spqk5nwps

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0.0.1 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.

0.1 Steps:-

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

[2]:
```
# 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')
```

[3]:
```
pd.set_option('display.max_columns', 500)
```

1 Reading and understanding the data

[4]:
```
# Reading the dataset
df = pd.read_csv('telecom_churn_data.csv')
df.head()
```

[4]:
```
   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
```

[5]:
```
df.shape
```

[5]:
```
(99999, 226)
```

[6]:
```
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
```

[7]:
```
df.describe()
```

[7]:
```
       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
```

1.1 Handling missing values

Handling missing values in columns

[8]:
```
# Cheking percent of missing values in columns
df_missing_columns = (round(((df.isnull().sum()/len(df.index))*100),2).
 ↪to_frame('null')).sort_values('null', ascending=False)
df_missing_columns
```

[8]:

	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]
```

[9]:
```
# List the columns having more than 30% missing values
col_list_missing_30 = list(df_missing_columns.index[df_missing_columns['null']␣
 ↪> 30])
```

[10]:
```
# Delete the columns having more than 30% missing values
df = df.drop(col_list_missing_30, axis=1)
```

[11]:
```
df.shape
```

[11]:
```
(99999, 186)
```

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

[12]:
```
# 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']
```

[13]:
```
# 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.

[14]:
```
# Drop circle_id column
df = df.drop('circle_id', axis=1)
```

[15]:
```
df.shape
```

[15]:
```
(99999, 177)
```

1.1.1 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.

[16]:
```
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

[17]:
```
X = df['avg_rech_amt_6_7'].quantile(0.7)
X
```

[17]:
```
368.5
```

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

[18]:
```
df = df[df['avg_rech_amt_6_7'] >= X]
df.head()
```

[18]:
```
    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
```

[19]:
```
df.shape
```

[19]: (30011, 178)

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

Handling missing values in rows

[20]:
```
# 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
```

[20]: (114, 178)

[21]:
```
# Deleting the rows having more than 50% missing values
df = df.drop(df_missing_rows_50.index)
df.shape
```

[21]: (29897, 178)

[22]:
```
# Checking the missing values in columns again
df_missing_columns = (round(((df.isnull().sum()/len(df.index))*100),2).
 ↪to_frame('null')).sort_values('null', ascending=False)
df_missing_columns
```

[22]:
```
                   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.

[23]:
```
# 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']
```

[24]:
```
# 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()
```

[24]:

```
     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

[25]:
```
df_null_mou_9.shape
```

[25]: (1590, 178)

[26]:
```
# Deleting the records for which MOU for Sep(9) are null
df = df.drop(df_null_mou_9.index)
```

[27]:
```
# Again Cheking percent of missing values in columns
df_missing_columns = (round(((df.isnull().sum()/len(df.index))*100),2).
 ↪to_frame('null')).sort_values('null', ascending=False)
df_missing_columns
```

[27]:

	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.

[28]:
```python
# 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']
```

[29]:
```
# 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()
```

[29]:
```
      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
```

[30]:

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

[31]:

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

[31]:

```
                  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.

[32]:
```
# 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']
```

[33]:
```
# 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()
```

[33]:
```
      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
```

[34]:
```
# Deleting the records for which MOU for Jun(6) are null
df = df.drop(df_null_mou_6.index)
```

[35]:
```
# Again cheking percent of missing values in columns
df_missing_columns = (round(((df.isnull().sum()/len(df.index))*100),2).
↪to_frame('null')).sort_values('null', ascending=False)
df_missing_columns
```

[35]:

	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.

[36]:
```python
# 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']
```

[37]:
```python
# 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()
```

[37]:
```
       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
```

[38]:

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

[39]:

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

[39]:

```
                  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.

[40]:
```python
df.shape
```

[40]:
```
(27991, 178)
```

[41]:
```python
# Checking percentage of rows we have lost while handling the missing values
round((1- (len(df.index)/30011)),2)
```

[41]:
```
0.07
```

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

1.1.2 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.

[42]:
```python
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)
```

[43]:
```python
df.head()
```

[43]:
```
    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

[44]:
```
# 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']
```

[45]:
```
# Deleting the churn month columns
df = df.drop(col_9, axis=1)
```

[46]:
```
# Dropping sep_vbc_3g column
df = df.drop('sep_vbc_3g', axis=1)
```

Checking churn percentage

[47]:
```
round(100*(df['churn'].mean()),2)
```

[47]:
```
3.39
```

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

1.2 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.

[48]:
```
df['mobile_number'] = df['mobile_number'].astype(object)
df['churn'] = df['churn'].astype(object)
```

[49]:
```
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
```

[50]:
```
# 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)
```

[51]:
```
# 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
```

[51]: (27705, 136)

1.2.1 Derive new features

[52]:
```
# List the columns of total mou, rech_num and rech_amt
[total for total in data.columns.to_list() if 'total' in total]
```

[52]:
```
['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.

[53]:
```
# Total mou at good phase incoming and outgoing
data['total_mou_good'] = (data['total_og_mou_6'] + data['total_ic_mou_6'])
```

[54]:
```
# 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
```

[55]:
```
# Difference avg_mou_good and avg_mou_action
data['diff_mou'] = data['avg_mou_action'] - data['total_mou_good']
```

[56]:
```
# Checking whether the mou has decreased in action phase
data['decrease_mou_action'] = np.where((data['diff_mou'] < 0), 1, 0)
```

[57]:
```
data.head()
```

[57]:
```
    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.

[58]:
```
# Avg rech number at action phase
data['avg_rech_num_action'] = (data['total_rech_num_7'] +␣
↪data['total_rech_num_8'])/2
```

[59]:
```
# Difference total_rech_num_6 and avg_rech_action
data['diff_rech_num'] = data['avg_rech_num_action'] - data['total_rech_num_6']
```

[60]:
```
# Checking if rech_num has decreased in action phase
data['decrease_rech_num_action'] = np.where((data['diff_rech_num'] < 0), 1, 0)
```

[61]:
```
data.head()
```

[61]:
```
    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.

[62]:
```
# Avg rech_amt in action phase
data['avg_rech_amt_action'] = (data['total_rech_amt_7'] +␣
↪data['total_rech_amt_8'])/2
```

[63]:
```
# 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']
```

[64]:
```
# Checking if rech_amt has decreased in action phase
data['decrease_rech_amt_action'] = np.where((data['diff_rech_amt'] < 0), 1, 0)
```

[66]:
```
data.head()
```

[66]:
```
    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.

[67]:
```
# ARUP in action phase
data['avg_arpu_action'] = (data['arpu_7'] + data['arpu_8'])/2
```

[68]:
```
# Difference of good and action phase ARPU
data['diff_arpu'] = data['avg_arpu_action'] - data['arpu_6']
```

[69]:
```
# Checking whether the arpu has decreased on the action month
data['decrease_arpu_action'] = np.where(data['diff_arpu'] < 0, 1, 0)
```

[70]:
```
data.head()
```

[70]:
```
   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.

[71]:
```python
# VBC in action phase
data['avg_vbc_3g_action'] = (data['jul_vbc_3g'] + data['aug_vbc_3g'])/2
```

[72]:
```python
# Difference of good and action phase VBC
data['diff_vbc'] = data['avg_vbc_3g_action'] - data['jun_vbc_3g']
```

[73]:
```python
# Checking whether the VBC has decreased on the action month
data['decrease_vbc_action'] = np.where(data['diff_vbc'] < 0 , 1, 0)
```

[74]:
```python
data.head()
```

[74]:
```
    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
```

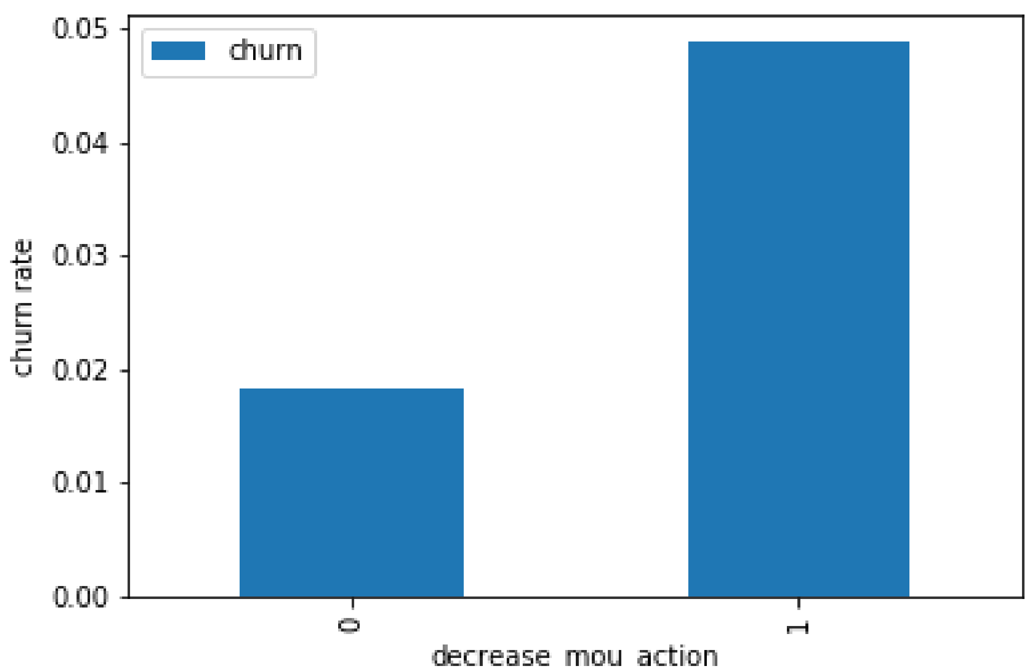
1.3 EDA

1.3.1 Univariate analysis

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

[75]:
```python
# Converting churn column to int in order to do aggfunc in the pivot table
data['churn'] = data['churn'].astype('int64')
```

[76]:
```python
data.pivot_table(values='churn', index='decrease_mou_action', aggfunc='mean').
↪plot.bar()
plt.ylabel('churn rate')
plt.show()
```

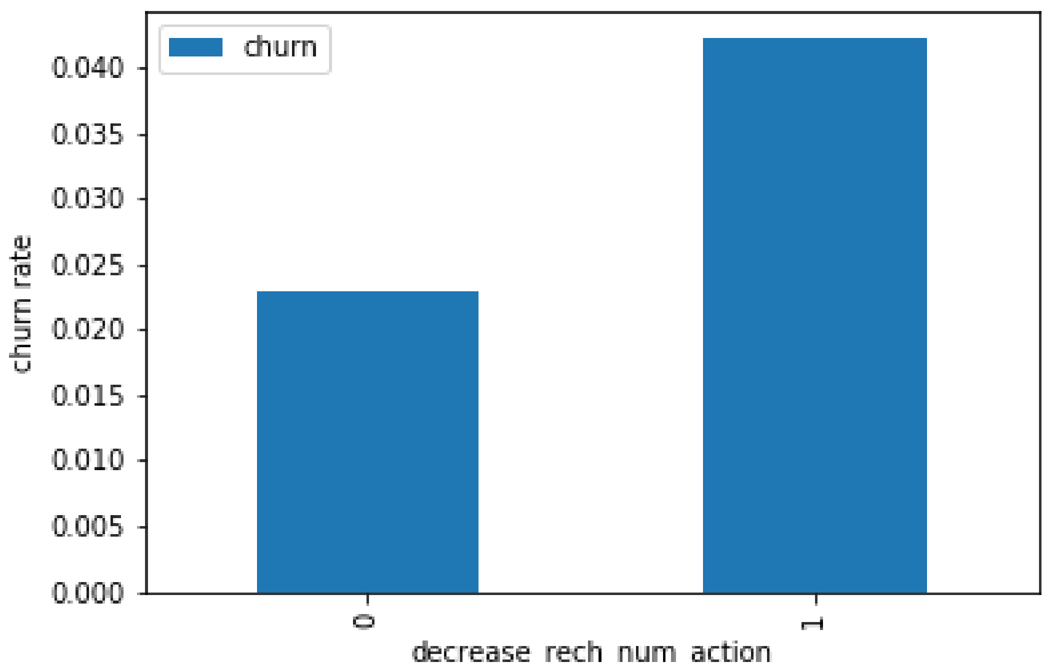


Analysis

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

[77]:
```
data.pivot_table(values='churn', index='decrease_rech_num_action',␣
 ↪aggfunc='mean').plot.bar()
plt.ylabel('churn rate')
plt.show()
```

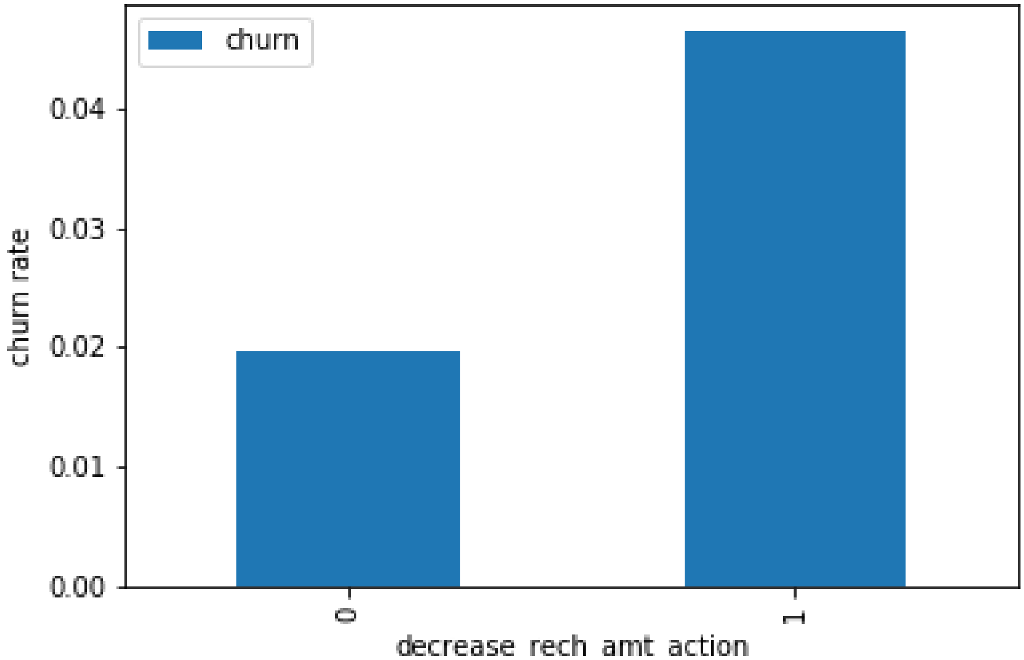


Analysis

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

[78]:
```
data.pivot_table(values='churn', index='decrease_rech_amt_action',␣
 ↪aggfunc='mean').plot.bar()
plt.ylabel('churn rate')
plt.show()
```

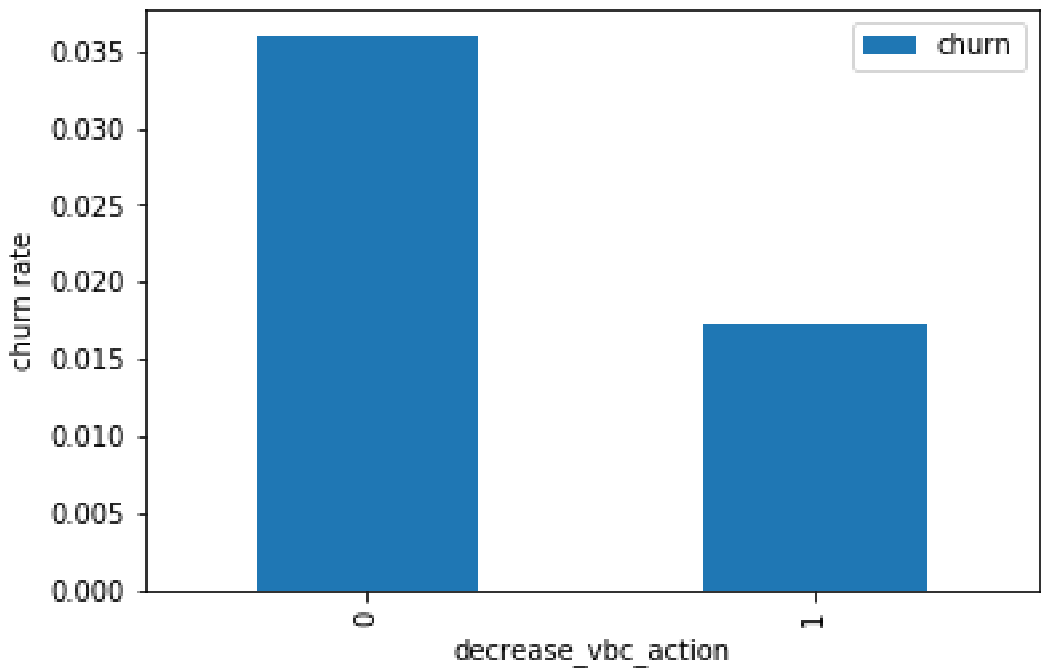


Analysis

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

[79]:
```
data.pivot_table(values='churn', index='decrease_vbc_action', aggfunc='mean').
  ↪plot.bar()
plt.ylabel('churn rate')
plt.show()
```



Analysis

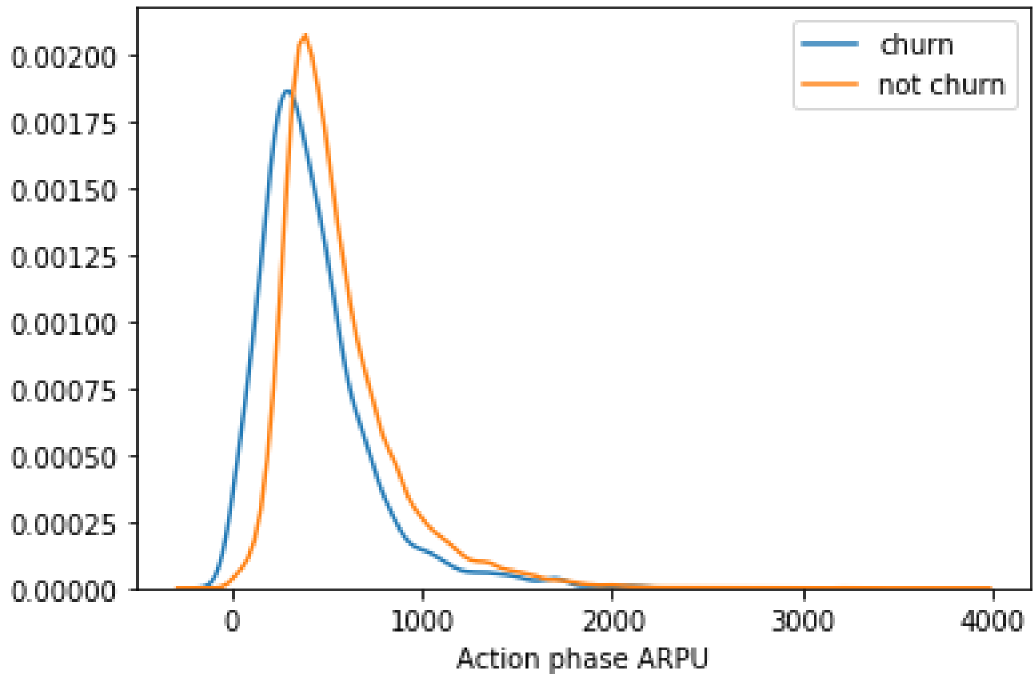
Here we see the expected result. The churn rate is more for the customers, whose volume based cost in action month is increased. That means the customers do not do the monthly recharge more when they are in the action phase.

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

[80]:
```
# Creating churn dataframe
data_churn = data[data['churn'] == 1]
# Creating not churn dataframe
data_non_churn = data[data['churn'] == 0]
```

[81]:
```
# 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')
```

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



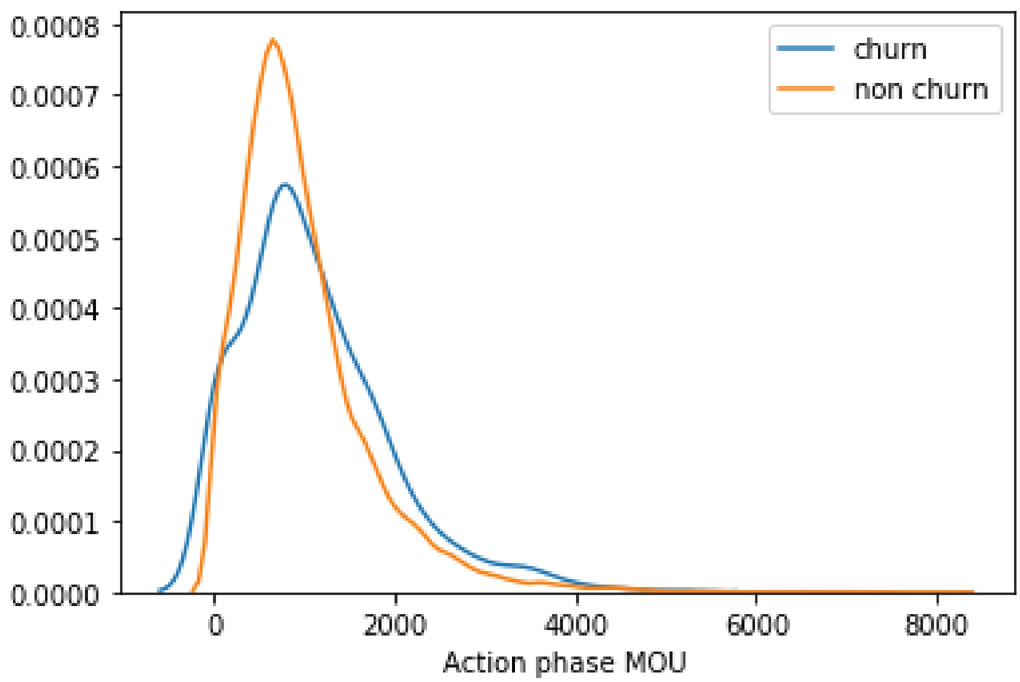
Average revenue per user (ARPU) for the churned customers is mostly densed on the 0 to 900. The higher ARPU customers are less likely to be churned.

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

[82]:
```
# 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')
```

[82]:
```
[Text(0.5, 0, 'Action phase MOU')]
```

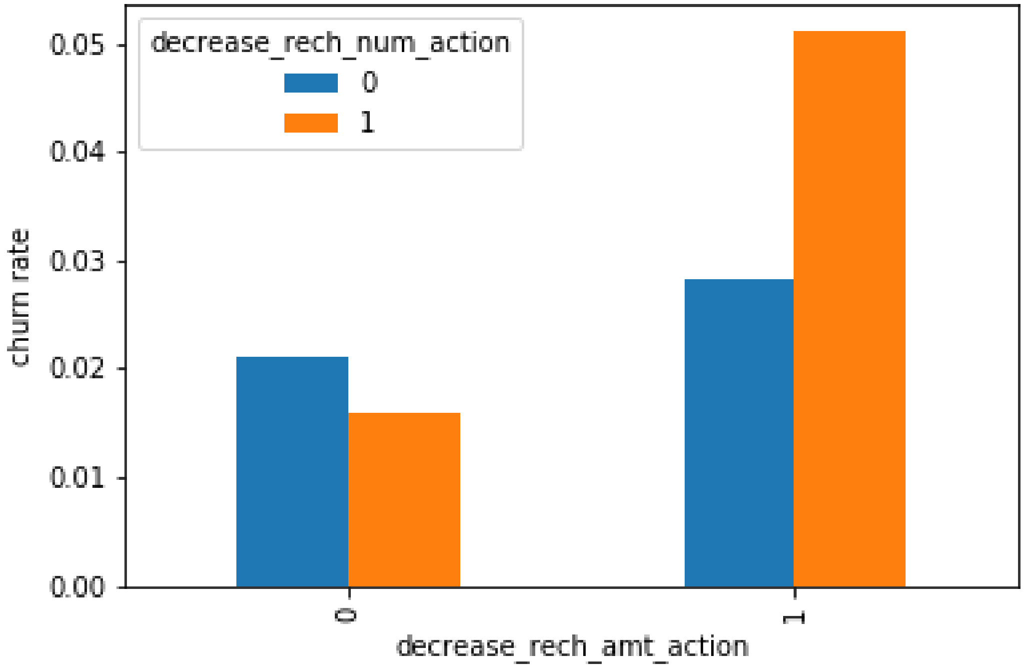


Minutes of usage(MOU) of the churn customers is mostly populated on the 0 to 2500 range. Higher the MOU, lesser the churn probability.

1.3.2 Bivariate analysis

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

[83]:
```
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()
```

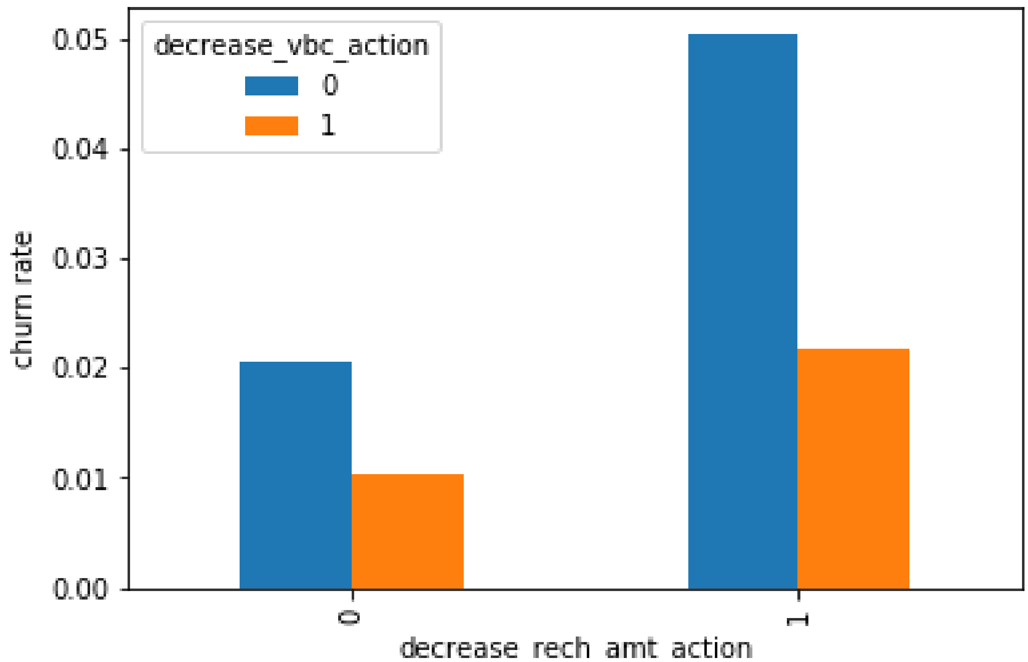


Analysis

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

[84]:
```
data.pivot_table(values='churn', index='decrease_rech_amt_action',␣
↪columns='decrease_vbc_action', aggfunc='mean').plot.bar()
plt.ylabel('churn rate')
plt.show()
```

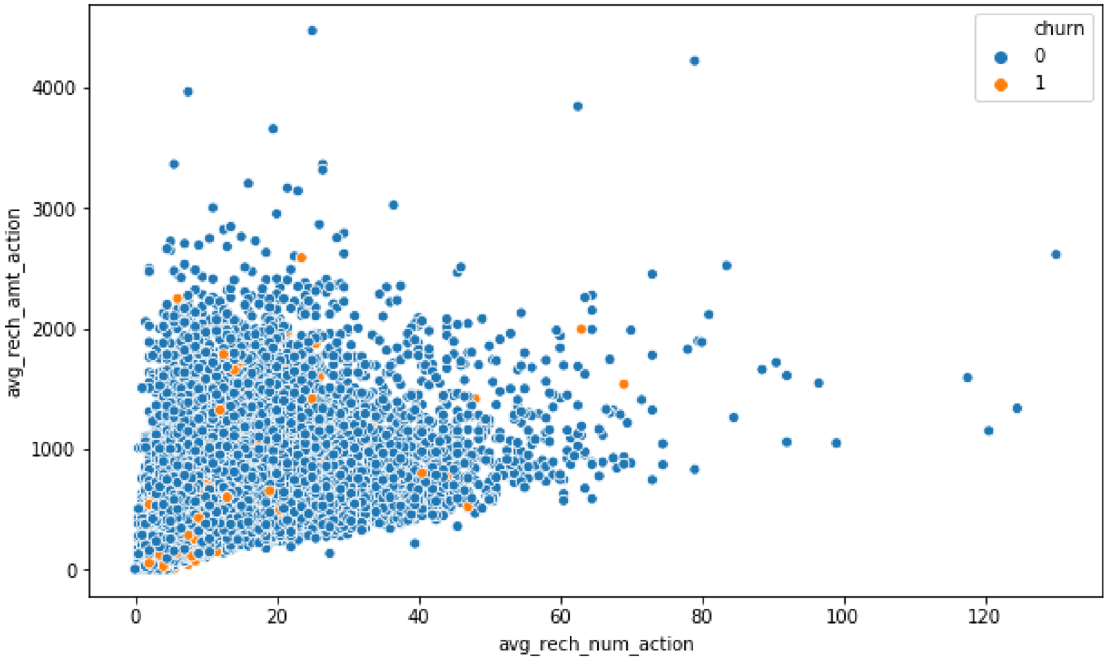


Analysis

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

[85]:
```
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

[86]:
```
data = data.
↪drop(['total_mou_good','avg_mou_action','diff_mou','avg_rech_num_action','diff_rech_num','a
      ␣
↪'diff_rech_amt','avg_arpu_action','diff_arpu','avg_vbc_3g_action','diff_vbc','avg_rech_amt_
↪axis=1)
```

1.4 Train-Test Split

[87]:
```
# Import library
from sklearn.model_selection import train_test_split
```

[88]:
```
# Putting feature variables into X
X = data.drop(['mobile_number','churn'], axis=1)
```

[89]:
```
# Putting target variable to y
y = data['churn']
```

[90]:
```
# 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)
```

1.4.1 Dealing with data imbalance

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

[91]:
```
# Imporing SMOTE
from imblearn.over_sampling import SMOTE
```

[92]:
```
# Instantiate SMOTE
sm = SMOTE(random_state=27)
```

[93]:
```
# Fittign SMOTE to the train set
X_train, y_train = sm.fit_sample(X_train, y_train)
```

1.4.2 Feature Scaling

[94]:
```
# Standardization method
from sklearn.preprocessing import StandardScaler
```

[95]:
```
# Instantiate the Scaler
scaler = StandardScaler()
```

[97]:
```
# 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')
```

[98]:
```
# Fit the data into scaler and transform
X_train[cols_scale] = scaler.fit_transform(X_train[cols_scale])
```

[99]:
```
X_train.head()
```

[99]:
```
   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.

[100]:
```python
# Transform the test set
X_test[cols_scale] = scaler.transform(X_test[cols_scale])
X_test.head()
```

[100]:
```
       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
```

2 Model with PCA

[101]:
```python
#Import PCA
from sklearn.decomposition import PCA
```

[102]:
```python
# Instantiate PCA
pca = PCA(random_state=42)
```

[103]:
```python
# Fit train set on PCA
pca.fit(X_train)
```

[103]:
```
PCA(copy=True, iterated_power='auto', n_components=None, random_state=42,
    svd_solver='auto', tol=0.0, whiten=False)
```

[104]:
```python
# Principal components
pca.components_
```

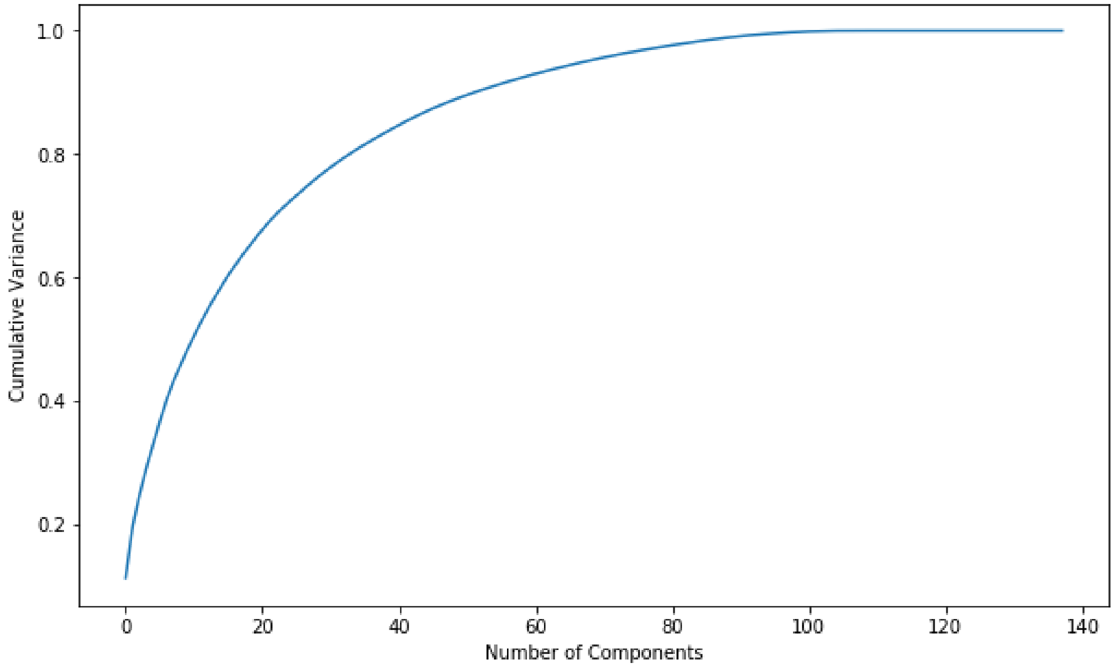
[104]:
```
array([[-7.50315936e-20,  4.16333634e-17,  1.11022302e-16, …,
         -2.59799614e-02, -2.57740516e-02,  1.40032998e-02],
        [-1.61507486e-19, -5.55111512e-17,  0.00000000e+00, …,
         -1.16737642e-02, -9.94022864e-03, -1.42598315e-02],
        [ 1.91332162e-19, -2.77555756e-17,  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]])
```

[105]:
```python
# 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.        ]
```

[106]:
```python
# Plotting scree plot
fig = plt.figure(figsize = (10,6))
plt.plot(variance_cumu)
plt.xlabel('Number of Components')
plt.ylabel('Cumulative Variance')
```

[106]: 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

[107]:
```
# Importing incremental PCA
from sklearn.decomposition import IncrementalPCA
```

[108]:
```
# Instantiate PCA with 60 components
pca_final = IncrementalPCA(n_components=60)
```

[109]:
```
# 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.

[110]:
```
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.

2.1 Logistic regression with PCA

[111]:
```
# Importing scikit logistic regression module
from sklearn.linear_model import LogisticRegression
```

[112]:
```
# 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.

[113]:
```
# 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
```

[114]:
```
# 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
```

[114]:
```
GridSearchCV(cv=KFold(n_splits=5, random_state=4, shuffle=True),
             error_score=nan,
             estimator=LogisticRegression(C=1.0, class_weight=None, dual=False,
```

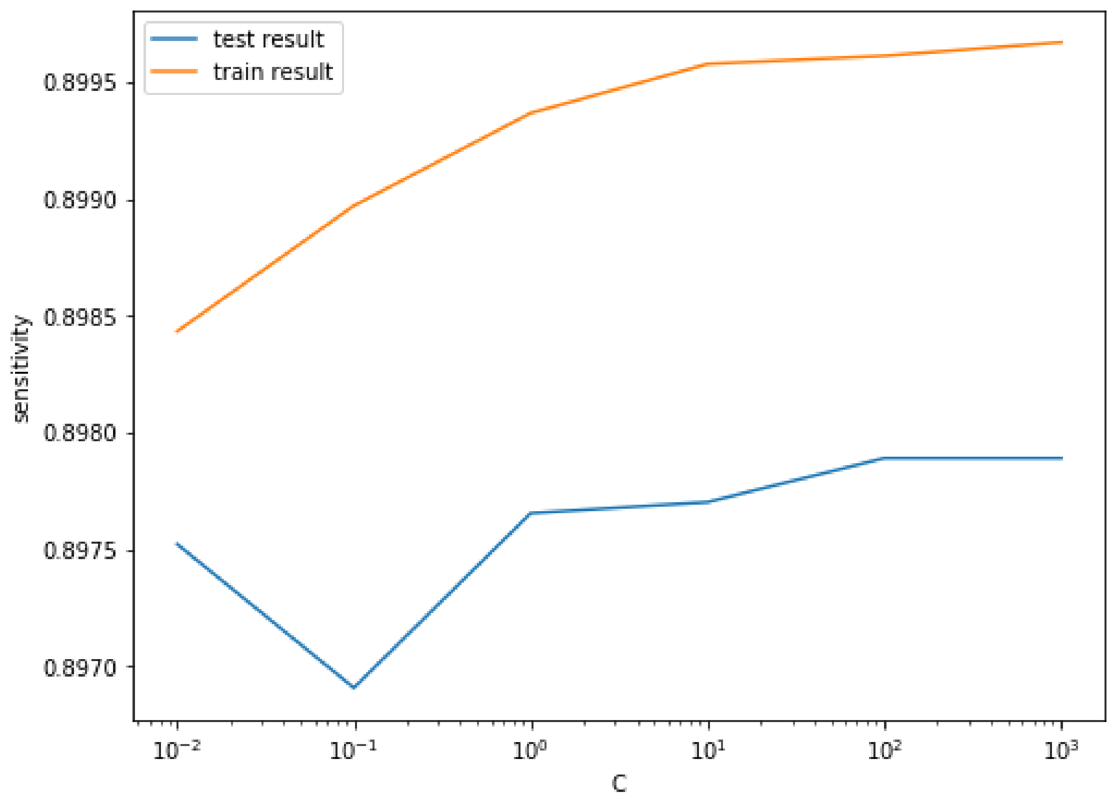
```
                                            fit_intercept=True,
                                            intercept_scaling=1, l1_ratio=None,
                                            max_iter=100, multi_class='auto',
                                            n_jobs=None, penalty='l2',
                                            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)
```

[115]:
```
# results of grid search CV
cv_results = pd.DataFrame(model_cv.cv_results_)
cv_results
```

[115]:
```
   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
```

[117]:
```
# 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')
```



[119]:
```
# 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

[120]:
```
# Instantiate the model with best C
logistic_pca = LogisticRegression(C=best_C)
```

[121]:
```
# Fit the model on the train set
log_pca_model = logistic_pca.fit(X_train_pca, y_train)
```

Prediction on the train set

[122]:
```
# Predictions on the train set
y_train_pred = log_pca_model.predict(X_train_pca)
```

[123]:
```
# Confusion matrix
confusion = metrics.confusion_matrix(y_train, y_train_pred)
print(confusion)
```

```
[[17908  3517]
 [ 2154 19271]]
```

[124]:
```
TP = confusion[1,1] # true positive
TN = confusion[0,0] # true negatives
FP = confusion[0,1] # false positives
FN = confusion[1,0] # false negatives
```

[125]:
```
# 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

[126]:
```
# Prediction on the test set
y_test_pred = log_pca_model.predict(X_test_pca)
```

[127]:
```
# Confusion matrix
confusion = metrics.confusion_matrix(y_test, y_test_pred)
print(confusion)
```

```
[[4452  896]
 [  36  157]]
```

[128]:
```
TP = confusion[1,1] # true positive
TN = confusion[0,0] # true negatives
FP = confusion[0,1] # false positives
FN = confusion[1,0] # false negatives
```

[129]:
```
# Accuracy
print("Accuracy:-",metrics.accuracy_score(y_test, y_test_pred))

# Sensitivity
print("Sensitivity:-",TP / float(TP+FN))
```

```python
# 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.

2.2 Support Vector Machine(SVM) with PCA

[130]:
```python
# Importing SVC
from sklearn.svm import SVC
```

Hyperparameter tuning C:- Regularization parameter.

gamma:- Handles non linear classifications.

[131]:
```python
# 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
```

[131]:
```
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)
```

[132]:
```python
# cv results
cv_results = pd.DataFrame(model_cv.cv_results_)
cv_results
```

[132]:

	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

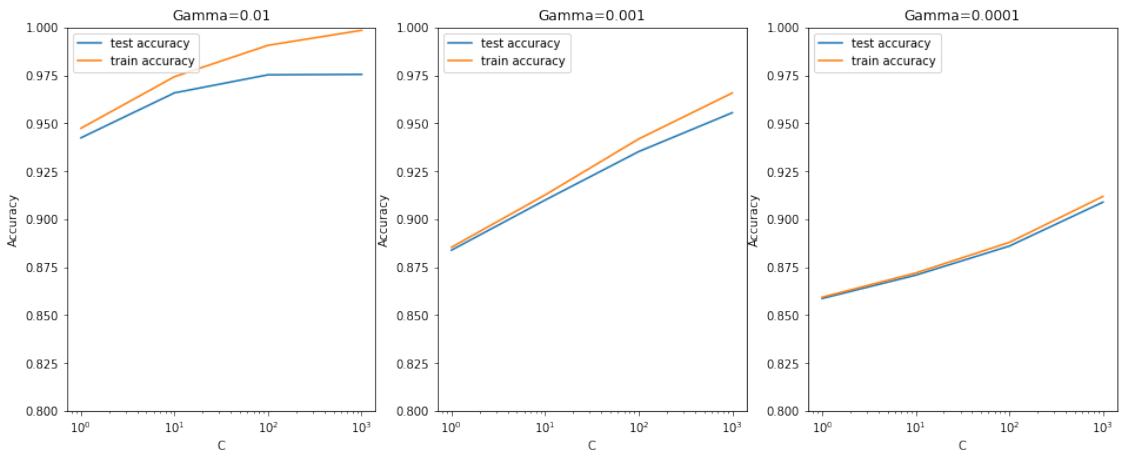
	param_gamma	params	split0_test_score
0	0.01	{'C': 1, 'gamma': 0.01}	0.944903
1	0.001	{'C': 1, 'gamma': 0.001}	0.883366
2	0.0001	{'C': 1, 'gamma': 0.0001}	0.858513
3	0.01	{'C': 10, 'gamma': 0.01}	0.967096
4	0.001	{'C': 10, 'gamma': 0.001}	0.910459
5	0.0001	{'C': 10, 'gamma': 0.0001}	0.870414
6	0.01	{'C': 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

[133]:

```
# 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')
```



[201]:
```
# 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

[134]:
```
# 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)
```

[134]:
```
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

[135]:
```python
# Predictions on the train set
y_train_pred = svm_pca_model.predict(X_train_pca)
```

[136]:
```python
# Confusion matrix
confusion = metrics.confusion_matrix(y_train, y_train_pred)
print(confusion)
```

```
[[18376  3049]
 [ 1585 19840]]
```

[137]:
```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
```

[138]:
```python
# 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:- 0.891855309218203
Sensitivity:- 0.9260210035005835
Specificity:- 0.8576896149358226
```

Prediction on the test set

[139]:
```python
# Prediction on the test set
y_test_pred = svm_pca_model.predict(X_test_pca)
```

[140]:
```python
# Confusion matrix
confusion = metrics.confusion_matrix(y_test, y_test_pred)
print(confusion)
```

```
[[4557  791]
 [  36  157]]
```

[141]:
```
TP = confusion[1,1] # true positive
TN = confusion[0,0] # true negatives
FP = confusion[0,1] # false positives
FN = confusion[1,0] # false negatives
```

[142]:
```
# 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

2.3 Decision tree with PCA

[143]:
```
# Importing decision tree classifier
from sklearn.tree import DecisionTreeClassifier
```

Hyperparameter tuning

[144]:
```
# 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
```

[144]:
```
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)
```

[145]:
```
# cv results
cv_results = pd.DataFrame(grid_search.cv_results_)
cv_results
```

[145]:
```
   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
```

[146]:
```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

[147]:
```
# 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)
```

[147]:
```
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

[148]:
```
# Predictions on the train set
y_train_pred = dt_pca_model.predict(X_train_pca)
```

[149]:
```
# Confusion matrix
confusion = metrics.confusion_matrix(y_train, y_train_pred)
print(confusion)
```

```
[[18913  2512]
 [ 1763 19662]]
```

[150]:
```
TP = confusion[1,1] # true positive
TN = confusion[0,0] # true negatives
FP = confusion[0,1] # false positives
FN = confusion[1,0] # false negatives
```

[151]:
```
# 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

[152]:
```python
# Prediction on the test set
y_test_pred = dt_pca_model.predict(X_test_pca)
```

[153]:
```python
# Confusion matrix
confusion = metrics.confusion_matrix(y_test, y_test_pred)
print(confusion)
```

```
[[4632  716]
 [  58  135]]
```

[154]:
```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
```

[155]:
```python
# 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.

2.4 Random forest with PCA

[156]:
```python
# Importing random forest classifier
from sklearn.ensemble import RandomForestClassifier
```

Hyperparameter tuning

[157]:
```python
param_grid = {
    'max_depth': range(5,10,5),
    'min_samples_leaf': range(50, 150, 50),
    'min_samples_split': range(50, 150, 50),
    '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
```

[157]:
```
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)
```

[158]:
```
# 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

[159]:
```
# 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)
```

[160]:
```
# Fit the model
rfc_model.fit(X_train_pca, y_train)
```

[160]:
```
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

[161]:
```
# Predictions on the train set
y_train_pred = rfc_model.predict(X_train_pca)
```

[162]:
```
# Confusion matrix
confusion = metrics.confusion_matrix(y_train, y_train_pred)
print(confusion)
```

```
[[17363  4062]
 [ 2419 19006]]
```

[163]:
```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
```

[164]:
```python
# 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

[165]:
```python
# Prediction on the test set
y_test_pred = rfc_model.predict(X_test_pca)
```

[166]:
```python
# Confusion matrix
confusion = metrics.confusion_matrix(y_test, y_test_pred)
print(confusion)
```

```
[[4294 1054]
 [  47  146]]
```

[167]:
```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
```

[168]:
```python
# 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.

2.4.1 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%.

3 Without PCA

3.1 Logistic regression with No PCA

[169]:
```
##### Importing stats model
import statsmodels.api as sm
```

[170]:
```
# 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())
```

[171]:
```
# Fit the model
log_no_pca = log_no_pca.fit().summary()
```

[172]:
```
# Summary
log_no_pca
```

[172]:
```
<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).

3.1.1 Feature Selection Using RFE

[173]:
```python
# Importing logistic regression from sklearn
from sklearn.linear_model import LogisticRegression
# Intantiate the logistic regression
logreg = LogisticRegression()
```

RFE with 15 columns

[174]:
```python
# 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)
```

[175]:
```python
# 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')
```

3.1.2 Model-1 with RFE selected columns

[176]:
```
# 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()
```

[176]:
```
<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

[177]:
```python
# Check for the VIF values of the feature variables.
from statsmodels.stats.outliers_influence import variance_inflation_factor
```

[178]:
```python
# 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
```

[178]:

	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

[179]:
```
# 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']
```

3.1.3 Model-2

Building the model after removing og_others_8 variable.

[180]:
```
# 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()
```

[180]:
```
<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

[181]:
```python
# 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
```

[181]:

```
                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.

[182]:

```
# Removing offnet_mou_8 column
log_cols.remove('offnet_mou_8')
```

3.1.4 Model-3

Model after removing offnet_mou_8 column.

[183]:

```
# 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()
```

[183]:

```
<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

```
[184]: 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
```

```
[184]:               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***.

3.1.5 Model performance on the train set

```
[185]: # 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()
```

```
[185]: 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

```
[186]: 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.
```

```python
y_train_pred_final['CustID'] = y_train_pred_final.index

y_train_pred_final.head()
```

[186]:

	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

[187]:
```python
# 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()
```

[187]:

	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

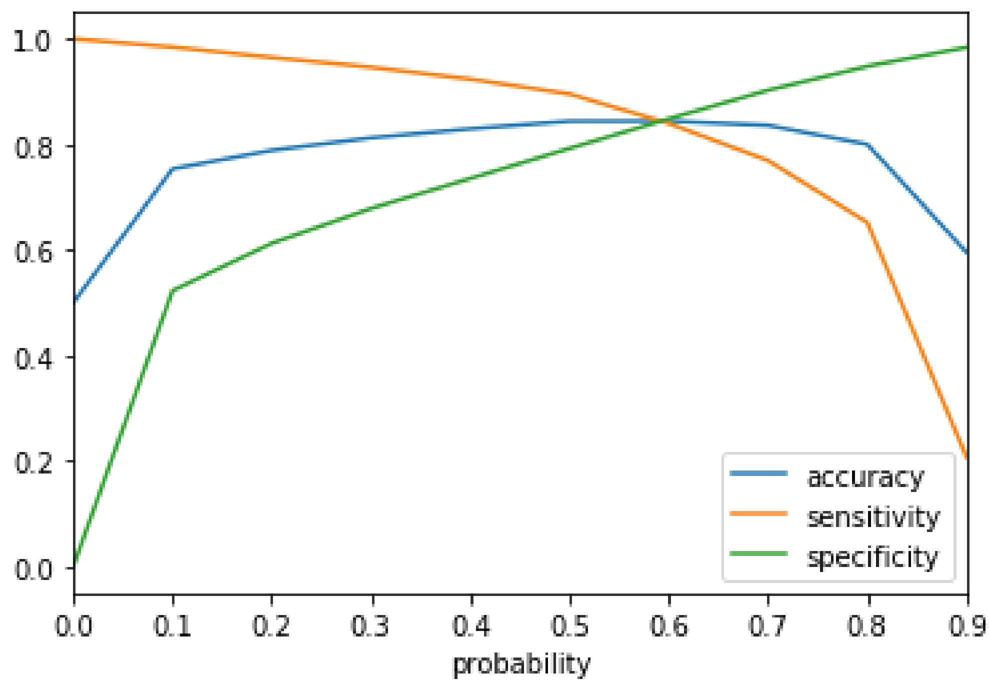
Now let's calculate the accuracy sensitivity and specificity for various probability cutoffs.

[188]:
```python
# 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
```

[189]:
```
# 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.

[190]:
```
# 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()
```

[190]:
```
   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

[191]:
```
# Confusion metrics
confusion = metrics.confusion_matrix(y_train_pred_final['churn'],␣
↪y_train_pred_final['predicted'])
print(confusion)
```

```
[[16978  4447]
 [ 2232 19193]]
```

[192]:
```
TP = confusion[1,1] # true positive
TN = confusion[0,0] # true negatives
FP = confusion[0,1] # false positives
FN = confusion[1,0] # false negatives
```

[193]:
```
# Accuracy
print("Accuracy:-",metrics.accuracy_score(y_train_pred_final['churn'],␣
↪y_train_pred_final['predicted']))
```

```python
# Sensitivity
print("Sensitivity:-",TP / float(TP+FN))

# Specificity
print("Specificity:-", TN / float(TN+FP))
```

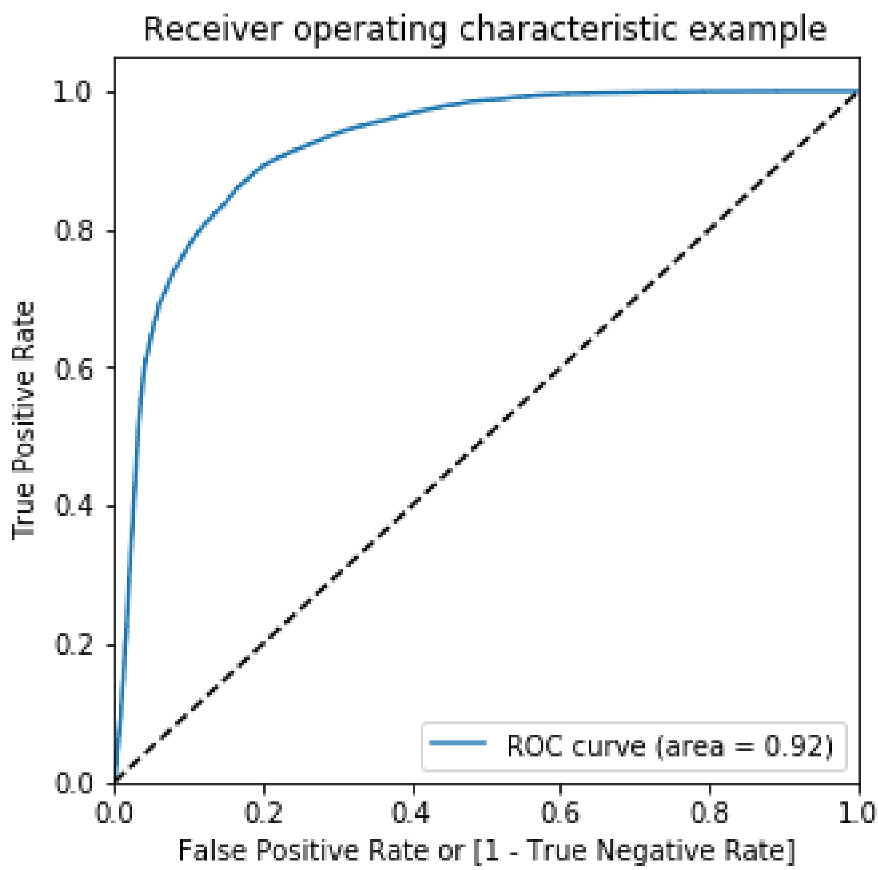
```
Accuracy:- 0.8441306884480747
Sensitivity:- 0.8958226371061844
Specificity:- 0.792438739789965
```

We have got good accuracy, sensitivity and specificity on the train set prediction.

Plotting the ROC Curve (Trade off between sensitivity & specificity)

[194]:
```python
# 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
```

[195]:
```python
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.

3.1.6 Testing the model on the test set

[196]:
```
# Taking a copy of the test set
X_test_log = X_test.copy()
```

[198]:
```
# 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]
```

[199]:
```
# Adding constant on the test set
X_test_sm = sm.add_constant(X_test_log)
```

Predictions on the test set with final model

[200]:
```
# Predict on the test set
y_test_pred = log_no_pca_3.predict(X_test_sm)
```

[201]:
```
y_test_pred.head()
```

[201]:
```
5704     0.034015
64892    0.000578
39613    0.513564
93118    0.020480
81235    0.034115
dtype: float64
```

[202]:
```
# 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()
```

[202]:

	0
5704	0.034015
64892	0.000578
39613	0.513564
93118	0.020480
81235	0.034115

[203]:
```
# Convetting y_test to a dataframe
y_test_df = pd.DataFrame(y_test)
y_test_df.head()
```

[203]:

	churn
5704	0
64892	0
39613	0
93118	0
81235	0

[204]:
```
# Putting index to Customer ID
y_test_df['CustID'] = y_test_df.index
```

[205]:
```
# 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)
```

[206]:
```
# Appending y_pred_1 and y_test_df
y_test_pred_final = pd.concat([y_test_df, y_pred_1], axis=1)
```

[207]:
```
y_test_pred_final.head()
```

[207]:

	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

[208]:
```python
# Renaming the '0' column as churn probablity
y_test_pred_final = y_test_pred_final.rename(columns={0:'churn_prob'})
```

[209]:
```python
# Rearranging the columns
y_test_pred_final = y_test_pred_final.
↪reindex_axis(['CustID','churn','churn_prob'], axis=1)
```

[210]:
```python
y_test_pred_final.head()
```

[210]:

	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

[211]:
```python
# 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)
```

[212]:
```python
y_test_pred_final.head()
```

[212]:

	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

[214]:
```python
# Confusion matrix
confusion = metrics.confusion_matrix(y_test_pred_final['churn'],␣
↪y_test_pred_final['test_predicted'])
print(confusion)
```

```
[[4190 1158]
 [  34  159]]
```

[215]:
```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
```

[216]:
```python
# 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.

3.2 Business recomendation

Top predictors Below are few top variables selected in the logistic regression model.

Variables	Coefficients
loc_ic_mou_8	-3.3287
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.:-

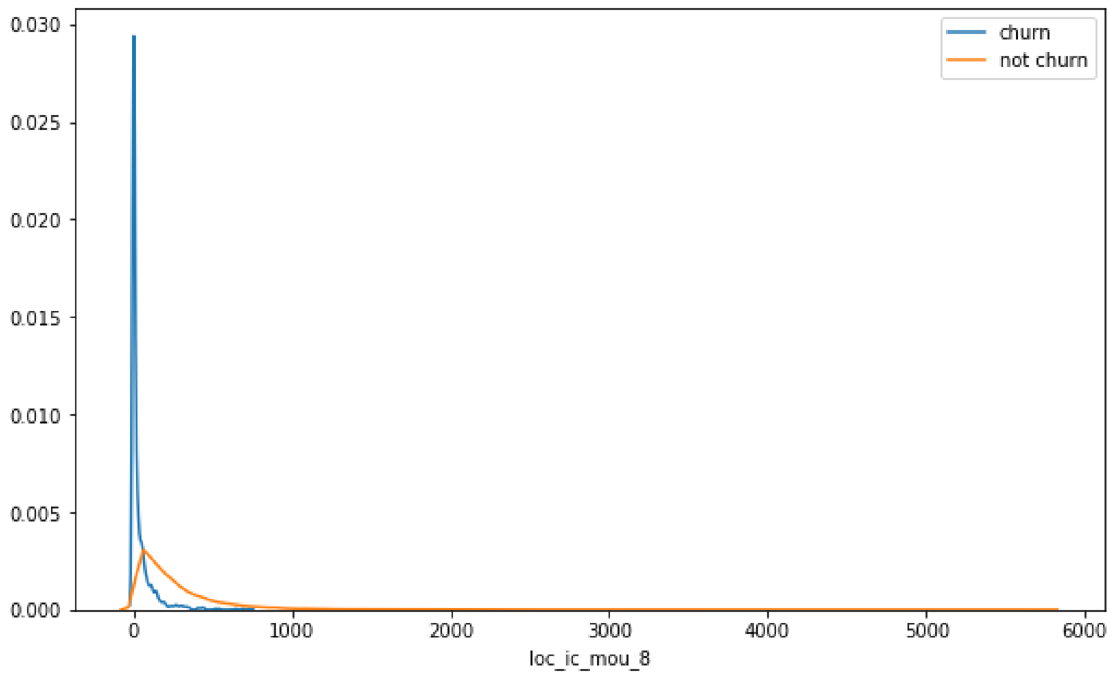
If the local incoming minutes of usage (loc_ic_mou_8) is lesser in the month of August than any other month, then there is a higher chance that the customer is likely to churn.

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.

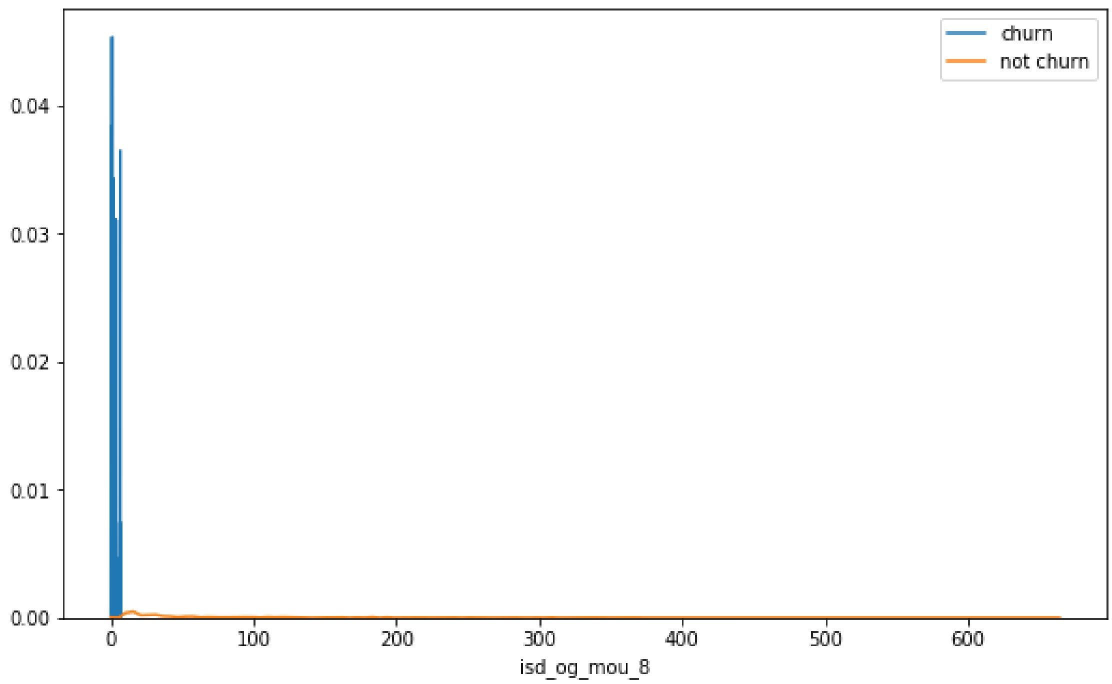
Plots of important predictors for churn and non churn customers

[217]:
```
# 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()
```



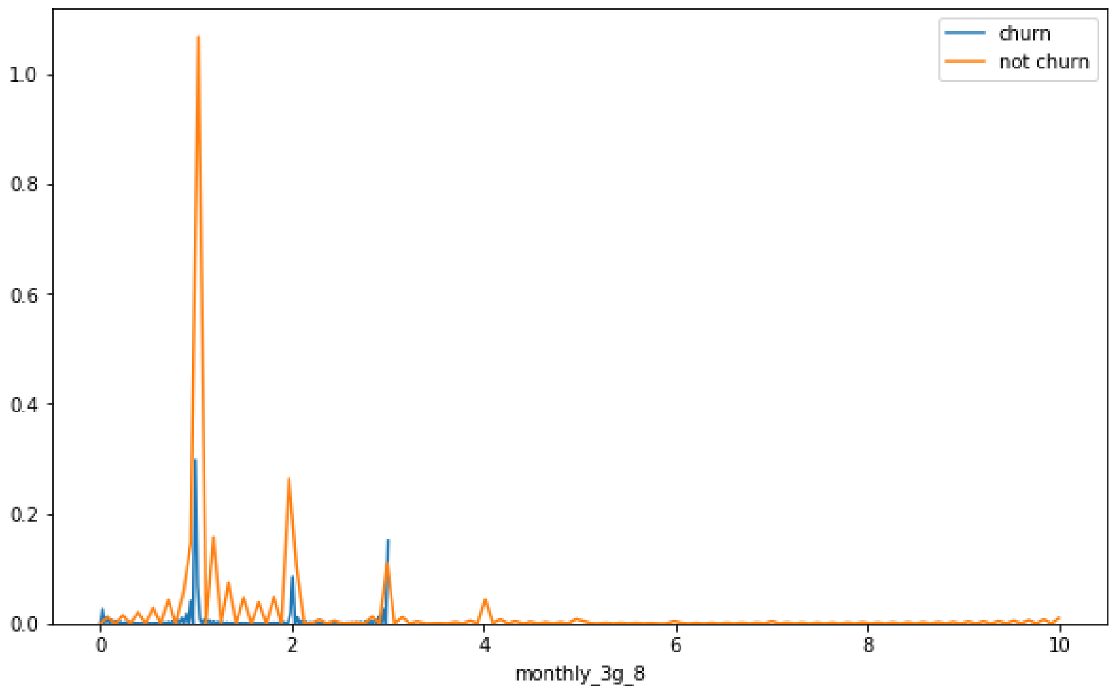
We can see that for the churn customers the minutes of usage for the month of August is mostly populated on the lower side than the non churn customers.

[218]:
```
# 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.

[219]:
```
# 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.