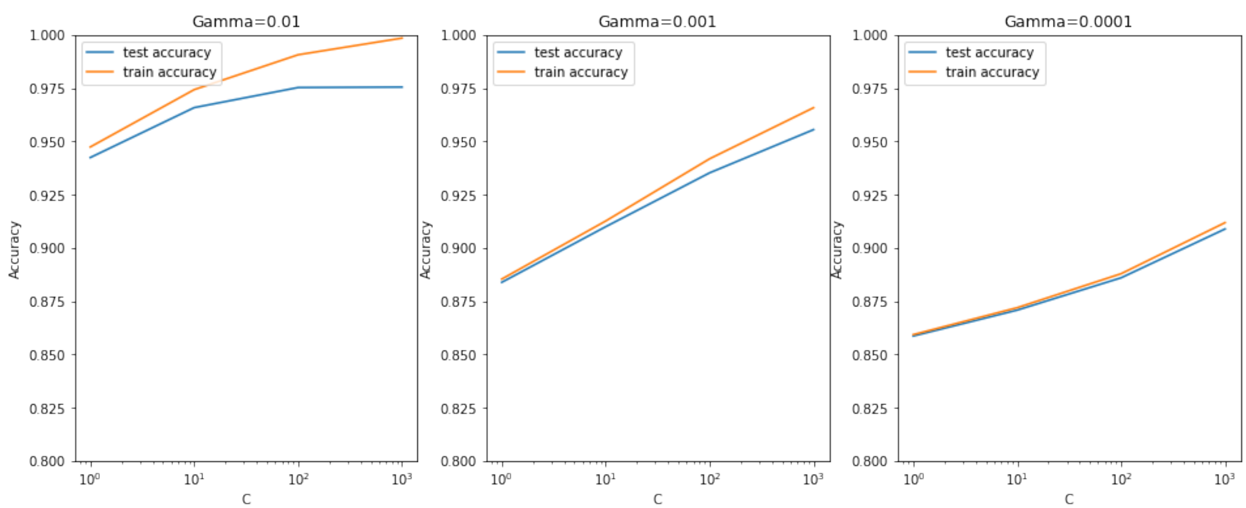
```
   param_gamma                          params  split0_test_score  \
0         0.01       {'C': 1, 'gamma': 0.01}           0.944903
1        0.001      {'C': 1, 'gamma': 0.001}           0.883366
2       0.0001     {'C': 1, 'gamma': 0.0001}           0.858513
3         0.01      {'C': 10, 'gamma': 0.01}           0.967096
4        0.001     {'C': 10, 'gamma': 0.001}           0.910459
5       0.0001    {'C': 10, 'gamma': 0.0001}           0.870414
6         0.01     {'C': 100, 'gamma': 0.01}           0.973397
7        0.001    {'C': 100, 'gamma': 0.001}           0.935662
8       0.0001   {'C': 100, 'gamma': 0.0001}           0.884906
9         0.01    {'C': 1000, 'gamma': 0.01}           0.972277
10       0.001   {'C': 1000, 'gamma': 0.001}           0.955965
11      0.0001  {'C': 1000, 'gamma': 0.0001}           0.908499

    split1_test_score  split2_test_score  mean_test_score
std_test_score  \
0            0.941679           0.940699         0.942427
0.001796
1            0.884268           0.884058         0.883897
0.000385
2            0.858433           0.859133         0.858693
0.000313
3            0.965413           0.965063         0.965858
0.000887
4            0.911433           0.908073         0.909988
0.001412
5            0.869355           0.872786         0.870852
0.001434
6            0.976686           0.975775         0.975286
0.001387
7            0.935518           0.934608         0.935263
0.000467
8            0.886438           0.886718         0.886021
0.000797
9            0.977876           0.976336         0.975496
0.002362
10           0.955121           0.955472         0.955519
0.000346
11           0.910943           0.907302         0.908915
0.001515

    rank_test_score  split0_train_score  split1_train_score  \
0                 5            0.947210            0.947247
1                10            0.883813            0.886757
2                12            0.858993            0.859908
3                 3            0.975040            0.973536
4                 7            0.913709            0.911891
5                11            0.871421            0.873875
6                 2            0.991318            0.990444
```

```
7                  6           0.941819            0.942066
8                  9           0.886368            0.888893
9                  1           0.998425            0.998495
10                 4           0.965623            0.965345
11                 8           0.912868            0.910806

    split2_train_score  mean_train_score  std_train_score
0             0.947702          0.947386         0.000224
1             0.885707          0.885426         0.001218
2             0.859173          0.859358         0.000396
3             0.974306          0.974294         0.000614
4             0.912381          0.912660         0.000768
5             0.870690          0.871995         0.001362
6             0.990198          0.990653         0.000481
7             0.941681          0.941855         0.000159
8             0.888543          0.887935         0.001117
9             0.998495          0.998471         0.000033
10            0.966465          0.965811         0.000476
11            0.911996          0.911890         0.000845
```

Plotting the accuracy with various C and gamma values

```python
# converting C to numeric type for plotting on x-axis
cv_results['param_C'] = cv_results['param_C'].astype('int')

# # plotting
plt.figure(figsize=(16,6))

# subplot 1/3
plt.subplot(131)
gamma_01 = cv_results[cv_results['param_gamma']==0.01]

plt.plot(gamma_01["param_C"], gamma_01["mean_test_score"])
plt.plot(gamma_01["param_C"], gamma_01["mean_train_score"])
plt.xlabel('C')
plt.ylabel('Accuracy')
plt.title("Gamma=0.01")
plt.ylim([0.80, 1])
plt.legend(['test accuracy', 'train accuracy'], loc='upper left')
plt.xscale('log')

# subplot 2/3
plt.subplot(132)
gamma_001 = cv_results[cv_results['param_gamma']==0.001]

plt.plot(gamma_001["param_C"], gamma_001["mean_test_score"])
plt.plot(gamma_001["param_C"], gamma_001["mean_train_score"])
plt.xlabel('C')
plt.ylabel('Accuracy')
plt.title("Gamma=0.001")
```

```
plt.ylim([0.80, 1])
plt.legend(['test accuracy', 'train accuracy'], loc='upper left')
plt.xscale('log')


# subplot 3/3
plt.subplot(133)
gamma_0001 = cv_results[cv_results['param_gamma']==0.0001]

plt.plot(gamma_0001["param_C"], gamma_0001["mean_test_score"])
plt.plot(gamma_0001["param_C"], gamma_0001["mean_train_score"])
plt.xlabel('C')
plt.ylabel('Accuracy')
plt.title("Gamma=0.0001")
plt.ylim([0.80, 1])
plt.legend(['test accuracy', 'train accuracy'], loc='upper left')
plt.xscale('log')
```




```
# Printing the best score
best_score = model_cv.best_score_
best_hyperparams = model_cv.best_params_

print("The best test score is {0} corresponding to hyperparameters
{1}".format(best_score, best_hyperparams))

The best test score is 0.9754959911159373 corresponding to
hyperparameters {'C': 1000, 'gamma': 0.01}
```

From the above plot, we can see that higher value of gamma leads to overfitting the model. With the lowest value of gamma (0.0001) we have train and test accuracy almost same.

Also, at C=100 we have a good accuracy and the train and test scores are comparable.

Though sklearn suggests the optimal scores mentioned above (gamma=0.01, C=1000), one could argue that it is better to choose a simpler, more non-linear model with gamma=0.0001. This is because the optimal values mentioned here are calculated based on the average test accuracy (but not considering subjective parameters such as model complexity).

We can achieve comparable average test accuracy (~90%) with gamma=0.0001 as well, though we'll have to increase the cost C for that. So to achieve high accuracy, there's a tradeoff between:

- High gamma (i.e. high non-linearity) and average value of C
- Low gamma (i.e. less non-linearity) and high value of C

We argue that the model will be simpler if it has as less non-linearity as possible, so we choose gamma=0.0001 and a high C=100.

Build the model with optimal hyperparameters

```
# Building the model with optimal hyperparameters
svm_pca_model = SVC(C=100, gamma=0.0001, kernel="rbf")

svm_pca_model.fit(X_train_pca, y_train)
```

```
SVC(C=100, break_ties=False, cache_size=200, class_weight=None,
coef0=0.0,
    decision_function_shape='ovr', degree=3, gamma=0.0001,
kernel='rbf',
    max_iter=-1, probability=False, random_state=None, shrinking=True,
    tol=0.001, verbose=False)
```

Prediction on the train set

```
# Predictions on the train set
y_train_pred = svm_pca_model.predict(X_train_pca)

# Confusion matrix
confusion = metrics.confusion_matrix(y_train, y_train_pred)
print(confusion)
```

```
[[18376  3049]
 [ 1585 19840]]
```

```
TP = confusion[1,1] # true positive
TN = confusion[0,0] # true negatives
FP = confusion[0,1] # false positives
FN = confusion[1,0] # false negatives

# Accuracy
print("Accuracy:-",metrics.accuracy_score(y_train, y_train_pred))

# Sensitivity
print("Sensitivity:-",TP / float(TP+FN))
```

```python
# Specificity
print("Specificity:-", TN / float(TN+FP))
```

```
Accuracy:- 0.891855309218203
Sensitivity:- 0.9260210035005835
Specificity:- 0.8576896149358226
```

Prediction on the test set

```python
# Prediction on the test set
y_test_pred = svm_pca_model.predict(X_test_pca)

# Confusion matrix
confusion = metrics.confusion_matrix(y_test, y_test_pred)
print(confusion)
```

```
[[4557  791]
 [  36  157]]
```

```python
TP = confusion[1,1] # true positive
TN = confusion[0,0] # true negatives
FP = confusion[0,1] # false positives
FN = confusion[1,0] # false negatives

# Accuracy
print("Accuracy:-",metrics.accuracy_score(y_test, y_test_pred))

# Sensitivity
print("Sensitivity:-",TP / float(TP+FN))

# Specificity
print("Specificity:-", TN / float(TN+FP))
```

```
Accuracy:- 0.8507489622811767
Sensitivity:- 0.8134715025906736
Specificity:- 0.8520942408376964
```

Model summary

- Train set
  - Accuracy = 0.89
  - Sensitivity = 0.92
  - Specificity = 0.85
- Test set
  - Accuracy = 0.85
  - Sensitivity = 0.81
  - Specificity = 0.85

Decision tree with PCA

```
# Importing decision tree classifier
from sklearn.tree import DecisionTreeClassifier
```

Hyperparameter tuning

```
# Create the parameter grid
param_grid = {
    'max_depth': range(5, 15, 5),
    'min_samples_leaf': range(50, 150, 50),
    'min_samples_split': range(50, 150, 50),
}


# Instantiate the grid search model
dtree = DecisionTreeClassifier()

grid_search = GridSearchCV(estimator = dtree,
                           param_grid = param_grid,
                           scoring= 'recall',
                           cv = 5,
                           verbose = 1)

# Fit the grid search to the data
grid_search.fit(X_train_pca,y_train)
```

```
Fitting 5 folds for each of 8 candidates, totalling 40 fits

[Parallel(n_jobs=1)]: Using backend SequentialBackend with 1
concurrent workers.
[Parallel(n_jobs=1)]: Done  40 out of  40 | elapsed:  1.7min finished

GridSearchCV(cv=5, error_score=nan,
             estimator=DecisionTreeClassifier(ccp_alpha=0.0,
class_weight=None,
                                              criterion='gini',
max_depth=None,
                                              max_features=None,
                                              max_leaf_nodes=None,

min_impurity_decrease=0.0,
                                              min_impurity_split=None,
                                              min_samples_leaf=1,
                                              min_samples_split=2,

min_weight_fraction_leaf=0.0,
                                              presort='deprecated',
                                              random_state=None,
                                              splitter='best'),
             iid='deprecated', n_jobs=None,
```

```
             param_grid={'max_depth': range(5, 15, 5),
                         'min_samples_leaf': range(50, 150, 50),
                         'min_samples_split': range(50, 150, 50)},
             pre_dispatch='2*n_jobs', refit=True,
return_train_score=False,
             scoring='recall', verbose=1)

# cv results
cv_results = pd.DataFrame(grid_search.cv_results_)
cv_results

   mean_fit_time  std_fit_time  mean_score_time  std_score_time  \
0       1.948911      0.023829         0.008601         0.00049
1       1.941111      0.010277         0.008400         0.00049
2       1.925310      0.003188         0.008400         0.00049
3       1.925510      0.002871         0.008600         0.00049
4       3.343991      0.015459         0.008601         0.00049
5       3.370193      0.083993         0.008601         0.00049
6       3.199783      0.044874         0.008801         0.00040
7       3.186582      0.025967         0.008801         0.00040

  param_max_depth param_min_samples_leaf param_min_samples_split  \
0               5                     50                      50
1               5                     50                     100
2               5                    100                      50
3               5                    100                     100
4              10                     50                      50
5              10                     50                     100
6              10                    100                      50
7              10                    100                     100

                                              params
split0_test_score  \
0  {'max_depth': 5, 'min_samples_leaf': 50, 'min_...
0.862310
1  {'max_depth': 5, 'min_samples_leaf': 50, 'min_...
0.862310
2  {'max_depth': 5, 'min_samples_leaf': 100, 'min...
0.858110
3  {'max_depth': 5, 'min_samples_leaf': 100, 'min...
0.858110
4  {'max_depth': 10, 'min_samples_leaf': 50, 'min...
0.886114
5  {'max_depth': 10, 'min_samples_leaf': 50, 'min...
0.886114
6  {'max_depth': 10, 'min_samples_leaf': 100, 'mi...
0.889615
7  {'max_depth': 10, 'min_samples_leaf': 100, 'mi...
0.889615
```

```
   split1_test_score  split2_test_score  split3_test_score
split4_test_score  \
0           0.855776           0.878413           0.875379
0.855309
1           0.855776           0.878413           0.875379
0.855309
2           0.855309           0.875846           0.869078
0.849008
3           0.855309           0.875846           0.869078
0.849008
4           0.894516           0.903851           0.905484
0.913652
5           0.894516           0.903851           0.905484
0.912485
6           0.869778           0.875613           0.891949
0.884247
7           0.871179           0.875613           0.891949
0.883781

   mean_test_score  std_test_score  rank_test_score
0         0.865438        0.009725                5
1         0.865438        0.009725                5
2         0.861470        0.009686                7
3         0.861470        0.009686                7
4         0.900723        0.009503                1
5         0.900490        0.009192                2
6         0.882240        0.008389                4
7         0.882427        0.007964                3
```

```python
# Printing the optimal sensitivity score and hyperparameters
print("Best sensitivity:-", grid_search.best_score_)
print(grid_search.best_estimator_)
```

```
Best sensitivity:- 0.9007234539089849
DecisionTreeClassifier(ccp_alpha=0.0, class_weight=None,
criterion='gini',
                       max_depth=10, max_features=None,
max_leaf_nodes=None,
                       min_impurity_decrease=0.0,
min_impurity_split=None,
                       min_samples_leaf=50, min_samples_split=50,
                       min_weight_fraction_leaf=0.0,
presort='deprecated',
                       random_state=None, splitter='best')
```

Model with optimal hyperparameters

```python
# Model with optimal hyperparameters
dt_pca_model = DecisionTreeClassifier(criterion = "gini",
                                  random_state = 100,
```

```
                                  max_depth=10,
                                  min_samples_leaf=50,
                                  min_samples_split=50)

dt_pca_model.fit(X_train_pca, y_train)
```

```
DecisionTreeClassifier(ccp_alpha=0.0, class_weight=None,
criterion='gini',
                       max_depth=10, max_features=None,
max_leaf_nodes=None,
                       min_impurity_decrease=0.0,
min_impurity_split=None,
                       min_samples_leaf=50, min_samples_split=50,
                       min_weight_fraction_leaf=0.0,
presort='deprecated',
                       random_state=100, splitter='best')
```

Prediction on the train set

```
# Predictions on the train set
y_train_pred = dt_pca_model.predict(X_train_pca)

# Confusion matrix
confusion = metrics.confusion_matrix(y_train, y_train_pred)
print(confusion)
```

```
[[18913  2512]
 [ 1763 19662]]
```

```
TP = confusion[1,1] # true positive
TN = confusion[0,0] # true negatives
FP = confusion[0,1] # false positives
FN = confusion[1,0] # false negatives

# Accuracy
print("Accuracy:-",metrics.accuracy_score(y_train, y_train_pred))

# Sensitivity
print("Sensitivity:-",TP / float(TP+FN))

# Specificity
print("Specificity:-", TN / float(TN+FP))
```

```
Accuracy:- 0.9002333722287048
Sensitivity:- 0.9177129521586931
Specificity:- 0.8827537922987164
```

Prediction on the test set

```
# Prediction on the test set
y_test_pred = dt_pca_model.predict(X_test_pca)
```

```
# Confusion matrix
confusion = metrics.confusion_matrix(y_test, y_test_pred)
print(confusion)

[[4632  716]
 [  58  135]]

TP = confusion[1,1] # true positive
TN = confusion[0,0] # true negatives
FP = confusion[0,1] # false positives
FN = confusion[1,0] # false negatives

# Accuracy
print("Accuracy:-",metrics.accuracy_score(y_test, y_test_pred))

# Sensitivity
print("Sensitivity:-",TP / float(TP+FN))

# Specificity
print("Specificity:-", TN / float(TN+FP))

Accuracy:- 0.8603140227395777
Sensitivity:- 0.6994818652849741
Specificity:- 0.8661181750186986
```

Model summary

- Train set
  - Accuracy = 0.90
  - Sensitivity = 0.91
  - Specificity = 0.88
- Test set
  - Accuracy = 0.86
  - Sensitivity = 0.70
  - Specificity = 0.87

We can see from the model performance that the Sesitivity has been decreased while evaluating the model on the test set. However, the accuracy and specificity is quite good in the test set.

Random forest with PCA

```
# Importing random forest classifier
from sklearn.ensemble import RandomForestClassifier
```

Hyperparameter tuning

```
param_grid = {
    'max_depth': range(5,10,5),
    'min_samples_leaf': range(50, 150, 50),
    'min_samples_split': range(50, 150, 50),
```

```python
    'n_estimators': [100,200,300],
    'max_features': [10, 20]
}
# Create a based model
rf = RandomForestClassifier()
# Instantiate the grid search model
grid_search = GridSearchCV(estimator = rf,
                           param_grid = param_grid,
                           cv = 3,
                           n_jobs = -1,
                           verbose = 1,
                           return_train_score=True)

# Fit the model
grid_search.fit(X_train_pca, y_train)
```

```
Fitting 3 folds for each of 24 candidates, totalling 72 fits

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 4 concurrent
workers.
[Parallel(n_jobs=-1)]: Done  42 tasks      | elapsed: 13.6min
[Parallel(n_jobs=-1)]: Done  72 out of  72 | elapsed: 132.9min
finished

GridSearchCV(cv=3, error_score=nan,
             estimator=RandomForestClassifier(bootstrap=True,
ccp_alpha=0.0,
                                              class_weight=None,
                                              criterion='gini',
max_depth=None,
                                              max_features='auto',
                                              max_leaf_nodes=None,
                                              max_samples=None,

min_impurity_decrease=0.0,
                                              min_impurity_split=None,
                                              min_samples_leaf=1,
                                              min_samples_split=2,

min_weight_fraction_leaf=0.0,
                                              n_estimators=100,
n_jobs=None,
                                              oob_score=False,
                                              random_state=None,
verbose=0,
                                              warm_start=False),
             iid='deprecated', n_jobs=-1,
             param_grid={'max_depth': range(5, 10, 5), 'max_features':
[10, 20],
                         'min_samples_leaf': range(50, 150, 50),
```

```
                             'min_samples_split': range(50, 150, 50),
                             'n_estimators': [100, 200, 300]},
             pre_dispatch='2*n_jobs', refit=True,
return_train_score=True,
             scoring=None, verbose=1)

# printing the optimal accuracy score and hyperparameters
print('We can get accuracy
of',grid_search.best_score_,'using',grid_search.best_params_)

We can get accuracy of 0.8449241538567582 using {'max_depth': 5,
'max_features': 20, 'min_samples_leaf': 50, 'min_samples_split': 100,
'n_estimators': 300}
```

Model with optimal hyperparameters

```
# model with the best hyperparameters

rfc_model = RandomForestClassifier(bootstrap=True,
                             max_depth=5,
                             min_samples_leaf=50,
                             min_samples_split=100,
                             max_features=20,
                             n_estimators=300)

# Fit the model
rfc_model.fit(X_train_pca, y_train)

RandomForestClassifier(bootstrap=True, ccp_alpha=0.0,
class_weight=None,
                       criterion='gini', max_depth=5, max_features=20,
                       max_leaf_nodes=None, max_samples=None,
                       min_impurity_decrease=0.0,
min_impurity_split=None,
                       min_samples_leaf=50, min_samples_split=100,
                       min_weight_fraction_leaf=0.0, n_estimators=300,
                       n_jobs=None, oob_score=False,
random_state=None,
                       verbose=0, warm_start=False)
```

Prediction on the train set

```
# Predictions on the train set
y_train_pred = rfc_model.predict(X_train_pca)

# Confusion matrix
confusion = metrics.confusion_matrix(y_train, y_train_pred)
print(confusion)

[[17363  4062]
 [ 2419 19006]]
```

```
TP = confusion[1,1] # true positive
TN = confusion[0,0] # true negatives
FP = confusion[0,1] # false positives
FN = confusion[1,0] # false negatives

# Accuracy
print("Accuracy:-",metrics.accuracy_score(y_train, y_train_pred))

# Sensitivity
print("Sensitivity:-",TP / float(TP+FN))

# Specificity
print("Specificity:-", TN / float(TN+FP))

Accuracy:- 0.8487514585764294
Sensitivity:- 0.8870945157526254
Specificity:- 0.8104084014002334
```

Prediction on the test set

```
# Prediction on the test set
y_test_pred = rfc_model.predict(X_test_pca)

# Confusion matrix
confusion = metrics.confusion_matrix(y_test, y_test_pred)
print(confusion)

[[4294 1054]
 [  47  146]]

TP = confusion[1,1] # true positive
TN = confusion[0,0] # true negatives
FP = confusion[0,1] # false positives
FN = confusion[1,0] # false negatives

# Accuracy
print("Accuracy:-",metrics.accuracy_score(y_test, y_test_pred))

# Sensitivity
print("Sensitivity:-",TP / float(TP+FN))

# Specificity
print("Specificity:-", TN / float(TN+FP))

Accuracy:- 0.8012994044396319
Sensitivity:- 0.7564766839378239
Specificity:- 0.8029169783096485
```

Model summary

- Train set
  - Accuracy = 0.84

  - Sensitivity = 0.88
  - Specificity = 0.80
- Test set
  - Accuracy = 0.80
  - Sensitivity = 0.75
  - Specificity = 0.80

We can see from the model performance that the Sesitivity has been decreased while evaluating the model on the test set. However, the accuracy and specificity is quite good in the test set.

Final conclusion with PCA

After trying several models we can see that for acheiving the best sensitivity, which was our ultimate goal, the classic Logistic regression or the SVM models preforms well. For both the models the sensitivity was approx 81%. Also we have good accuracy of apporx 85%.

Without PCA

Logistic regression with No PCA

```
##### Importing stats model
import statsmodels.api as sm

# Instantiate the model
# Adding the constant to X_train
log_no_pca = sm.GLM(y_train,(sm.add_constant(X_train)),
family=sm.families.Binomial())

# Fit the model
log_no_pca = log_no_pca.fit().summary()

# Summary
log_no_pca

<class 'statsmodels.iolib.summary.Summary'>
"""
                 Generalized Linear Model Regression Results

======================================================================
========
Dep. Variable:                  churn   No. Observations:
42850
Model:                            GLM   Df Residuals:
42720
Model Family:                Binomial   Df Model:
129
Link Function:                  logit   Scale:
1.0000
```

```
Method:                                IRLS   Log-Likelihood:
nan
Date:                      Sat, 16 May 2020   Deviance:
nan
Time:                              17:56:38   Pearson chi2:
3.70e+05
No. Iterations:                         100

Covariance Type:                  nonrobust

======================================================================
======================
                                   coef    std err          z      P>|z|
[0.025      0.975]
----------------------------------------------------------------------
----------------------
const                          -73.1903   4452.100     -0.016      0.987
-8799.145    8652.765
loc_og_t2o_mou                7.163e-07   4.32e-05      0.017      0.987
-8.39e-05    8.53e-05
std_og_t2o_mou                2.572e-07   1.42e-05      0.018      0.986
-2.75e-05    2.81e-05
loc_ic_t2o_mou                1.441e-06   6.09e-05      0.024      0.981
-0.000       0.000
arpu_6                          -0.0338      0.081     -0.418      0.676
-0.192       0.124
arpu_7                           0.0855      0.086      0.994      0.320
-0.083       0.254
arpu_8                           0.0909      0.110      0.828      0.407
-0.124       0.306
onnet_mou_6                     15.5129      3.573      4.342      0.000
8.510      22.516
onnet_mou_7                     -4.3251      1.817     -2.380      0.017
-7.886      -0.764
onnet_mou_8                      2.3528      1.825      1.289      0.197
-1.225       5.930
offnet_mou_6                    15.0874      3.361      4.489      0.000
8.500      21.674
offnet_mou_7                    -1.7629      1.721     -1.024      0.306
-5.136       1.611
offnet_mou_8                    -0.5496      1.883     -0.292      0.770
-4.240       3.141
roam_ic_mou_6                    0.1622      0.036      4.473      0.000
0.091       0.233
roam_ic_mou_7                   -0.0099      0.052     -0.189      0.850
-0.112       0.093
roam_ic_mou_8                    0.2041      0.044      4.663      0.000
0.118       0.290
roam_og_mou_6                   -5.1505      1.131     -4.554      0.000
```

```
-7.367      -2.934
roam_og_mou_7                  0.8855      0.474      1.867      0.062
-0.044       1.815
roam_og_mou_8                  0.0927      0.531      0.175      0.861
-0.948       1.133
loc_og_t2t_mou_6           -3302.8216    656.377     -5.032      0.000
-4589.297   -2016.346
loc_og_t2t_mou_7           -1474.6175    679.783     -2.169      0.030
-2806.968    -142.267
loc_og_t2t_mou_8            5516.1251    628.160      8.781      0.000
4284.953    6747.297
loc_og_t2m_mou_6           -3342.4429    664.131     -5.033      0.000
-4644.116   -2040.770
loc_og_t2m_mou_7           -1392.1079    641.104     -2.171      0.030
-2648.649    -135.567
loc_og_t2m_mou_8            5887.3829    670.271      8.784      0.000
4573.677    7201.089
loc_og_t2f_mou_6            -285.2245     56.710     -5.030      0.000
-396.373    -174.076
loc_og_t2f_mou_7            -123.0165     56.677     -2.171      0.030
-234.101     -11.933
loc_og_t2f_mou_8             487.3991     55.519      8.779      0.000
378.584     596.214
loc_og_t2c_mou_6               0.0433      0.022      1.982      0.048
0.000       0.086
loc_og_t2c_mou_7               0.0099      0.021      0.463      0.643
-0.032       0.052
loc_og_t2c_mou_8               0.0673      0.023      2.988      0.003
0.023       0.111
loc_og_mou_6                3756.2132   1269.036      2.960      0.003
1268.947    6243.479
loc_og_mou_7                5686.5575   1330.512      4.274      0.000
3078.802    8294.313
loc_og_mou_8                -265.7885   1351.069     -0.197      0.844
-2913.835    2382.258
std_og_t2t_mou_6           -1.309e+04   1867.084     -7.011      0.000
-1.67e+04   -9430.445
std_og_t2t_mou_7           -9674.1364   1822.022     -5.310      0.000
-1.32e+04   -6103.040
std_og_t2t_mou_8            5854.8113   1510.088      3.877      0.000
2895.093    8814.530
std_og_t2m_mou_6           -1.214e+04   1732.071     -7.011      0.000
-1.55e+04   -8749.312
std_og_t2m_mou_7           -9438.8725   1777.374     -5.311      0.000
-1.29e+04   -5955.284
std_og_t2m_mou_8            5966.0664   1538.126      3.879      0.000
2951.394    8980.739
std_og_t2f_mou_6            -255.4281     36.393     -7.019      0.000
-326.757    -184.099
```

```
std_og_t2f_mou_7         -213.5957     40.259     -5.306      0.000
-292.502    -134.689
std_og_t2f_mou_8          142.4571     36.758      3.876      0.000
70.412     214.502
std_og_t2c_mou_6        -3.536e-06      0.000     -0.018      0.986
-0.000       0.000
std_og_t2c_mou_7        -2.353e-06      0.000     -0.014      0.989
-0.000       0.000
std_og_t2c_mou_8        -2.486e-06      0.000     -0.017      0.986
-0.000       0.000
std_og_mou_6             1.446e+04   2966.600      4.875      0.000
8646.469    2.03e+04
std_og_mou_7             2.105e+04   3103.817      6.783      0.000
1.5e+04    2.71e+04
std_og_mou_8             7815.2524   2767.836      2.824      0.005
2390.393    1.32e+04
isd_og_mou_6              -51.5636     29.686     -1.737      0.082
-109.747       6.620
isd_og_mou_7               94.2299     27.788      3.391      0.001
39.767     148.693
isd_og_mou_8              320.5622     34.133      9.392      0.000
253.663     387.462
spl_og_mou_6              -83.1552     47.782     -1.740      0.082
-176.805      10.495
spl_og_mou_7              229.8600     67.719      3.394      0.001
97.134     362.586
spl_og_mou_8              523.1539     55.587      9.411      0.000
414.206     632.102
og_others_6               -10.0916      5.818     -1.734      0.083
-21.496       1.312
og_others_7                15.6443      4.903      3.191      0.001
6.034      25.255
og_others_8             -5276.7831   3.24e+05     -0.016      0.987
-6.41e+05     6.3e+05
total_og_mou_6           3406.4402   1971.608      1.728      0.084
-457.840    7270.720
total_og_mou_7          -7829.5225   2307.277     -3.393      0.001
-1.24e+04   -3307.343
total_og_mou_8          -1.894e+04   2011.752     -9.413      0.000
-2.29e+04    -1.5e+04
loc_ic_t2t_mou_6         -471.9694    401.748     -1.175      0.240
-1259.382     315.443
loc_ic_t2t_mou_7         2043.4379    441.193      4.632      0.000
1178.715    2908.161
loc_ic_t2t_mou_8         6411.9241    417.700     15.351      0.000
5593.247    7230.601
loc_ic_t2m_mou_6         -662.3378    563.889     -1.175      0.240
-1767.540     442.865
loc_ic_t2m_mou_7         2751.5586    593.997      4.632      0.000
```

```
1587.346    3915.772
loc_ic_t2m_mou_8              9239.7305    601.928     15.350      0.000
8059.973    1.04e+04
loc_ic_t2f_mou_6              -130.8717    111.320     -1.176      0.240
-349.055      87.312
loc_ic_t2f_mou_7               595.9951    128.711      4.630      0.000
343.725     848.265
loc_ic_t2f_mou_8              1755.6262    114.390     15.348      0.000
1531.426    1979.826
loc_ic_mou_6                 -1472.7581   1056.667     -1.394      0.163
-3543.788     598.272
loc_ic_mou_7                 -2703.9336   1115.928     -2.423      0.015
-4891.113    -516.754
loc_ic_mou_8                  3460.7823   1136.224      3.046      0.002
1233.824    5687.740
std_ic_t2t_mou_6             -2047.5989    316.623     -6.467      0.000
-2668.169   -1427.028
std_ic_t2t_mou_7              -414.5246    317.544     -1.305      0.192
-1036.900     207.851
std_ic_t2t_mou_8              -551.5337    227.041     -2.429      0.015
-996.526    -106.541
std_ic_t2m_mou_6             -2117.6774    327.457     -6.467      0.000
-2759.481   -1475.874
std_ic_t2m_mou_7              -425.3418    325.663     -1.306      0.192
-1063.630     212.946
std_ic_t2m_mou_8              -844.5218    347.926     -2.427      0.015
-1526.445    -162.599
std_ic_t2f_mou_6              -364.6880     56.406     -6.465      0.000
-475.242    -254.134
std_ic_t2f_mou_7               -79.5903     61.102     -1.303      0.193
-199.347      40.167
std_ic_t2f_mou_8              -138.8260     56.895     -2.440      0.015
-250.338     -27.314
std_ic_t2o_mou_6             -5.826e-07   2.86e-05     -0.020      0.984
-5.67e-05    5.55e-05
std_ic_t2o_mou_7              1.092e-06   7.95e-05      0.014      0.989
-0.000       0.000
std_ic_t2o_mou_8               1.37e-06   8.38e-05      0.016      0.987
-0.000       0.000
std_ic_mou_6                  1980.5760    602.710      3.286      0.001
799.287    3161.865
std_ic_mou_7                  1297.3541    611.724      2.121      0.034
98.398    2496.310
std_ic_mou_8                  8343.2863    569.153     14.659      0.000
7227.768    9458.805
total_ic_mou_6                2863.2928    942.847      3.037      0.002
1015.348    4711.238
total_ic_mou_7               -1538.9468   1008.240     -1.526      0.127
-3515.061     437.167
```

```
total_ic_mou_8          -1.982e+04   1035.030    -19.153      0.000
-2.19e+04   -1.78e+04
spl_ic_mou_6               -1.5369      0.562     -2.733      0.006
-2.639      -0.435
spl_ic_mou_7                0.5833      0.518      1.127      0.260
-0.431       1.598
spl_ic_mou_8                5.2078      0.295     17.671      0.000
4.630       5.785
isd_ic_mou_6             -483.9815    159.328     -3.038      0.002
-796.259    -171.704
isd_ic_mou_7              274.3329    179.671      1.527      0.127
-77.816     626.482
isd_ic_mou_8             3507.8222    183.152     19.153      0.000
3148.851    3866.794
ic_others_6               -81.0624     26.650     -3.042      0.002
-133.295     -28.829
ic_others_7                42.4590     27.835      1.525      0.127
-12.096      97.014
ic_others_8               550.1144     28.772     19.120      0.000
493.723     606.506
total_rech_num_6            0.0224      0.035      0.638      0.523
-0.046       0.091
total_rech_num_7            0.0726      0.040      1.804      0.071
-0.006       0.151
total_rech_num_8           -0.6403      0.041    -15.682      0.000
-0.720      -0.560
total_rech_amt_6            0.6131      0.082      7.465      0.000
0.452       0.774
total_rech_amt_7           -0.2171      0.080     -2.701      0.007
-0.375      -0.060
total_rech_amt_8            0.2182      0.114      1.913      0.056
-0.005       0.442
max_rech_amt_6             -0.2237      0.037     -6.053      0.000
-0.296      -0.151
max_rech_amt_7             -0.0587      0.036     -1.645      0.100
-0.129       0.011
max_rech_amt_8              0.1475      0.043      3.398      0.001
0.062       0.233
last_day_rch_amt_6         -0.1756      0.029     -6.043      0.000
-0.233      -0.119
last_day_rch_amt_7          0.0028      0.029      0.098      0.922
-0.054       0.059
last_day_rch_amt_8         -0.5102      0.033    -15.449      0.000
-0.575      -0.445
vol_2g_mb_6                 0.1398      0.030      4.724      0.000
0.082       0.198
vol_2g_mb_7                 0.0299      0.032      0.927      0.354
-0.033       0.093
vol_2g_mb_8                 0.0882      0.034      2.580      0.010
```

```
0.021       0.155
vol_3g_mb_6                  0.3625      0.044      8.158      0.000
0.275       0.450
vol_3g_mb_7                  0.4089      0.056      7.289      0.000
0.299       0.519
vol_3g_mb_8                 -0.1838      0.068     -2.700      0.007
-0.317      -0.050
monthly_2g_6                -0.6068      0.045    -13.514      0.000
-0.695      -0.519
monthly_2g_7                -0.4095      0.042     -9.834      0.000
-0.491      -0.328
monthly_2g_8                -0.6419      0.059    -10.961      0.000
-0.757      -0.527
sachet_2g_6                 -0.0239      0.031     -0.773      0.439
-0.085       0.037
sachet_2g_7                 -0.2143      0.033     -6.464      0.000
-0.279      -0.149
sachet_2g_8                 -0.2391      0.032     -7.513      0.000
-0.301      -0.177
monthly_3g_6                -0.3220      0.046     -6.989      0.000
-0.412      -0.232
monthly_3g_7                -0.5808      0.052    -11.100      0.000
-0.683      -0.478
monthly_3g_8                -0.8649      0.078    -11.083      0.000
-1.018      -0.712
sachet_3g_6                 -0.0281      0.032     -0.871      0.384
-0.091       0.035
sachet_3g_7                 -0.0829      0.042     -1.964      0.050
-0.166      -0.000
sachet_3g_8                 -0.1553      0.048     -3.222      0.001
-0.250      -0.061
aon                         -0.1564      0.022     -7.269      0.000
-0.199      -0.114
aug_vbc_3g                  -0.1965      0.057     -3.441      0.001
-0.308      -0.085
jul_vbc_3g                  -0.0522      0.047     -1.118      0.264
-0.144       0.039
jun_vbc_3g                   0.2364      0.047      5.007      0.000
0.144       0.329
decrease_mou_action         -0.4989      0.053     -9.461      0.000
-0.602      -0.396
decrease_rech_num_action    -1.0229      0.048    -21.429      0.000
-1.116      -0.929
decrease_rech_amt_action    -0.3065      0.065     -4.720      0.000
-0.434      -0.179
decrease_arpu_action        -0.1797      0.067     -2.701      0.007
-0.310      -0.049
decrease_vbc_action         -1.7537      0.130    -13.538      0.000
-2.008      -1.500
```

```
==========================================================================
======================
"""
```

Model analysis

1. We can see that there are few features have positive coefficients and few have negative.
2. Many features have higher p-values and hence became insignificant in the model.

Coarse tuning (Auto+Manual)

We'll first eliminate a few features using Recursive Feature Elimination (RFE), and once we have reached a small set of variables to work with, we can then use manual feature elimination (i.e. manually eliminating features based on observing the p-values and VIFs).

Feature Selection Using RFE

```
# Importing logistic regression from sklearn
from sklearn.linear_model import LogisticRegression
# Intantiate the logistic regression
logreg = LogisticRegression()
```

RFE with 15 columns

```
# Importing RFE
from sklearn.feature_selection import RFE

# Intantiate RFE with 15 columns
rfe = RFE(logreg, 15)

# Fit the rfe model with train set
rfe = rfe.fit(X_train, y_train)

# RFE selected columns
rfe_cols = X_train.columns[rfe.support_]
print(rfe_cols)

Index(['offnet_mou_7', 'offnet_mou_8', 'roam_og_mou_8',
'std_og_t2m_mou_8',
       'isd_og_mou_8', 'og_others_7', 'og_others_8',
'loc_ic_t2f_mou_8',
       'loc_ic_mou_8', 'std_ic_t2f_mou_8', 'ic_others_8',
'total_rech_num_8',
       'monthly_2g_8', 'monthly_3g_8', 'decrease_vbc_action'],
      dtype='object')
```

Model-1 with RFE selected columns

```
# Adding constant to X_train
X_train_sm_1 = sm.add_constant(X_train[rfe_cols])
```

```
#Instantiate the model
log_no_pca_1 = sm.GLM(y_train, X_train_sm_1,
family=sm.families.Binomial())

# Fit the model
log_no_pca_1 = log_no_pca_1.fit()

log_no_pca_1.summary()

<class 'statsmodels.iolib.summary.Summary'>
"""
                 Generalized Linear Model Regression Results

======================================================================
========
Dep. Variable:                   churn   No. Observations:
42850
Model:                             GLM   Df Residuals:
42834
Model Family:                 Binomial   Df Model:
15
Link Function:                   logit   Scale:
1.0000
Method:                           IRLS   Log-Likelihood:
nan
Date:                 Sat, 16 May 2020   Deviance:
nan
Time:                         18:04:18   Pearson chi2:
4.49e+06
No. Iterations:                    100

Covariance Type:             nonrobust

======================================================================
=================
                          coef    std err          z      P>|z|
[0.025      0.975]
----------------------------------------------------------------------
-----------------
const                 -58.6610   4419.624     -0.013      0.989   -
8720.965    8603.643
offnet_mou_7            0.6096      0.026     23.449      0.000
0.559       0.661
offnet_mou_8           -3.2532      0.106    -30.548      0.000      -
3.462      -3.045
roam_og_mou_8           1.2482      0.032     39.496      0.000
1.186       1.310
std_og_t2m_mou_8        2.4408      0.094     26.101      0.000
2.258       2.624
isd_og_mou_8           -1.0212      0.194     -5.271      0.000      -
```

```
1.401      -0.641
og_others_7            -1.1915      0.862     -1.382      0.167      -
2.881       0.498
og_others_8         -4191.9652   3.22e+05     -0.013      0.990   -
6.35e+05    6.27e+05
loc_ic_t2f_mou_8       -0.7547      0.072    -10.487      0.000      -
0.896      -0.614
loc_ic_mou_8           -1.9744      0.066    -30.078      0.000      -
2.103      -1.846
std_ic_t2f_mou_8       -0.7922      0.075    -10.607      0.000      -
0.939      -0.646
ic_others_8            -1.4913      0.132    -11.305      0.000      -
1.750      -1.233
total_rech_num_8       -0.4840      0.018    -26.977      0.000      -
0.519      -0.449
monthly_2g_8           -0.9031      0.043    -20.851      0.000      -
0.988      -0.818
monthly_3g_8           -0.9871      0.043    -22.711      0.000      -
1.072      -0.902
decrease_vbc_action    -1.3078      0.073    -17.956      0.000      -
1.451      -1.165
======================================================================
=================
"""
```

Checking VIFs

```
# Check for the VIF values of the feature variables.
from statsmodels.stats.outliers_influence import
variance_inflation_factor

# Create a dataframe that will contain the names of all the feature
variables and their respective VIFs
vif = pd.DataFrame()
vif['Features'] = X_train[rfe_cols].columns
vif['VIF'] = [variance_inflation_factor(X_train[rfe_cols].values, i)
for i in range(X_train[rfe_cols].shape[1])]
vif['VIF'] = round(vif['VIF'], 2)
vif = vif.sort_values(by = "VIF", ascending = False)
vif

               Features   VIF
1          offnet_mou_8  7.45
3      std_og_t2m_mou_8  6.27
0          offnet_mou_7  1.92
8          loc_ic_mou_8  1.68
7      loc_ic_t2f_mou_8  1.21
11     total_rech_num_8  1.19
2          roam_og_mou_8  1.16
14  decrease_vbc_action  1.08
```

```
13         monthly_3g_8  1.06
6           og_others_8  1.05
12         monthly_2g_8  1.05
5           og_others_7  1.04
9      std_ic_t2f_mou_8  1.02
10          ic_others_8  1.02
4          isd_og_mou_8  1.01
```

Removing column og_others_8, which is insignificatnt as it has the highest p-value 0.99

```
# Removing og_others_8 column
log_cols = rfe_cols.to_list()
log_cols.remove('og_others_8')
print(log_cols)

['offnet_mou_7', 'offnet_mou_8', 'roam_og_mou_8', 'std_og_t2m_mou_8',
'isd_og_mou_8', 'og_others_7', 'loc_ic_t2f_mou_8', 'loc_ic_mou_8',
'std_ic_t2f_mou_8', 'ic_others_8', 'total_rech_num_8', 'monthly_2g_8',
'monthly_3g_8', 'decrease_vbc_action']
```

Model-2

Building the model after removing og_others_8 variable.

```
# Adding constant to X_train
X_train_sm_2 = sm.add_constant(X_train[log_cols])

#Instantiate the model
log_no_pca_2 = sm.GLM(y_train, X_train_sm_2,
family=sm.families.Binomial())

# Fit the model
log_no_pca_2 = log_no_pca_2.fit()

log_no_pca_2.summary()

<class 'statsmodels.iolib.summary.Summary'>
"""
                 Generalized Linear Model Regression Results

======================================================================
========
Dep. Variable:                  churn   No. Observations:
42850
Model:                            GLM   Df Residuals:
42835
Model Family:                Binomial   Df Model:
14
Link Function:                  logit   Scale:
1.0000
```

```
Method:                          IRLS   Log-Likelihood:
-15034.
Date:                Sat, 16 May 2020   Deviance:
30068.
Time:                        18:06:36   Pearson chi2:
4.51e+06
No. Iterations:                    11

Covariance Type:            nonrobust

======================================================================
=================
                          coef    std err          z      P>|z|
[0.025      0.975]
----------------------------------------------------------------------
-----------------
const                  -1.1052      0.031    -35.342      0.000       -
1.167      -1.044
offnet_mou_7            0.6081      0.026     23.427      0.000
0.557       0.659
offnet_mou_8           -3.2557      0.106    -30.603      0.000       -
3.464      -3.047
roam_og_mou_8           1.2491      0.031     39.747      0.000
1.188       1.311
std_og_t2m_mou_8        2.4428      0.093     26.146      0.000
2.260       2.626
isd_og_mou_8           -1.0982      0.196     -5.590      0.000       -
1.483      -0.713
og_others_7            -1.8793      0.818     -2.299      0.022       -
3.482      -0.277
loc_ic_t2f_mou_8       -0.7548      0.072    -10.491      0.000       -
0.896      -0.614
loc_ic_mou_8           -1.9714      0.066    -30.058      0.000       -
2.100      -1.843
std_ic_t2f_mou_8       -0.8020      0.075    -10.727      0.000       -
0.949      -0.655
ic_others_8            -1.4871      0.132    -11.278      0.000       -
1.746      -1.229
total_rech_num_8       -0.4864      0.018    -27.146      0.000       -
0.522      -0.451
monthly_2g_8           -0.9066      0.043    -20.866      0.000       -
0.992      -0.821
monthly_3g_8           -0.9862      0.043    -22.700      0.000       -
1.071      -0.901
decrease_vbc_action    -1.3097      0.073    -17.994      0.000       -
1.452      -1.167
======================================================================
=================
"""
```

Checking VIF for Model-2

```
# Create a dataframe that will contain the names of all the feature
variables and their respective VIFs
vif = pd.DataFrame()
vif['Features'] = X_train[log_cols].columns
vif['VIF'] = [variance_inflation_factor(X_train[log_cols].values, i)
for i in range(X_train[log_cols].shape[1])]
vif['VIF'] = round(vif['VIF'], 2)
vif = vif.sort_values(by = "VIF", ascending = False)
vif
```

	Features	VIF
1	offnet_mou_8	7.45
3	std_og_t2m_mou_8	6.27
0	offnet_mou_7	1.92
7	loc_ic_mou_8	1.68
6	loc_ic_t2f_mou_8	1.21
10	total_rech_num_8	1.19
2	roam_og_mou_8	1.16
13	decrease_vbc_action	1.08
12	monthly_3g_8	1.06
11	monthly_2g_8	1.05
8	std_ic_t2f_mou_8	1.02
4	isd_og_mou_8	1.01
9	ic_others_8	1.01
5	og_others_7	1.00

As we can see from the model summary that all the variables p-values are significant and offnet_mou_8 column has the highest VIF 7.45. Hence, deleting offnet_mou_8 column.

```
# Removing offnet_mou_8 column
log_cols.remove('offnet_mou_8')
```

Model-3

Model after removing offnet_mou_8 column.

```
# Adding constant to X_train
X_train_sm_3 = sm.add_constant(X_train[log_cols])

#Instantiate the model
log_no_pca_3 = sm.GLM(y_train, X_train_sm_3,
family=sm.families.Binomial())

# Fit the model
log_no_pca_3 = log_no_pca_3.fit()

log_no_pca_3.summary()
```

```
<class 'statsmodels.iolib.summary.Summary'>
"""
                 Generalized Linear Model Regression Results

======================================================================
========
Dep. Variable:                  churn   No. Observations:
42850
Model:                            GLM   Df Residuals:
42836
Model Family:                Binomial   Df Model:
13
Link Function:                  logit   Scale:
1.0000
Method:                          IRLS   Log-Likelihood:
-15720.
Date:                Sat, 16 May 2020   Deviance:
31440.
Time:                        18:07:30   Pearson chi2:
3.92e+06
No. Iterations:                    11

Covariance Type:            nonrobust

======================================================================
=================
                          coef    std err          z      P>|z|
[0.025      0.975]
----------------------------------------------------------------------
-----------------
const                  -1.2058      0.032    -37.536      0.000      -
1.269      -1.143
offnet_mou_7            0.3665      0.022     16.456      0.000
0.323       0.410
roam_og_mou_8           0.7135      0.024     29.260      0.000
0.666       0.761
std_og_t2m_mou_8       -0.2474      0.022    -11.238      0.000      -
0.291      -0.204
isd_og_mou_8           -1.3811      0.212     -6.511      0.000      -
1.797      -0.965
og_others_7            -2.4711      0.872     -2.834      0.005      -
4.180      -0.762
loc_ic_t2f_mou_8       -0.7102      0.075     -9.532      0.000      -
0.856      -0.564
loc_ic_mou_8           -3.3287      0.057    -58.130      0.000      -
3.441      -3.216
std_ic_t2f_mou_8       -0.9503      0.078    -12.181      0.000      -
1.103      -0.797
ic_others_8            -1.5131      0.129    -11.771      0.000      -
1.765      -1.261
```

```
total_rech_num_8         -0.5060      0.018    -28.808      0.000      -
0.540      -0.472
monthly_2g_8             -0.9279      0.044    -21.027      0.000      -
1.014      -0.841
monthly_3g_8             -1.0943      0.046    -23.615      0.000      -
1.185      -1.004
decrease_vbc_action      -1.3293      0.072    -18.478      0.000      -
1.470      -1.188
======================================================================
=================
"""
```

VIF Model-3

```
vif = pd.DataFrame()
vif['Features'] = X_train[log_cols].columns
vif['VIF'] = [variance_inflation_factor(X_train[log_cols].values, i)
for i in range(X_train[log_cols].shape[1])]
vif['VIF'] = round(vif['VIF'], 2)
vif = vif.sort_values(by = "VIF", ascending = False)
vif
```

	Features	VIF
2	std_og_t2m_mou_8	1.87
0	offnet_mou_7	1.72
6	loc_ic_mou_8	1.33
5	loc_ic_t2f_mou_8	1.21
9	total_rech_num_8	1.17
12	decrease_vbc_action	1.07
1	roam_og_mou_8	1.06
11	monthly_3g_8	1.06
10	monthly_2g_8	1.05
7	std_ic_t2f_mou_8	1.02
3	isd_og_mou_8	1.01
8	ic_others_8	1.01
4	og_others_7	1.00

Now from the model summary and the VIF list we can see that all the variables are significant and there is no multicollinearity among the variables.

Hence, we can conclused that ***Model-3 log_no_pca_3 will be the final model***.

Model performance on the train set

```
# Getting the predicted value on the train set
y_train_pred_no_pca = log_no_pca_3.predict(X_train_sm_3)
y_train_pred_no_pca.head()

0    2.687411e-01
1    7.047483e-02
```

```
2    8.024370e-02
3    3.439222e-03
4    5.253815e-19
dtype: float64
```

Creating a dataframe with the actual churn and the predicted probabilities

```
y_train_pred_final = pd.DataFrame({'churn':y_train.values,
'churn_prob':y_train_pred_no_pca.values})

#Assigning Customer ID for each record for better readblity
#CustID is the index of each record.
y_train_pred_final['CustID'] = y_train_pred_final.index

y_train_pred_final.head()

   churn    churn_prob  CustID
0      0  2.687411e-01       0
1      0  7.047483e-02       1
2      0  8.024370e-02       2
3      0  3.439222e-03       3
4      0  5.253815e-19       4
```

Finding Optimal Probablity Cutoff Point

```
# Creating columns for different probablity cutoffs
prob_cutoff = [float(p/10) for p in range(10)]

for i in prob_cutoff:
    y_train_pred_final[i] =
y_train_pred_final['churn_prob'].map(lambda x : 1 if x > i else 0)

y_train_pred_final.head()

   churn    churn_prob  CustID  0.0  0.1  0.2  0.3  0.4  0.5  0.6  0.7
0.8  \
0      0  2.687411e-01       0    1    1    1    0    0    0    0    0
0
1      0  7.047483e-02       1    1    0    0    0    0    0    0    0
0
2      0  8.024370e-02       2    1    0    0    0    0    0    0    0
0
3      0  3.439222e-03       3    1    0    0    0    0    0    0    0
0
4      0  5.253815e-19       4    1    0    0    0    0    0    0    0
0

   0.9
0    0
1    0
2    0
```

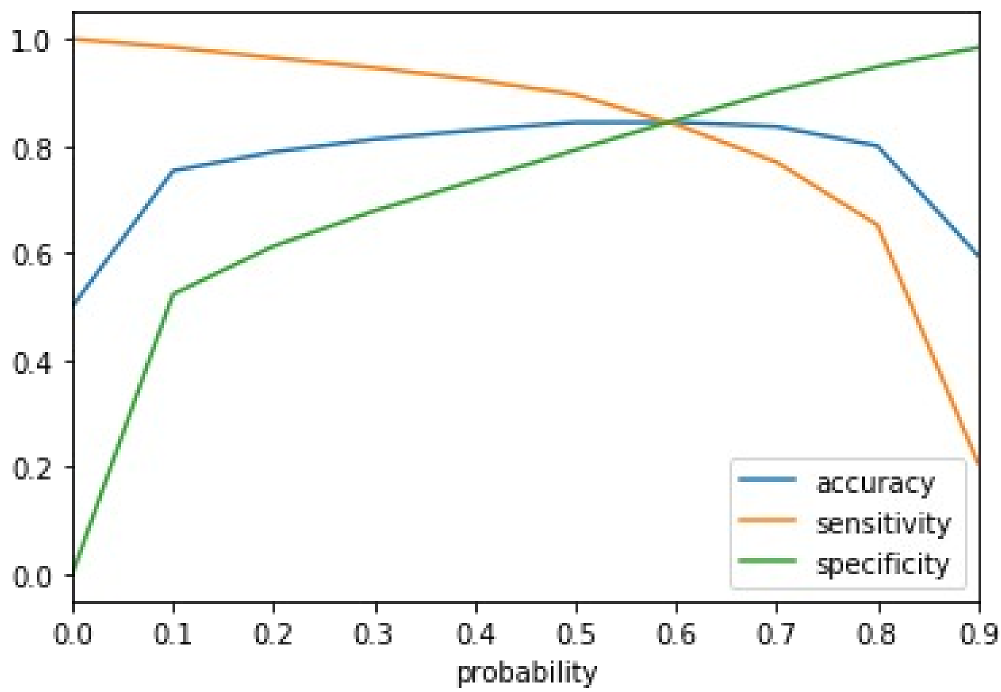
```
3    0
4    0
```

Now let's calculate the accuracy sensitivity and specificity for various probability cutoffs.

```
# Creating a dataframe
cutoff_df = pd.DataFrame(columns=['probability', 'accuracy',
'sensitivity', 'specificity'])

for i in prob_cutoff:
    cm1 = metrics.confusion_matrix(y_train_pred_final['churn'],
y_train_pred_final[i] )
    total1=sum(sum(cm1))
    accuracy = (cm1[0,0]+cm1[1,1])/total1

    speci = cm1[0,0]/(cm1[0,0]+cm1[0,1])
    sensi = cm1[1,1]/(cm1[1,0]+cm1[1,1])
    cutoff_df.loc[i] =[ i ,accuracy,sensi,speci]
print(cutoff_df)
```

	probability	accuracy	sensitivity	specificity
0.0	0.0	0.500000	1.000000	0.000000
0.1	0.1	0.753629	0.984411	0.522847
0.2	0.2	0.788751	0.964714	0.612789
0.3	0.3	0.812509	0.946371	0.678646
0.4	0.4	0.829638	0.923874	0.735403
0.5	0.5	0.844131	0.895823	0.792439
0.6	0.6	0.844271	0.839860	0.848681
0.7	0.7	0.836173	0.769522	0.902824
0.8	0.8	0.800163	0.652275	0.948051
0.9	0.9	0.595426	0.207001	0.983851

```
# Plotting accuracy, sensitivity and specificity for different
probabilities.
cutoff_df.plot('probability',
['accuracy','sensitivity','specificity'])
plt.show()
```



Analysis of the above curve

Accuracy - Becomes stable around 0.6

Sensitivity - Decreases with the increased probablity.

Specificity - Increases with the increasing probablity.

`At point 0.6` where the three parameters cut each other, we can see that there is a balance bethween sensitivity and specificity with a good accuracy.

Here we are intended to acheive better sensitivity than accuracy and specificity. Though as per the above curve, we should take 0.6 as the optimum probability cutoff, we are taking ***0.5*** for acheiving higher sensitivity, which is our main goal.

```
# Creating a column with name "predicted", which is the predicted
value for 0.5 cutoff
y_train_pred_final['predicted'] =
y_train_pred_final['churn_prob'].map(lambda x: 1 if x > 0.5 else 0)
y_train_pred_final.head()
```

```
   churn    churn_prob  CustID  0.0  0.1  0.2  0.3  0.4  0.5  0.6  0.7
0.8  \
0      0  2.687411e-01       0    1    1    1    0    0    0    0    0
0
1      0  7.047483e-02       1    1    0    0    0    0    0    0    0
0
2      0  8.024370e-02       2    1    0    0    0    0    0    0    0
0
3      0  3.439222e-03       3    1    0    0    0    0    0    0    0
```

```
0
4       0  5.253815e-19       4    1    0    0    0    0    0    0    0
0

   0.9  predicted
0    0          0
1    0          0
2    0          0
3    0          0
4    0          0
```

Metrics

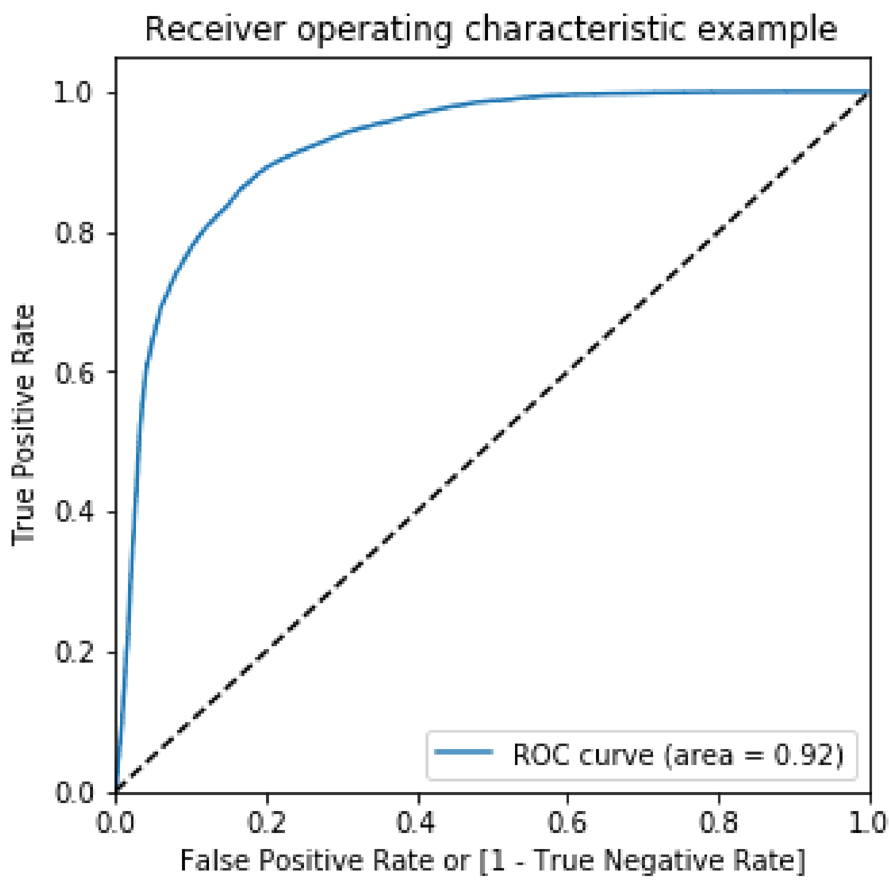
```
# Confusion metrics
confusion = metrics.confusion_matrix(y_train_pred_final['churn'],
y_train_pred_final['predicted'])
print(confusion)

[[16978  4447]
 [ 2232 19193]]

TP = confusion[1,1] # true positive
TN = confusion[0,0] # true negatives
FP = confusion[0,1] # false positives
FN = confusion[1,0] # false negatives

# Accuracy
print("Accuracy:-",metrics.accuracy_score(y_train_pred_final['churn'],
y_train_pred_final['predicted']))

# Sensitivity
print("Sensitivity:-",TP / float(TP+FN))

# Specificity
print("Specificity:-", TN / float(TN+FP))

Accuracy:- 0.8441306884480747
Sensitivity:- 0.8958226371061844
Specificity:- 0.792438739789965
```

We have got good accuracy, sensitivity and specificity on the train set prediction.

Plotting the ROC Curve (Trade off between sensitivity & specificity)

```
# ROC Curve function

def draw_roc( actual, probs ):
    fpr, tpr, thresholds = metrics.roc_curve( actual, probs,
                                              drop_intermediate =
False )
    auc_score = metrics.roc_auc_score( actual, probs )
    plt.figure(figsize=(5, 5))
```

```
    plt.plot( fpr, tpr, label='ROC curve (area = %0.2f)' % auc_score )
    plt.plot([0, 1], [0, 1], 'k--')
    plt.xlim([0.0, 1.0])
    plt.ylim([0.0, 1.05])
    plt.xlabel('False Positive Rate or [1 - True Negative Rate]')
    plt.ylabel('True Positive Rate')
    plt.title('Receiver operating characteristic example')
    plt.legend(loc="lower right")
    plt.show()

    return None

draw_roc(y_train_pred_final['churn'],
y_train_pred_final['churn_prob'])
```



We can see the area of the ROC curve is closer to 1, whic is the Gini of the model.

Testing the model on the test set

```
# Taking a copy of the test set
X_test_log = X_test.copy()
```

```
# Taking only the columns, which are selected in the train set after removing insignificant and multicollinear variables
X_test_log = X_test_log[log_cols]

# Adding constant on the test set
X_test_sm = sm.add_constant(X_test_log)
```

Predictions on the test set with final model

```
# Predict on the test set
y_test_pred = log_no_pca_3.predict(X_test_sm)

y_test_pred.head()

5704     0.034015
64892    0.000578
39613    0.513564
93118    0.020480
81235    0.034115
dtype: float64

# Converting y_test_pred to a dataframe because y_test_pred is an array
y_pred_1 = pd.DataFrame(y_test_pred)
y_pred_1.head()

              0
5704   0.034015
64892  0.000578
39613  0.513564
93118  0.020480
81235  0.034115

# Convetting y_test to a dataframe
y_test_df = pd.DataFrame(y_test)
y_test_df.head()

       churn
5704       0
64892      0
39613      0
93118      0
81235      0

# Putting index to Customer ID
y_test_df['CustID'] = y_test_df.index

# Removing index form the both dataframes for merging them side by side
y_pred_1.reset_index(drop=True, inplace=True)
y_test_df.reset_index(drop=True, inplace=True)
```

```
# Appending y_pred_1 and y_test_df
y_test_pred_final = pd.concat([y_test_df, y_pred_1], axis=1)

y_test_pred_final.head()
```

	churn	CustID	0
0	0	5704	0.034015
1	0	64892	0.000578
2	0	39613	0.513564
3	0	93118	0.020480
4	0	81235	0.034115

```
# Renaming the '0' column as churn probablity
y_test_pred_final = y_test_pred_final.rename(columns={0:'churn_prob'})

# Rearranging the columns
y_test_pred_final =
y_test_pred_final.reindex_axis(['CustID','churn','churn_prob'],
axis=1)

y_test_pred_final.head()
```

	CustID	churn	churn_prob
0	5704	0	0.034015
1	64892	0	0.000578
2	39613	0	0.513564
3	93118	0	0.020480
4	81235	0	0.034115

```
# In the test set using probablity cutoff 0.5, what we got in the
train set
y_test_pred_final['test_predicted'] =
y_test_pred_final['churn_prob'].map(lambda x: 1 if x > 0.5 else 0)

y_test_pred_final.head()
```

	CustID	churn	churn_prob	test_predicted
0	5704	0	0.034015	0
1	64892	0	0.000578	0
2	39613	0	0.513564	1
3	93118	0	0.020480	0
4	81235	0	0.034115	0

Metrics

```
# Confusion matrix
confusion = metrics.confusion_matrix(y_test_pred_final['churn'],
y_test_pred_final['test_predicted'])
print(confusion)

[[4190 1158]
 [  34  159]]
```

```
TP = confusion[1,1] # true positive
TN = confusion[0,0] # true negatives
FP = confusion[0,1] # false positives
FN = confusion[1,0] # false negatives

# Accuracy
print("Accuracy:-",metrics.accuracy_score(y_test_pred_final['churn'],
y_test_pred_final['test_predicted']))

# Sensitivity
print("Sensitivity:-",TP / float(TP+FN))

# Specificity
print("Specificity:-", TN / float(TN+FP))

Accuracy:- 0.7848763761053962
Sensitivity:- 0.8238341968911918
Specificity:- 0.7834704562453254
```

Model summary

- Train set
  - Accuracy = 0.84
  - Sensitivity = 0.81
  - Specificity = 0.83
- Test set
  - Accuracy = 0.78
  - Sensitivity = 0.82
  - Specificity = 0.78

Overall, the model is performing well in the test set, what it had learnt from the train set.

Final conclusion with no PCA

We can see that the logistic model with no PCA has good sensitivity and accuracy, which are comparable to the models with PCA. So, we can go for the more simplistic model such as logistic regression with PCA as it expliains the important predictor variables as well as the significance of each variable. The model also hels us to identify the variables which should be act upon for making the decision of the to be churned customers. Hence, the model is more relevant in terms of explaining to the business.

Business recomendation

Top predictors

Below are few top variables selected in the logistic regression model.

Variables	Coefficients
loc_ic_mou_8	-3.3287

Variables	Coefficients
og_others_7	-2.4711
ic_others_8	-1.5131
isd_og_mou_8	-1.3811
decrease_vbc_action	-1.3293
monthly_3g_8	-1.0943
std_ic_t2f_mou_8	-0.9503
monthly_2g_8	-0.9279
loc_ic_t2f_mou_8	-0.7102
roam_og_mou_8	0.7135

We can see most of the top variables have negative coefficients. That means, the variables are inversely correlated with the churn probablity.

E.g.:-

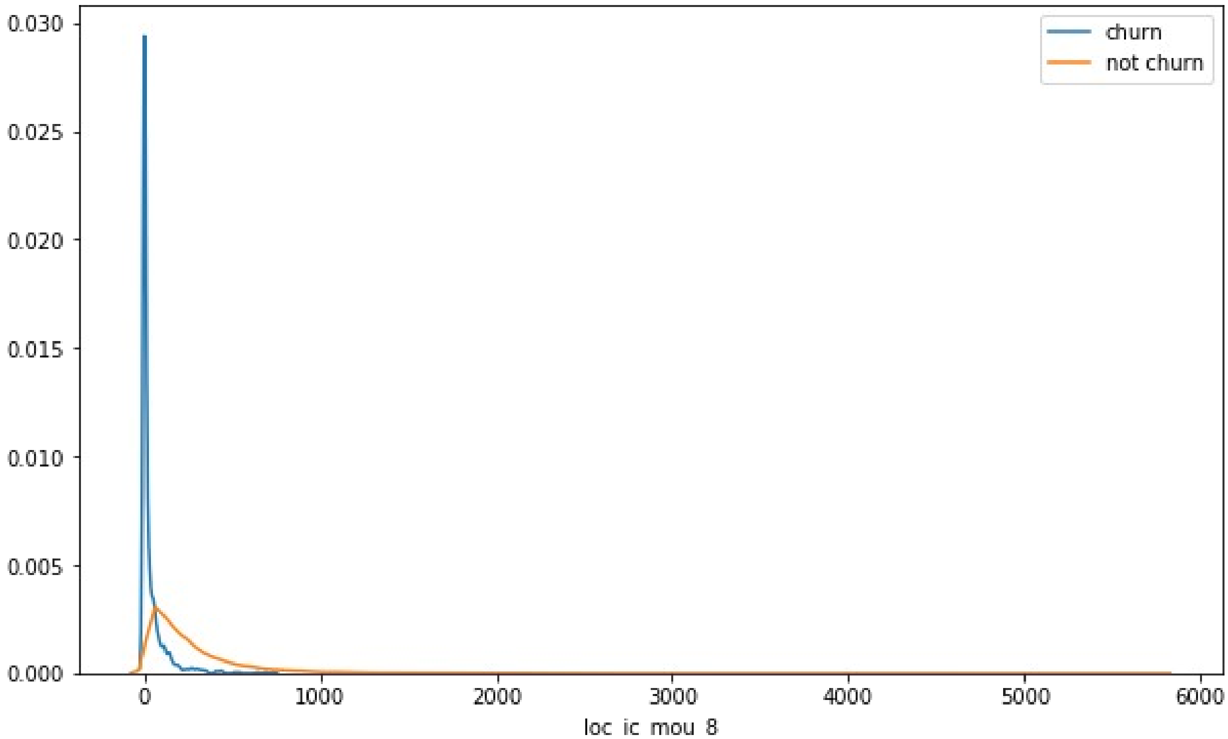
If the local incoming minutes of usage (loc_ic_mou_8) is lesser in the month of August than any other month, then there is a higher chance that the customer is likely to churn.

Recomendations

1. Target the customers, whose minutes of usage of the incoming local calls and outgoing ISD calls are less in the action phase (mostly in the month of August).
2. Target the customers, whose outgoing others charge in July and incoming others on August are less.
3. Also, the customers having value based cost in the action phase increased are more likely to churn than the other customers. Hence, these customers may be a good target to provide offer.
4. Cutomers, whose monthly 3G recharge in August is more, are likely to be churned.
5. Customers having decreasing STD incoming minutes of usage for operators T to fixed lines of T for the month of August are more likely to churn.
6. Cutomers decreasing monthly 2g usage for August are most probable to churn.
7. Customers having decreasing incoming minutes of usage for operators T to fixed lines of T for August are more likely to churn.
8. roam_og_mou_8 variables have positive coefficients (0.7135). That means for the customers, whose roaming outgoing minutes of usage is increasing are more likely to churn.

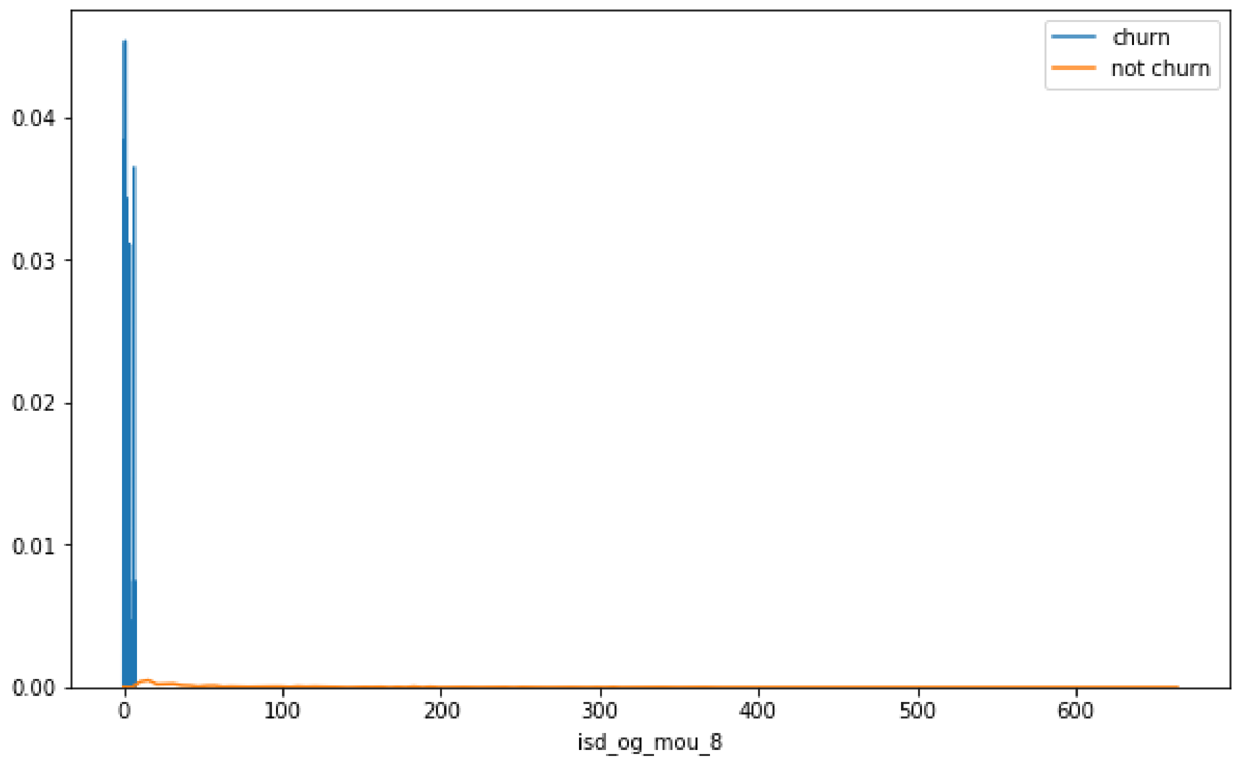
Plots of important predictors for churn and non churn customers

```
# Plotting loc_ic_mou_8 predictor for churn and not churn customers
fig = plt.figure(figsize=(10,6))
sns.distplot(data_churn['loc_ic_mou_8'],label='churn',hist=False)
sns.distplot(data_non_churn['loc_ic_mou_8'],label='not 
churn',hist=False)
plt.show()
```



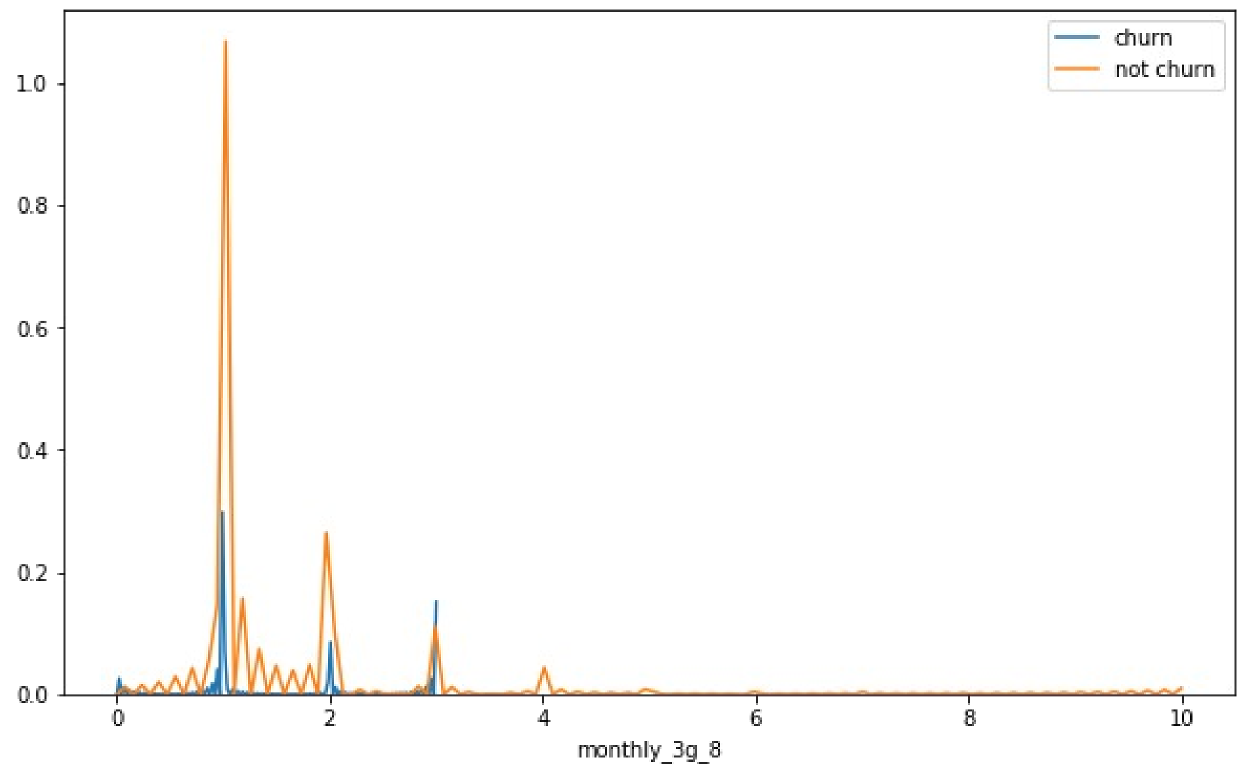
We can see that for the churn customers the minutes of usage for the month of August is mostly populated on the lower side than the non churn customers.

```
# Plotting isd_og_mou_8 predictor for churn and not churn customers
fig = plt.figure(figsize=(10,6))
sns.distplot(data_churn['isd_og_mou_8'],label='churn',hist=False)
sns.distplot(data_non_churn['isd_og_mou_8'],label='not
churn',hist=False)
plt.show()
```



We can see that the ISD outgoing minutes of usage for the month of August for churn customers is densed approximately to zero. On the onther hand for the non churn customers it is little more than the churn customers.

```
# Plotting monthly_3g_8 predictor for churn and not churn customers
fig = plt.figure(figsize=(10,6))
sns.distplot(data_churn['monthly_3g_8'],label='churn',hist=False)
sns.distplot(data_non_churn['monthly_3g_8'],label='not
churn',hist=False)
plt.show()
```



The number of mothly 3g data for August for the churn customers are very much populated aroud 1, whereas of non churn customers it spreaded accross various numbers.

Similarly we can plot each variables, which have higher coefficients, churn distribution.