Prison DataSet

May 9, 2017

1 Predicting Recidivsm using Machine Learning

Done By: Sahil Phule and Pooja Katte

```
In [229]: %matplotlib inline
          import mpld3
          mpld3.enable_notebook()

In [230]: from pylab import rcParams
          rcParams['figure.figsize'] = 12, 5

In [9]: df_pa = spark.read.option("delimiter","\t").option("header","true") \
            .csv("/project/data/ICPSR_36404/pris_admis/36404-0002-Data.tsv")

In [10]: df_tr = spark.read.option("delimiter","\t").option("header","true") \
             .csv("/project/data/ICPSR_36404/term_rec/36404-0001-Data.tsv")

In [11]: df_pr = spark.read.option("delimiter","\t").option("header","true") \
             .csv("/project/data/ICPSR_36404/pris_rel/36404-0003-Data.tsv")

In [12]: df_yep = spark.read.option("delimiter","\t").option("header","true") \
             .csv("/project/data/ICPSR_36404/year_end_pop/36404-0004-Data.tsv")

In [13]: df_tr.createOrReplaceTempView("term_rec")

In [14]: spark.sql("select * from term_rec limit 1")

Out[14]: DataFrame[ABT_INMATE_ID: string, SEX: string, ADMTYPE: string, OFFGENERAL: string, EDUC

In [15]: spark.sql("select count(*) from term_rec").show()

+--------+
|count(1)|
+--------+
|10907333|
+--------+
```

2 Counting values and plotting graph

2.1 In term records

2.1.1 For ADMTYPE

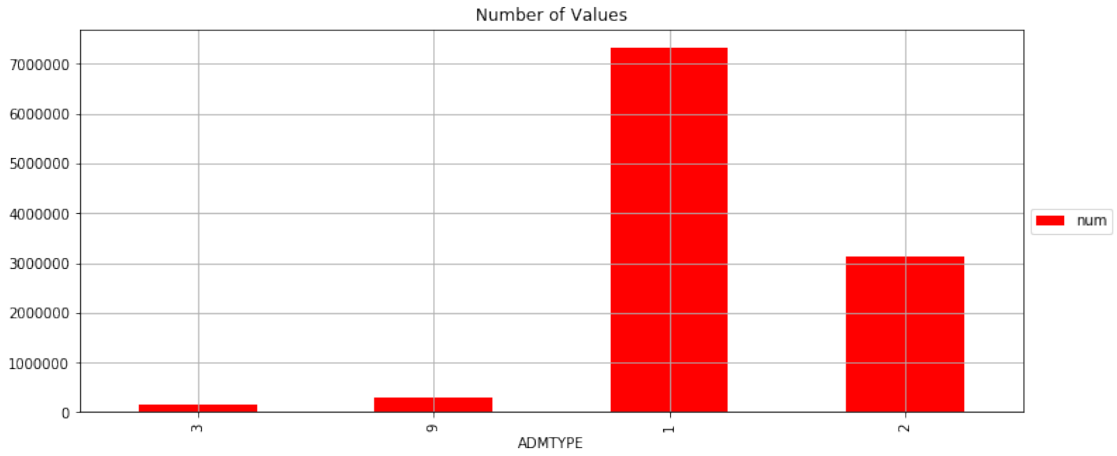
```
In [16]: spark.sql("select ADMTYPE, count(1)as num from term_rec group by ADMTYPE ").show()
```

```
+-------+-------+
|ADMTYPE|    num|
+-------+-------+
|      3| 140478|
|      9| 295414|
|      1|7331789|
|      2|3139652|
+-------+-------+
```

```
In [144]: admtype = spark.sql("select ADMTYPE, count(1)as num from term_rec group by ADMTYPE ").

In [145]: admtype
```

```
Out[145]:   ADMTYPE      num
          0       3   140478
          1       9   295414
          2       1  7331789
          3       2  3139652
```

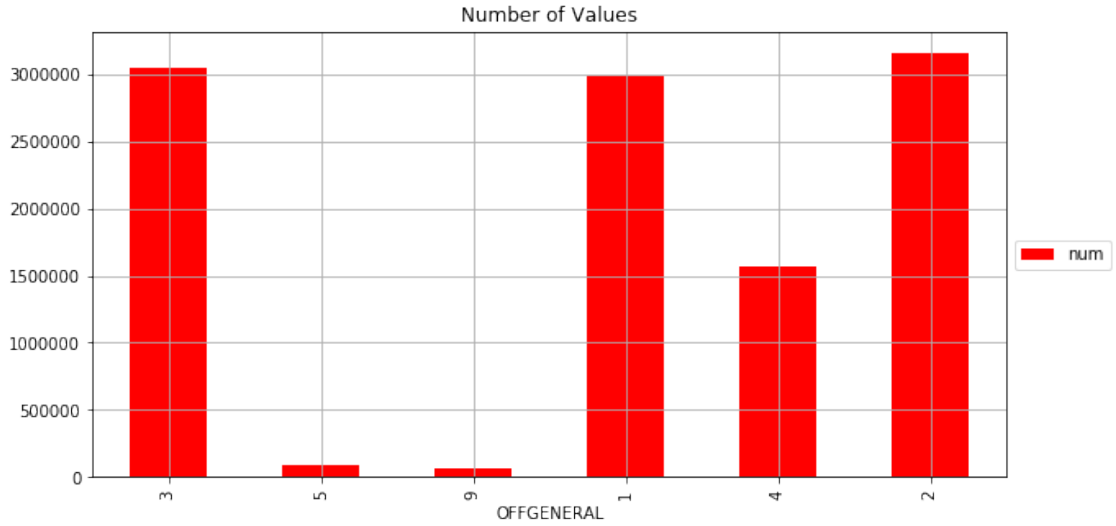
```
In [231]: admtype.plot(x=admtype.columns[0], kind='bar', color='Red', title="Number of Values",

Out[231]: <matplotlib.legend.Legend at 0x7f5ae2e90278>
```



Missing Values are: 295414

2.1.2 For OFFGENERAL

```
In [20]: offgeneral = spark.sql("select OFFGENERAL, count(1)as num from term_rec group by OFFGEN

In [21]: offgeneral

Out[21]:   OFFGENERAL      num
         0           3  3044926
         1           5    87010
         2           9    71108
         3           1  2984039
         4           4  1561247
         5           2  3159003

In [22]: offgeneral.plot(x=offgeneral.columns[0], kind='bar', color='Red', title="Number of Valu

Out[22]: <matplotlib.legend.Legend at 0x7f5af36c9c18>
```



Missing Value are 71108

2.1.3 For EDUCATION

```
In [23]: education = spark.sql("select EDUCATION, count(1)as num from term_rec group by EDUCATIO

In [24]: education

Out[24]:   EDUCATION      num
         0         9  10907333
```

All the education values are missing

2.1.4 For ADMITYR

```
In [25]: admityr = spark.sql("select ADMITYR, count(1)as num from term_rec group by ADMITYR orde

In [26]: admityr
```

Out[26]:

	ADMITYR	num
0	1950	22
1	1951	25
2	1952	40
3	1953	22
4	1954	36
5	1955	21
6	1956	35
7	1957	37
8	1958	61
9	1959	67
10	1960	69
11	1961	94
12	1962	141
13	1963	217
14	1964	199
15	1965	291
16	1966	463
17	1967	606
18	1968	943
19	1969	1464
20	1970	2823
21	1971	5934
22	1972	6151
23	1973	6639
24	1974	7562
25	1975	8869
26	1976	7870
27	1977	8679
28	1978	8782
29	1979	9365
..	...	...
36	1986	27872
37	1987	34821
38	1988	44532
39	1989	66018
40	1990	85823
41	1991	131862
42	1992	175771
43	1993	198047
44	1994	220846
45	1995	239064
46	1996	253978

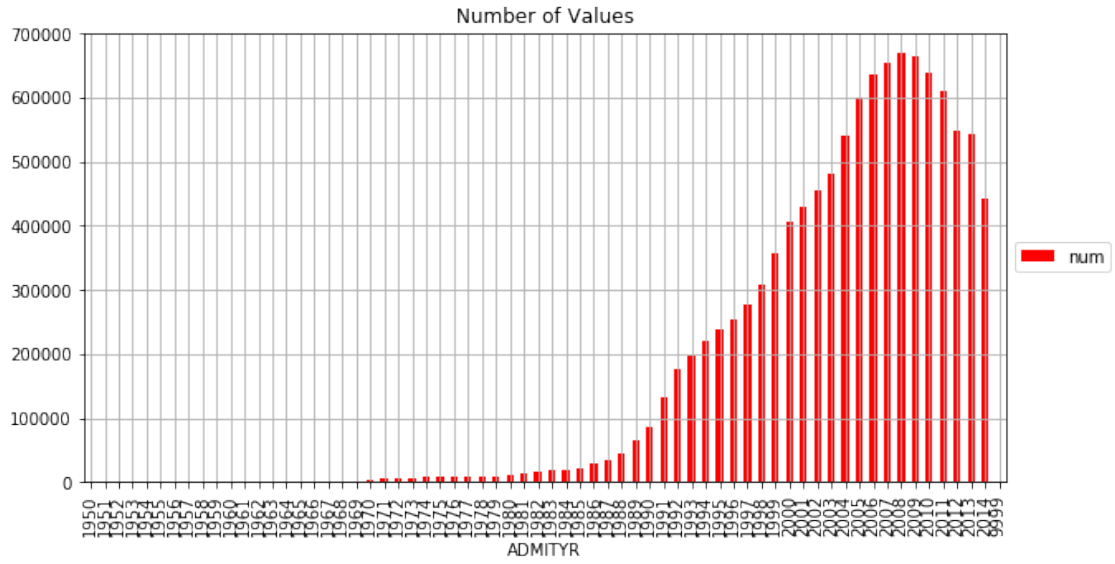
```
47    1997  277395
48    1998  307713
49    1999  355979
50    2000  406433
51    2001  428164
52    2002  454643
53    2003  480289
54    2004  540189
55    2005  599517
56    2006  635266
57    2007  652384
58    2008  667859
59    2009  663952
60    2010  639264
61    2011  610835
62    2012  547109
63    2013  541763
64    2014  442238
65    9999     496

[66 rows x 2 columns]
```

```
In [27]: admityr.columns[1]
```

```
Out[27]: 'num'
```

```
In [28]: admityr.plot(x=admityr.columns[0], kind='bar', color='Red', title="Number of Values", g
```

```
Out[28]: <matplotlib.legend.Legend at 0x7f5af0da65f8>
```



```
In [29]: admityr.loc[admityr['ADMITYR']=='9999']
```

```
Out[29]:    ADMITYR  num
         65    9999  496
```

Missing Values are 496

2.1.5 For RELEASEYR

```
In [30]: releaseyr = spark.sql("select RELEASEYR, count(1)as num from term_rec group by RELEASEY
```

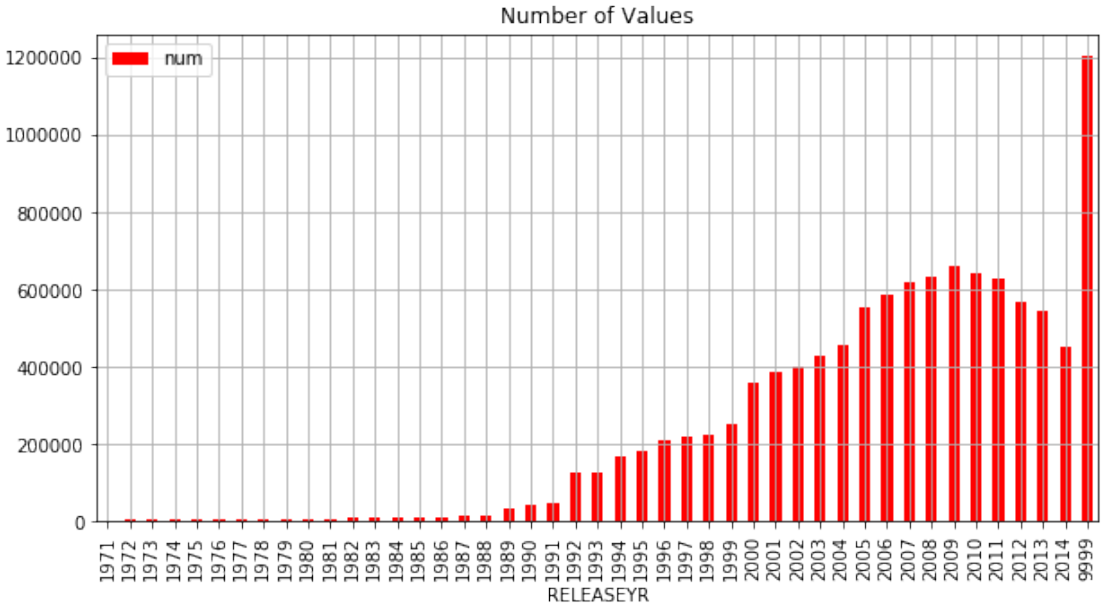
```
In [31]: releaseyr
```

```
Out[31]:    RELEASEYR      num
         0       1971     3560
         1       1972     5388
         2       1973     5199
         3       1974     5842
         4       1975     6263
         5       1976     6101
         6       1977     6616
         7       1978     7280
         8       1979     6097
         9       1980     7832
         10      1981     7952
         11      1982     8724
         12      1983    10832
         13      1984    11420
         14      1985    11906
         15      1986    12626
         16      1987    13950
         17      1988    13106
         18      1989    36109
         19      1990    44569
         20      1991    45571
         21      1992   125984
         22      1993   127135
         23      1994   170061
         24      1995   183847
         25      1996   211459
         26      1997   221267
         27      1998   224996
         28      1999   252509
         29      2000   360524
         30      2001   387361
         31      2002   399387
         32      2003   426085
         33      2004   454785
         34      2005   555016
```

```
35      2006   585194
36      2007   617222
37      2008   631928
38      2009   659168
39      2010   641632
40      2011   626805
41      2012   568810
42      2013   545792
43      2014   452537
44      9999  1200886
```

In [32]:
```
releaseyr.plot(x=releaseyr.columns[0], kind='bar', color='Red', title="Number of Values
```

```
---------------------------------------------------------------------------

AttributeError                            Traceback (most recent call last)

<ipython-input-32-14a50af1af09> in <module>()
----> 1 releaseyr.plot(x=releaseyr.columns[0], kind='bar', color='Red', title="Number of Val


AttributeError: 'AxesSubplot' object has no attribute 'figsize'
```



In [ ]:
```
releaseyr.loc[releaseyr['RELEASEYR']=='9999']
```

2.1.6 For MAND_PRISREL_YEAR

```
In [ ]: mand_prisrel_year = releaseyr = spark.sql("select MAND_PRISREL_YEAR, count(1)as num from

In [ ]: mand_prisrel_year

In [ ]: mand_prisrel_year.plot(x=mand_prisrel_year.columns[0], kind='bar', color='Red', title="N

In [ ]:
```

2.1.7 For PROJ_PRISREL_YEAR

```
In [33]: proj_prisrel_year = releaseyr = spark.sql("select PROJ_PRISREL_YEAR, count(1)as num fro

In [34]: proj_prisrel_year
```

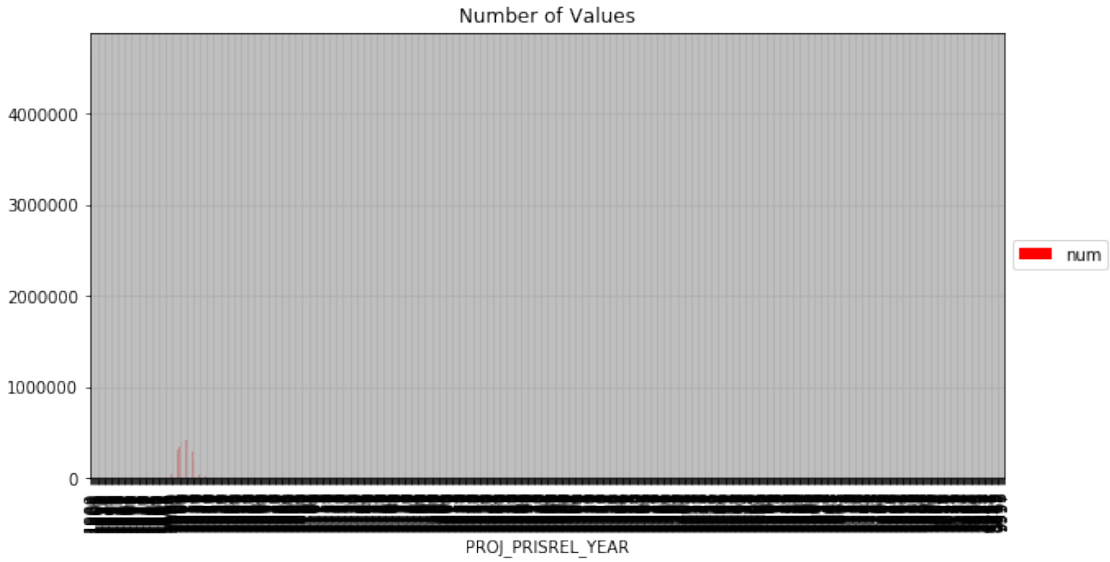
Out[34]:

	PROJ_PRISREL_YEAR	num
0		4662333
1	1900	1
2	1904	1
3	1905	2
4	1906	1
5	1907	2
6	1908	2
7	1909	9
8	1910	8
9	1913	1
10	1930	1
11	1937	1
12	1940	1
13	1945	1
14	1948	1
15	1949	1
16	1950	1
17	1953	1
18	1955	7
19	1956	5
20	1957	2
21	1958	10
22	1959	7
23	1960	6
24	1961	3
25	1962	3
26	1963	3
27	1964	1
28	1966	3
29	1967	2
..	...	...
662	3333	16

```
663              3369        1
664              3393        1
665              3465        1
666              3478        1
667              3483        1
668              3494        1
669              3497        1
670              3500        1
671              3501        1
672              3508        1
673              3509        1
674              3522        1
675              3779        1
676              3853        1
677              3974        2
678              4001        1
679              4019        1
680              4343        1
681              4654        1
682              4978        1
683              4997        1
684              5001        1
685              5245        1
686              5479        1
687              5555        5
688              7777      179
689              9993      526
690              9996      957
691              9997       84

[692 rows x 2 columns]
```

```
In [35]: proj_prisrel_year.plot(x=proj_prisrel_year.columns[0], kind='bar', color='Red', title="
```

```
Out[35]: <matplotlib.legend.Legend at 0x7f5af01fb908>
```



2.1.8 for PARELIG_YEAR

```
In [36]: parelig_year = spark.sql("select PARELIG_YEAR, count(1)as num from term_rec group by PA

In [37]: parelig_year
```

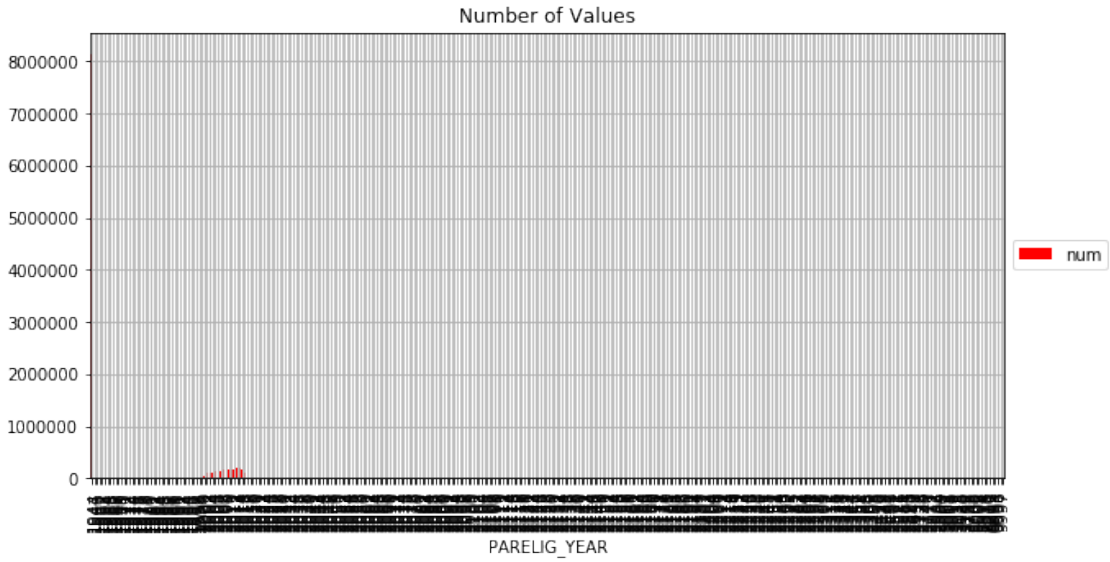
Out[37]:

	PARELIG_YEAR	num
0		8148769
1	1944	1
2	1947	1
3	1960	1
4	1962	1
5	1963	2
6	1964	3
7	1965	1
8	1966	5
9	1967	5
10	1968	9
11	1969	6
12	1970	14
13	1971	22
14	1972	26
15	1973	39
16	1974	27
17	1975	61
18	1976	69
19	1977	68
20	1978	101
21	1979	116

```
22          1980      172
23          1981      215
24          1982      265
25          1983      303
26          1984      351
27          1985      417
28          1986      725
29          1987     1379
..           ...      ...
310         2739        1
311         2740        3
312         2777        1
313         2911        1
314         2912        1
315         2986        1
316         2994        1
317         3000      100
318         3001        7
319         3003        4
320         3005        1
321         3010        1
322         3013        2
323         3023        2
324         3025        1
325         3180        1
326         3288        1
327         3733        1
328         3745        1
329         5000      246
330         5005        1
331         5008        1
332         5014        1
333         7378        9
334         8010        1
335         8201        1
336         8999        1
337         9993     5596
338         9996        2
339         9997       99

[340 rows x 2 columns]
```

```
In [38]: parelig_year.plot(x=parelig_year.columns[0], kind='bar', color='Red', title="Number of
```

```
Out[38]: <matplotlib.legend.Legend at 0x7f5aeaeb96a0>
```



2.1.9 For SENTLGTH

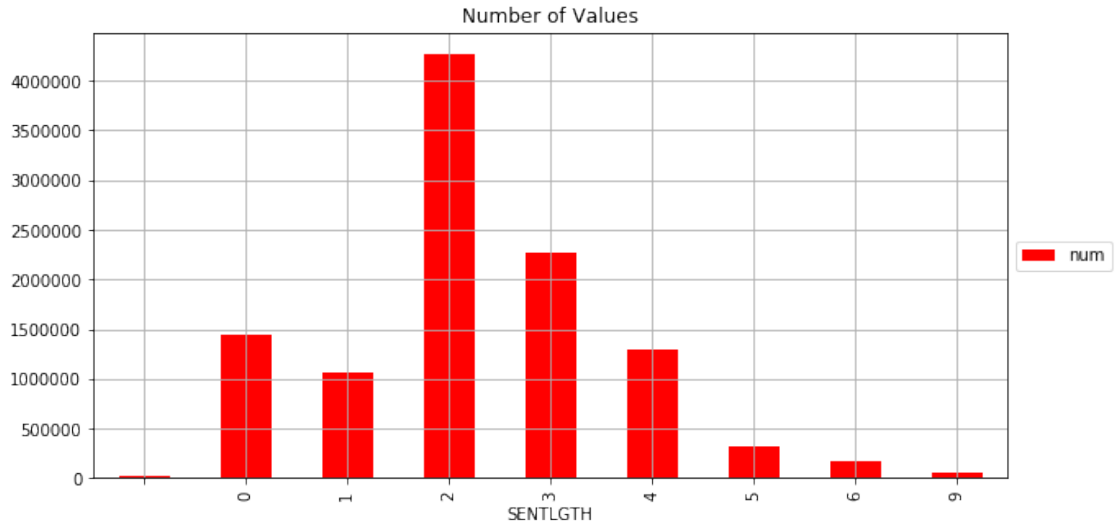
```
In [39]: sentlgth = spark.sql("select SENTLGTH, count(1)as num from term_rec group by SENTLGTH o

In [40]: sentlgth
```

Out[40]:

	SENTLGTH	num
0		20063
1	0	1442194
2	1	1057800
3	2	4274803
4	3	2271497
5	4	1287790
6	5	324961
7	6	173756
8	9	54469

```
In [41]: sentlgth.plot(x=sentlgth.columns[0], kind='bar', color='Red', title="Number of Values",
```

```
Out[41]: <matplotlib.legend.Legend at 0x7f5aea2a8780>
```



Missing values are 20063 + 54469 = 74532

2.1.10 For OFFDETAIL

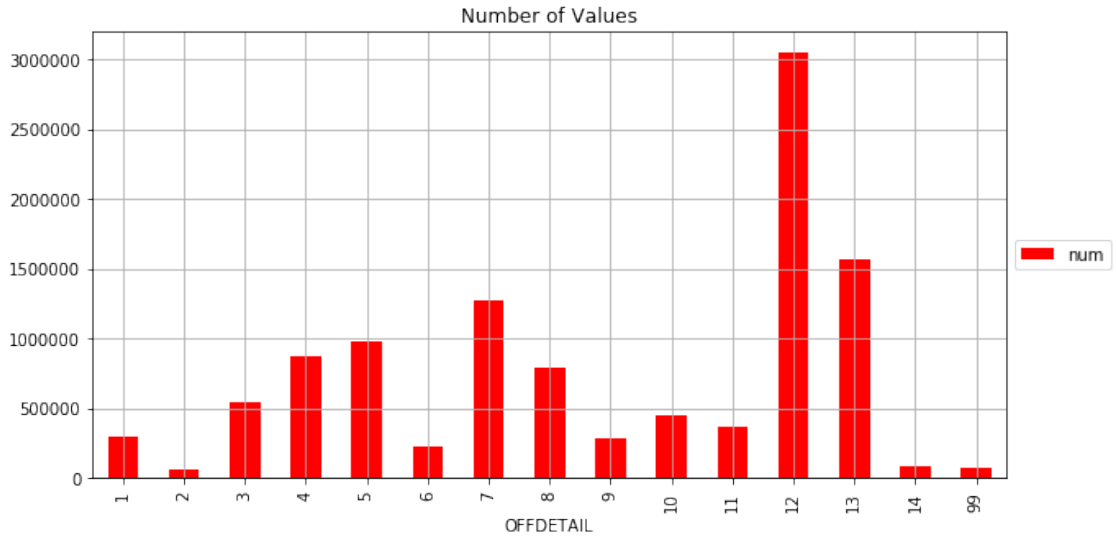
```
In [42]: offdetail = spark.sql("select OFFDETAIL, count(1)as num from term_rec group by OFFDETAI
```

```
In [43]: offdetail
```

```
Out[43]:    OFFDETAIL      num
         0          1   299288
         1          2    64662
         2          3   545237
         3          4   875687
         4          5   971245
         5          6   227920
         6          7  1270749
         7          8   786043
         8          9   287965
         9         10   444212
         10        11   370034
         11        12  3044926
         12        13  1561247
         13        14    87010
         14        99    71108
```

```
In [44]: offdetail.plot(x=offdetail.columns[0], kind='bar', color='Red', title="Number of Values
```

```
Out[44]: <matplotlib.legend.Legend at 0x7f5ae998ec18>
```



Missing value are: 71108

2.1.11 For RACE

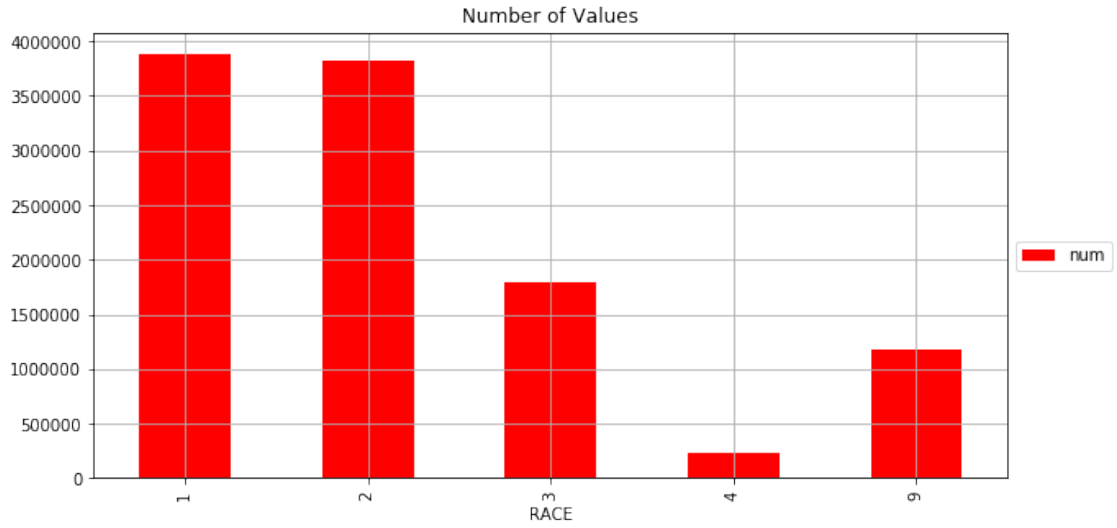
```
In [45]: race = spark.sql("select RACE, count(1)as num from term_rec group by RACE order by RACE
```

```
In [46]: race
```

```
Out[46]:   RACE      num
         0     1  3886774
         1     2  3820429
         2     3  1795022
         3     4   224126
         4     9  1180982
```

```
In [47]: race.plot(x=race.columns[0], kind='bar', color='Red', title="Number of Values", grid=Tr
```

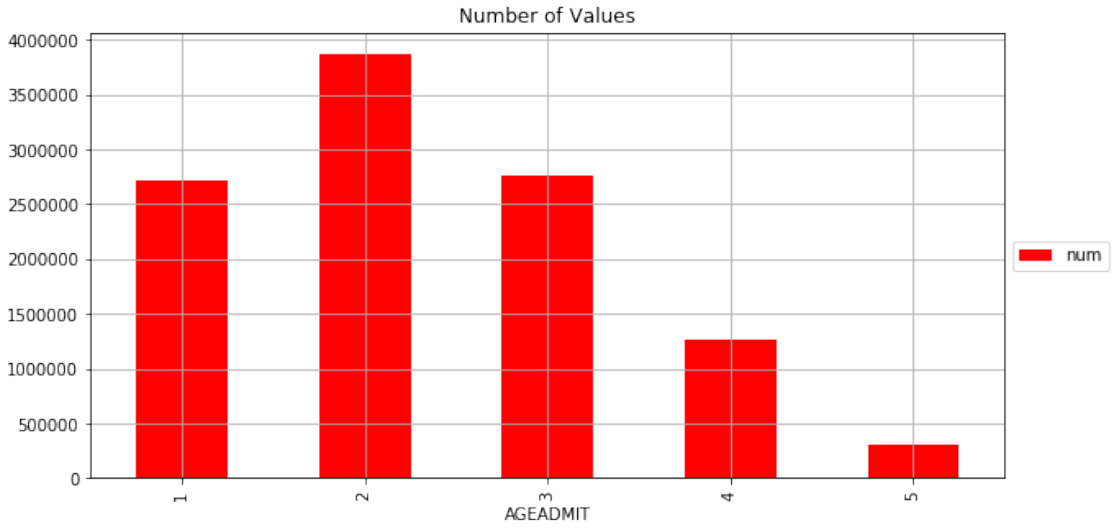
```
Out[47]: <matplotlib.legend.Legend at 0x7f5ae9c28e10>
```



Missing Vales are 1180982

2.1.12 For AGEADMIT

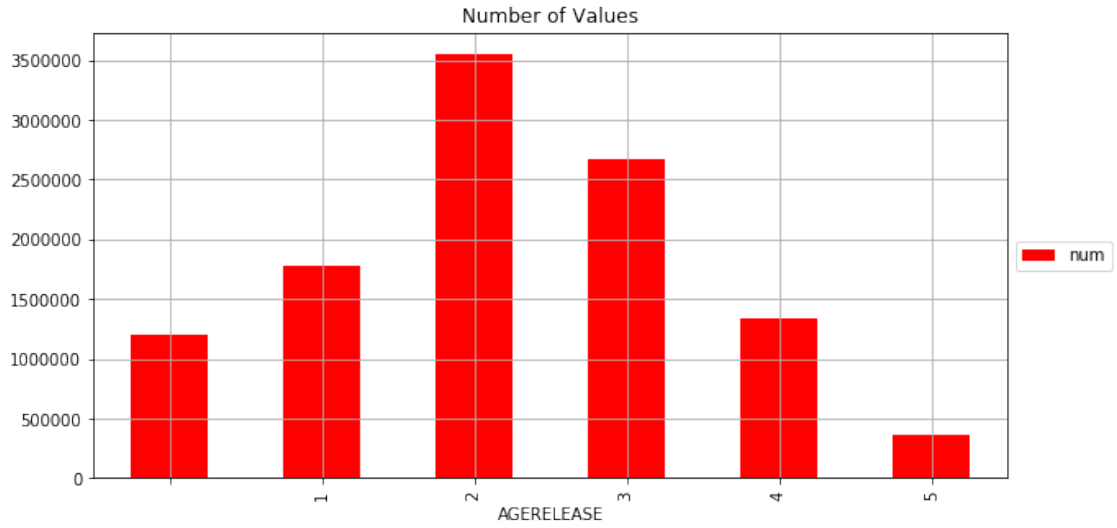
```
In [48]: ageadmit = spark.sql("select AGEADMIT, count(1)as num from term_rec group by AGEADMIT o

In [49]: ageadmit

Out[49]:   AGEADMIT      num
         0         1  2712139
         1         2  3875867
         2         3  2754302
         3         4  1261538
         4         5   303487

In [50]: ageadmit.plot(x=ageadmit.columns[0], kind='bar', color='Red', title="Number of Values",

Out[50]: <matplotlib.legend.Legend at 0x7f5aeae08d68>
```



No Missing values

2.1.13 For AGERELEASE

```
In [51]: agerelease = spark.sql("select AGERELEASE, count(1)as num from term_rec group by AGEREL

In [52]: agerelease

Out[52]:   AGERELEASE      num
         0             1200886
         1           1  1775026
         2           2  3556931
         3           3  2678000
         4           4  1336658
         5           5   359832

In [53]: agerelease.plot(x=agerelease.columns[0], kind='bar', color='Red', title="Number of Valu

Out[53]: <matplotlib.legend.Legend at 0x7f5ae995c630>
```



No missing values apart from blank values

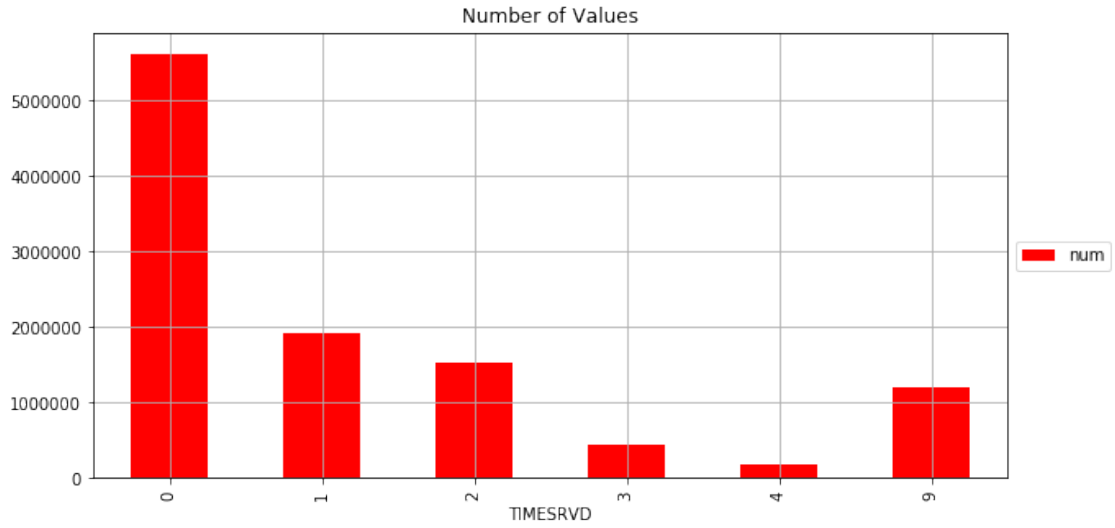
2.1.14 For TIMESRVD

```
In [54]: timesrvd = spark.sql("select TIMESRVD, count(1)as num from term_rec group by TIMESRVD o

In [55]: timesrvd
```

Out[55]:

	TIMESRVD	num
0	0	5617334
1	1	1929443
2	2	1524290
3	3	447602
4	4	187778
5	9	1200886

```
In [56]: timesrvd.plot(x=timesrvd.columns[0], kind='bar', color='Red', title="Number of Values",

Out[56]: <matplotlib.legend.Legend at 0x7f5ae9840b70>
```

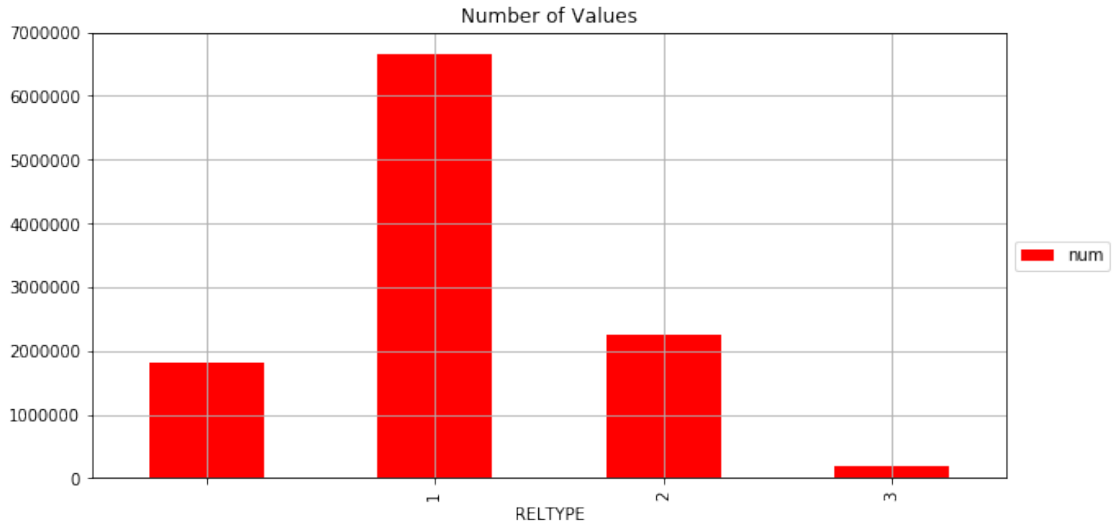


Missing values are 1200886

In [ ]:

2.1.15 For RELTYPE

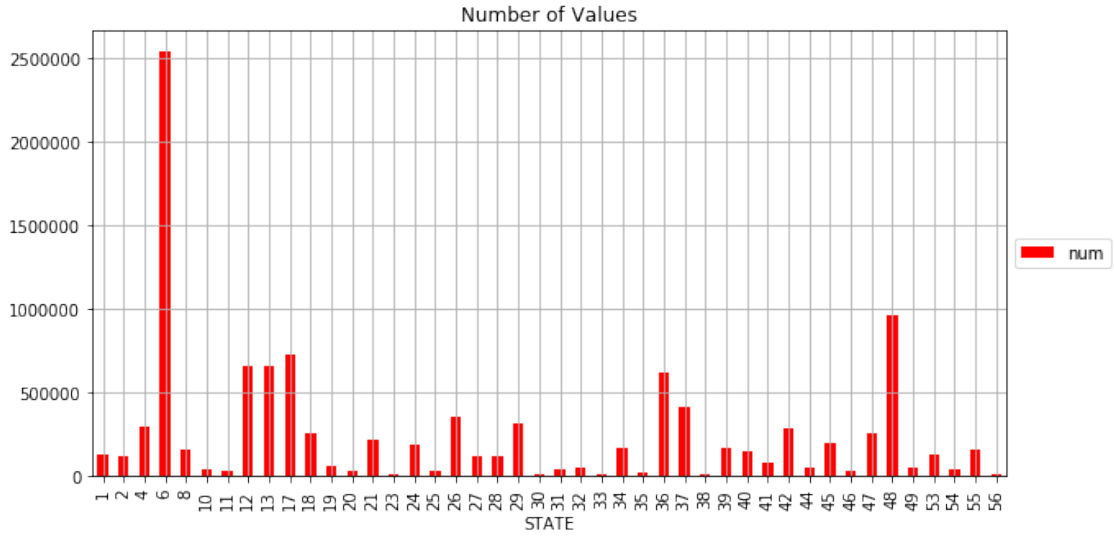
```
In [57]: reltype = spark.sql("select RELTYPE, count(1)as num from term_rec group by RELTYPE orde

In [58]: reltype

Out[58]:   RELTYPE      num
         0          1809372
         1        1  6665600
         2        2  2245899
         3        3   186462

In [60]: reltype.plot(x=reltype.columns[0], kind='bar', color='Red', title="Number of Values", g

Out[60]: <matplotlib.legend.Legend at 0x7f5ae98075c0>
```



No missing Values

2.1.16 For STATE

```
In [61]: state = spark.sql("select STATE, count(1)as num from term_rec group by STATE order by S

In [62]: state.plot(x=state.columns[0], kind='bar', color='Red', title="Number of Values", grid=

Out[62]: <matplotlib.legend.Legend at 0x7f5ae9749748>
```



2.1.17 dropping columns MAND_PRISREL_YEAR, PROJ_PRISREL_YEAR, PARELIG_YEAR,AGERELEASE as they contain a lot of missing values also dropping education as all values are missing

```
In [63]: spark.sql("select ABT_INMATE_ID,SEX,ADMTYPE,OFFGENERAL,ADMITYR,RELEASEYR,SENTLGTH,OFFDE
```

2.1.18 removing missing data

```
In [64]: spark.sql("select * from term_rec_clV1 where RELEASEYR != '9999' AND ADMTYPE != '9' AND

In [65]: spark.sql("select count(*) from term_rec_clean").show()
```

```
+--------+
|count(1)|
+--------+
| 7727018|
+--------+
```

2.1.19 creating rep off and class

```
In [66]: spark.sql("select ABT_INMATE_ID ,count(*) as num from term_rec_clean group by ABT_INMAT

In [67]: spark.sql("select * from rep_off").show()
```

```
+------------------+---+
|      ABT_INMATE_ID|num|
+------------------+---+
|A062015000001907370|  5|
|A062015000002568681| 13|
|A062015000000545050|  2|
|A062015000001131898|  3|
|A062015000000648432|  5|
|A062015000002615407|  1|
|A062015000001653894|  9|
|A062015000002327469| 12|
|A062015000002037956|  5|
|A062015000001841836|  2|
|A062015000002142148|  3|
|A062015000002216790|  2|
|A062015000002014729|  8|
|A062015000000508065|  3|
|A062015000001999103|  6|
|A062015000001426783| 10|
|A062015000000680899| 13|
|A062015000000678389|  1|
|A062015000001616635|  1|
|A062015000002427954|  2|
```

```
+------------------+---+
only showing top 20 rows
```

```
In [68]: spark.sql("select count (*) from rep_off").show()
```

```
+--------+
|count(1)|
+--------+
| 4415146|
+--------+
```

```
In [69]: spark.sql("select *, case when num = '1' then 0 else 1 end as class from rep_off").crea

In [70]: spark.sql("select * from rep_off_class where ABT_INMATE_ID = 'A132015000000535415'").sh
```

```
+------------------+---+-----+
|      ABT_INMATE_ID|num|class|
+------------------+---+-----+
|A132015000000535415|  3|    1|
+------------------+---+-----+
```

```
In [71]: spark.sql("select * from term_rec_clean where ABT_INMATE_ID='A132015000000535415'").sho
```

```
+------------------+---+-------+----------+-------+---------+--------+---------+----+--------+-
|      ABT_INMATE_ID|SEX|ADMTYPE|OFFGENERAL|ADMITYR|RELEASEYR|SENTLGTH|OFFDETAIL|RACE|AGEADMIT|T
+------------------+---+-------+----------+-------+---------+--------+---------+----+--------+-
|A132015000000535415|  1|      2|         2|   1978|     1979|       0|        7|   1|       1|
|A132015000000535415|  1|      1|         2|   1978|     1978|       1|        7|   1|       1|
|A132015000000535415|  1|      1|         2|   1980|     1980|       0|        7|   1|       1|
+------------------+---+-------+----------+-------+---------+--------+---------+----+--------+-
```

2.1.20 adding rep offence and class column

```
In [72]: spark.sql("select a.SEX,a.ADMTYPE,a.OFFGENERAL,a.ADMITYR,a.RELEASEYR,a.SENTLGTH,a.OFFDE

In [129]: spark.sql("select * from pris_data ").show()
```

```
+---+-------+----------+-------+---------+--------+---------+----+--------+--------+-------+----
|SEX|ADMTYPE|OFFGENERAL|ADMITYR|RELEASEYR|SENTLGTH|OFFDETAIL|RACE|AGEADMIT|TIMESRVD|RELTYPE|STAT
+---+-------+----------+-------+---------+--------+---------+----+--------+--------+-------+----
|  1|      1|         1|   2010|     2010|       4|        5|   1|       2|       0|      3|
```

```
|  1|      1|         3|   2007|     2008|       3|       12|   1|       2|       0|      2|
|  1|      1|         4|   2012|     2012|       0|       13|   1|       2|       0|      1|
|  1|      1|         2|   2014|     2014|       0|        8|   1|       4|       0|      3|
|  1|      1|         2|   2009|     2009|       0|        7|   1|       4|       0|      3|
|  1|      3|         3|   2007|     2009|       2|       12|   1|       1|       1|      1|
|  1|      1|         2|   2007|     2008|       2|        8|   1|       1|       0|      2|
|  1|      1|         1|   2009|     2010|       2|        5|   1|       3|       0|      3|
|  1|      1|         2|   2013|     2014|       0|        8|   1|       1|       0|      1|
|  1|      1|         1|   2013|     2013|       0|        3|   1|       4|       0|      1|
|  1|      1|         3|   2011|     2012|       1|       12|   1|       2|       0|      3|
|  1|      1|         3|   2011|     2014|       3|       12|   1|       2|       2|      1|
|  1|      1|         4|   2005|     2008|       2|       13|   1|       3|       2|      3|
|  1|      1|         2|   2008|     2009|       4|        8|   1|       2|       1|      1|
|  1|      1|         2|   2007|     2007|       4|        8|   1|       2|       0|      1|
|  1|      1|         2|   2014|     2014|       0|        8|   1|       2|       0|      3|
|  1|      2|         2|   2006|     2007|       3|       10|   1|       3|       0|      2|
|  1|      3|         2|   2012|     2012|       2|        8|   1|       3|       0|      1|
|  1|      3|         3|   2007|     2008|       5|       12|   1|       2|       1|      1|
|  1|      2|         3|   2014|     2014|       5|       12|   1|       3|       0|      1|
+---+-------+----------+-------+---------+--------+---------+----+--------+--------+-------+----
only showing top 20 rows
```

```
In [73]: spark.sql("select count(*) from pris_data ").show()
```

```
+--------+
|count(1)|
+--------+
| 7727018|
+--------+
```

```
In [74]: pris_data_converted = spark.sql("select cast(SEX as int),cast(ADMTYPE as int),cast(OFFG

In [75]: pris_data_converted.printSchema()
```

```
root
 |-- SEX: integer (nullable = true)
 |-- ADMTYPE: integer (nullable = true)
 |-- OFFGENERAL: integer (nullable = true)
 |-- ADMITYR: integer (nullable = true)
 |-- RELEASEYR: integer (nullable = true)
 |-- SENTLGTH: integer (nullable = true)
 |-- OFFDETAIL: integer (nullable = true)
 |-- RACE: integer (nullable = true)
 |-- AGEADMIT: integer (nullable = true)
 |-- TIMESRVD: integer (nullable = true)
```

```
 |-- RELTYPE: integer (nullable = true)
 |-- STATE: integer (nullable = true)
 |-- label: double (nullable = true)
```

2.2 Transforming Data

```
In [76]: #from pyspark.ml.feature import StringIndexer
         from pyspark.ml.feature import VectorAssembler

         #label_indexer = StringIndexer(inputCol = 'class', outputCol = 'label')
         #plan_indexer = StringIndexer(inputCol = 'intl_plan', outputCol = 'intl_plan_indexed')

         numeric_cols = ["SEX","ADMTYPE","OFFGENERAL","ADMITYR","RELEASEYR","SENTLGTH",
                         "OFFDETAIL","RACE","AGEADMIT","TIMESRVD","RELTYPE","STATE"]

         assembler = VectorAssembler( inputCols = numeric_cols,outputCol = 'features')
```

2.3 Splitting into train and test data

```
In [77]: train, test = pris_data_converted.randomSplit([0.7, 0.3], seed=42)
```

2.4 Predictions using logistic regression

```
In [78]: from pyspark.ml import Pipeline
         from pyspark.ml.classification import LogisticRegression

         lr = LogisticRegression(maxIter=10, regParam=0.3, elasticNetParam=0.8,featuresCol = 'fe
         pipeline_lr = Pipeline(stages=[assembler, lr])
         model_lr=pipeline_lr.fit(train)

In [79]: predictions_lr=model_lr.transform(test)

In [82]: from pyspark.ml.evaluation import BinaryClassificationEvaluator
         evaluator = BinaryClassificationEvaluator()
         auroc_lr = evaluator.evaluate(predictions_lr, {evaluator.metricName: "areaUnderROC"})

In [83]: auroc_lr

Out[83]: 0.5
```

2.5 Predictions using random forest

```
In [84]: from pyspark.ml.classification import RandomForestClassifier

         #classifier = RandomForestClassifier(labelCol = 'class', featuresCol = 'features')
         classifier = RandomForestClassifier(featuresCol = 'features')
         pipeline = Pipeline(stages=[assembler, classifier])
         model = pipeline.fit(train)
```

```
In [85]: from pyspark.ml.evaluation import BinaryClassificationEvaluator

         predictions = model.transform(test)

In [86]: #evaluator = BinaryClassificationEvaluator(labelCol='class')
         evaluator = BinaryClassificationEvaluator()
         auroc = evaluator.evaluate(predictions, {evaluator.metricName: "areaUnderROC"})

In [87]: auroc

Out[87]: 0.773421178031108

In [ ]:
```

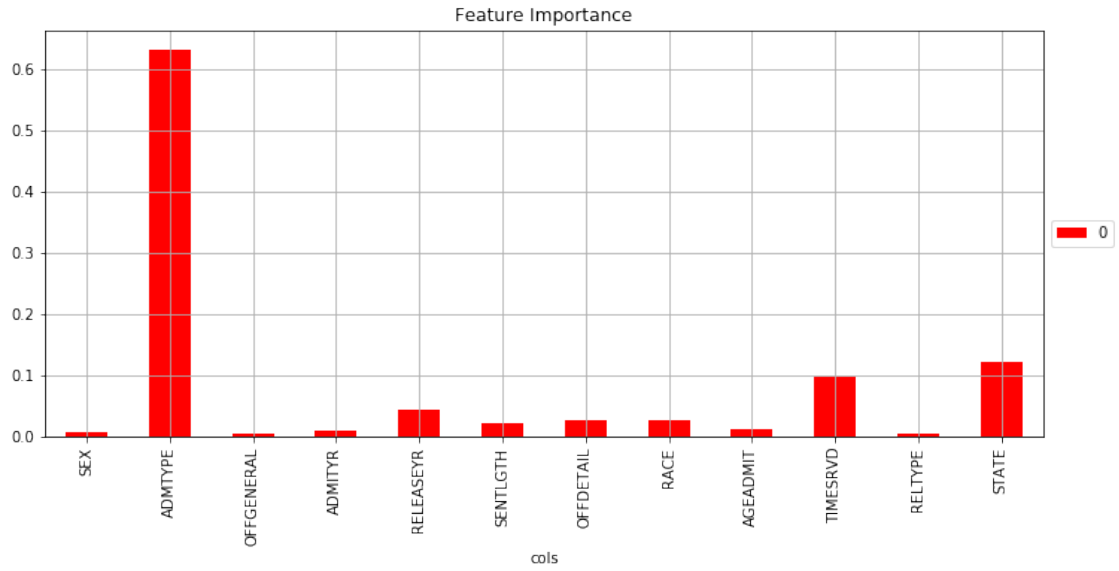
2.6 second method

```
In [88]: modelv2 = classifier.fit(assembler.transform(train))

In [89]: predictionsv2 = modelv2.transform(assembler.transform(test))

In [90]: auroc = evaluator.evaluate(predictionsv2, {evaluator.metricName: "areaUnderROC"})

In [91]: auroc

Out[91]: 0.7734211780311083

In [92]: modelv2.featureImportances

Out[92]: SparseVector(12, {0: 0.0066, 1: 0.6314, 2: 0.0047, 3: 0.0086, 4: 0.0425, 5: 0.0212, 6:
```

2.6.1 Plotting graph of features importance

```
In [174]:

In [196]: import pandas as pd
          import numpy as np
          cols = np.array(['SEX',
          'ADMTYPE',
          'OFFGENERAL',
          'ADMITYR',
          'RELEASEYR',
          'SENTLGTH',
          'OFFDETAIL',
          'RACE',
          'AGEADMIT',
          'TIMESRVD',
          'RELTYPE',
          'STATE'])

          tempdf = pd.DataFrame(modelv2.featureImportances.toArray().tolist())
```

```
In [200]: tempdf['cols'] = cols

In [201]: tempdf

Out[201]:            0        cols
          0   0.006554         SEX
          1   0.631351     ADMTYPE
          2   0.004750  OFFGENERAL
          3   0.008583     ADMITYR
          4   0.042548   RELEASEYR
          5   0.021240    SENTLGTH
          6   0.025794   OFFDETAIL
          7   0.026464        RACE
          8   0.012028    AGEADMIT
          9   0.097150    TIMESRVD
          10  0.002948     RELTYPE
          11  0.120592       STATE

In [225]: tempdf.plot(x= tempdf['cols'], kind='bar', color='Red', title="Feature Importance", gr

Out[225]: <matplotlib.legend.Legend at 0x7f5ae33fba20>
```




```
In [538]: predictions

Out[538]: DataFrame[SEX: int, ADMTYPE: int, OFFGENERAL: int, ADMITYR: int, RELEASEYR: int, SENTL

In [133]: predictions.select("rawPrediction","probability","prediction").show()
```

```
+--------------------+--------------------+----------+
|       rawPrediction|         probability|prediction|
+--------------------+--------------------+----------+
|[13.0917100331090...|[0.65458550165545...|       0.0|
|[10.3510384987686...|[0.51755192493843...|       0.0|
|[13.3052978304523...|[0.66526489152261...|       0.0|
|[8.66845117924706...|[0.43342255896235...|       1.0|
|[8.97732678655179...|[0.44886633932758...|       1.0|
|[8.82894423746939...|[0.44144721187346...|       1.0|
|[8.9018615036745,...|[0.44509307518372...|       1.0|
|[8.83485816752092...|[0.44174290837604...|       1.0|
|[13.7810648270564...|[0.68905324135282...|       0.0|
|[8.67436510929858...|[0.43371825546492...|       1.0|
|[8.83485816752092...|[0.44174290837604...|       1.0|
|[10.7664295861607...|[0.53832147930803...|       0.0|
|[8.66845117924706...|[0.43342255896235...|       1.0|
|[9.19439273301764...|[0.45971963665088...|       1.0|
|[9.5680641996221,...|[0.47840320998110...|       1.0|
|[14.4502218479031...|[0.72251109239515...|       0.0|
|[14.6273168433547...|[0.73136584216773...|       0.0|
|[11.2129635110421...|[0.56064817555210...|       0.0|
|[8.67436510929858...|[0.43371825546492...|       1.0|
|[9.5680641996221,...|[0.47840320998110...|       1.0|
+--------------------+--------------------+----------+
only showing top 20 rows
```

In [ ]:

In [ ]:

In [ ]:

2.7 Re creating the class variable

```
In [93]: spark.sql("select ABT_INMATE_ID,ADMITYR, count(*) as num from term_rec_clean group by A
```

```
In [94]: spark.sql("select * from rep_off_v2").show()
```

```
+------------------+-------+---+
|      ABT_INMATE_ID|ADMITYR|num|
+------------------+-------+---+
|A062015000001095798|   2003|  1|
|A062015000001294777|   2009|  1|
|A062015000001476138|   2003|  1|
|A062015000002218142|   2005|  1|
|A062015000000012492|   1997|  1|
|A062015000001100182|   2001|  1|
```

```
|A062015000001365745|   2006|  2|
|A062015000001357854|   2008|  1|
|A062015000001638888|   1996|  1|
|A062015000000452040|   1996|  1|
|A062015000001534588|   2010|  1|
|A062015000000011223|   1999|  1|
|A062015000000279403|   2010|  3|
|A062015000002207240|   1992|  3|
|A062015000000912428|   1997|  1|
|A062015000000424586|   2008|  1|
|A062015000000667529|   2007|  1|
|A062015000000108087|   2001|  1|
|A062015000001922513|   1993|  1|
|A062015000002006056|   1992|  1|
+-------------------+-------+---+
only showing top 20 rows
```

```
In [95]: spark.sql("select * from rep_off_v2 where ABT_INMATE_ID = 'A132015000000535415'").show(
```

```
+-------------------+-------+---+
|      ABT_INMATE_ID|ADMITYR|num|
+-------------------+-------+---+
|A132015000000535415|   1978|  2|
|A132015000000535415|   1980|  1|
+-------------------+-------+---+
```

```
In [96]: spark.sql("select * from rep_off_v2 where ABT_INMATE_ID = 'A272015000000081052'").show(
```

```
+-------------------+-------+---+
|      ABT_INMATE_ID|ADMITYR|num|
+-------------------+-------+---+
|A272015000000081052|   2008|  1|
|A272015000000081052|   2011|  1|
|A272015000000081052|   2013|  1|
|A272015000000081052|   2007|  1|
+-------------------+-------+---+
```

```
In [97]: spark.sql("select ABT_INMATE_ID,count (*) as num from rep_off_v2 group by ABT_INMATE_ID
```

```
In [ ]:
```

```
In [98]: spark.sql("select * from rep_off_v2_actual where ABT_INMATE_ID = 'A132015000000535415'"
```

```
+------------------+---+
|      ABT_INMATE_ID|num|
+------------------+---+
|A132015000000535415|  2|
+------------------+---+
```

assignining class column to the corrected inmate column

```
In [99]: spark.sql("select *, case when num = '1' then 0 else 1 end as class from rep_off_v2_act
```

```
In [100]: spark.sql("select * from rep_off_v2_actual_class where ABT_INMATE_ID = 'A1320150000005
```

```
+------------------+---+-----+
|      ABT_INMATE_ID|num|class|
+------------------+---+-----+
|A132015000000535415|  2|    1|
+------------------+---+-----+
```

```
In [101]: spark.sql("select * from term_rec_clean where ABT_INMATE_ID='A132015000000535415'").sh
```

```
+------------------+---+-------+----------+-------+---------+--------+---------+----+--------+-
|      ABT_INMATE_ID|SEX|ADMTYPE|OFFGENERAL|ADMITYR|RELEASEYR|SENTLGTH|OFFDETAIL|RACE|AGEADMIT|T
+------------------+---+-------+----------+-------+---------+--------+---------+----+--------+-
|A132015000000535415|  1|      2|         2|   1978|     1979|       0|        7|   1|       1|
|A132015000000535415|  1|      1|         2|   1978|     1978|       1|        7|   1|       1|
|A132015000000535415|  1|      1|         2|   1980|     1980|       0|        7|   1|       1|
+------------------+---+-------+----------+-------+---------+--------+---------+----+--------+-
```

```
In [ ]:
```

```
In [ ]:
```

```
In [ ]:
```

2.7.1 adding corrected rep offence and class column

```
In [103]: spark.sql("select a.SEX,a.ADMTYPE,a.OFFGENERAL,a.ADMITYR,a.RELEASEYR,a.SENTLGTH,a.OFFD
```

```
In [104]: spark.sql("select count(*) from pris_data_v2 ").show()
```

```
+--------+
|count(1)|
+--------+
| 7727018|
+--------+
```

```
In [105]: pris_data_v2_converted = spark.sql("select cast(SEX as int),cast(ADMTYPE as int),cast(

In [106]: pris_data_v2_converted.printSchema()

root
 |-- SEX: integer (nullable = true)
 |-- ADMTYPE: integer (nullable = true)
 |-- OFFGENERAL: integer (nullable = true)
 |-- ADMITYR: integer (nullable = true)
 |-- RELEASEYR: integer (nullable = true)
 |-- SENTLGTH: integer (nullable = true)
 |-- OFFDETAIL: integer (nullable = true)
 |-- RACE: integer (nullable = true)
 |-- AGEADMIT: integer (nullable = true)
 |-- TIMESRVD: integer (nullable = true)
 |-- RELTYPE: integer (nullable = true)
 |-- STATE: integer (nullable = true)
 |-- label: double (nullable = true)
```

2.8 Transforming Data

```
In [107]: #from pyspark.ml.feature import StringIndexer
          #from pyspark.ml.feature import VectorAssembler

          #label_indexer = StringIndexer(inputCol = 'class', outputCol = 'label')
          #plan_indexer = StringIndexer(inputCol = 'intl_plan', outputCol = 'intl_plan_indexed')

          numeric_cols = ["SEX","ADMTYPE","OFFGENERAL","ADMITYR","RELEASEYR","SENTLGTH",
                          "OFFDETAIL","RACE","AGEADMIT","TIMESRVD","RELTYPE","STATE"]

          assembler = VectorAssembler( inputCols = numeric_cols,outputCol = 'features')
```

2.9 Splitting new data into train and test data

```
In [108]: train_v2, test_v2 = pris_data_v2_converted.randomSplit([0.7, 0.3], seed=42)
```

2.10 Predictions using logistic regression for new data

```
In [586]: from pyspark.ml import Pipeline
          from pyspark.ml.classification import LogisticRegression

          lr = LogisticRegression(maxIter=10, regParam=0.3, elasticNetParam=0.8,featuresCol = 'f
          pipeline_lr_v2 = Pipeline(stages=[assembler, lr])
          model_lr_v2=pipeline_lr_v2.fit(train_v2)

In [587]: predictions_lr_v2=model_lr_v2.transform(test_v2)
```

```
In [588]: auroc_lr_v2 = evaluator.evaluate(predictions_lr_v2, {evaluator.metricName: "areaUnderR

In [589]: auroc_lr_v2

Out[589]: 0.5
```

2.11 Predictions using random forest for new data

```
In [109]: #classifier = RandomForestClassifier(labelCol = 'class', featuresCol = 'features')
          classifier = RandomForestClassifier(featuresCol = 'features')
          pipeline = Pipeline(stages=[assembler, classifier])
          model_v2 = pipeline.fit(train_v2)

In [110]: from pyspark.ml.evaluation import BinaryClassificationEvaluator

          predictions_v2 = model_v2.transform(test_v2)

In [111]: #evaluator = BinaryClassificationEvaluator(labelCol='class')
          evaluator = BinaryClassificationEvaluator()
          auroc_v2 = evaluator.evaluate(predictions_v2, {evaluator.metricName: "areaUnderROC"})

In [112]: auroc_v2

Out[112]: 0.7699123943498619
```

2.12 Calculating average average time that it took inmates to return to prison after release

Here only 3 colums are required: iname id, admit year, release year

```
In [113]: spark.sql("select ABT_INMATE_ID,ADMITYR,RELEASEYR from term_rec_clean group by ABT_INM

In [114]: spark.sql("select *, row_number() over (partition by ABT_INMATE_ID order by ADMITYR,RE

In [115]: pris_adm_rel = spark.sql("select * from avg_time_idx where ABT_INMATE_ID = 'A272015000

In [116]: pris_adm_rel.show()

+------------------+-------+---------+---+
|      ABT_INMATE_ID|ADMITYR|RELEASEYR|idx|
+------------------+-------+---------+---+
|A132015000000535415|   1978|     1978|  1|
|A132015000000535415|   1978|     1979|  2|
|A132015000000535415|   1980|     1980|  3|
|A272015000000081052|   2007|     2007|  1|
|A272015000000081052|   2008|     2009|  2|
|A272015000000081052|   2011|     2012|  3|
|A272015000000081052|   2013|     2014|  4|
+------------------+-------+---------+---+
```

```
In [117]: pris_adm_rel.show()

+------------------+-------+---------+---+
|      ABT_INMATE_ID|ADMITYR|RELEASEYR|idx|
+------------------+-------+---------+---+
|A132015000000535415|   1978|     1978|  1|
|A132015000000535415|   1978|     1979|  2|
|A132015000000535415|   1980|     1980|  3|
|A272015000000081052|   2007|     2007|  1|
|A272015000000081052|   2008|     2009|  2|
|A272015000000081052|   2011|     2012|  3|
|A272015000000081052|   2013|     2014|  4|
+------------------+-------+---------+---+
```

Now that we have created the ids, we will select all the elements

```
In [118]: pris_adm_rel = spark.sql("select * from avg_time_idx ")

In [128]: spark.sql("select * from avg_time_idx where ABt_INMATE_ID = 'A4920150000000017034'").sh

+------------------+-------+---------+---+
|      ABT_INMATE_ID|ADMITYR|RELEASEYR|idx|
+------------------+-------+---------+---+
|A492015000000017034|   1994|     2000|  1|
|A492015000000017034|   2000|     2000|  2|
+------------------+-------+---------+---+


In [119]: pris_adm_rel.show()

+------------------+-------+---------+---+
|      ABT_INMATE_ID|ADMITYR|RELEASEYR|idx|
+------------------+-------+---------+---+
|A012015000000000158|   2010|     2010|  1|
|A012015000000000593|   2007|     2008|  1|
|A012015000000000593|   2012|     2012|  2|
|A012015000000000886|   2009|     2009|  1|
|A012015000000000886|   2014|     2014|  2|
|A012015000000001131|   2007|     2009|  1|
|A012015000000001260|   2007|     2008|  1|
|A012015000000001841|   2009|     2010|  1|
|A012015000000002380|   2013|     2014|  1|
|A012015000000005151|   2013|     2013|  1|
|A012015000000006679|   2011|     2012|  1|
|A012015000000007678|   2011|     2014|  1|
|A012015000000007988|   2005|     2008|  1|
```

```
|A012015000000008288|   2007|     2007|  1|
|A012015000000008288|   2008|     2009|  2|
|A012015000000008900|   2014|     2014|  1|
|A012015000000009357|   2006|     2007|  1|
|A012015000000009357|   2012|     2012|  2|
|A012015000000009454|   2007|     2008|  1|
|A012015000000009454|   2014|     2014|  2|
+-------------------+-------+---------+---+
only showing top 20 rows
```

```
In [121]: pris_admrel_rdd = pris_adm_rel.rdd

In [122]: pris_admrel_rdd.map(tuple).groupBy(lambda a: a[0]).mapValues(lambda xs: [(x) for x in

Out[122]: [('A042015000000326661', [('A042015000000326661', '2011', '2011', 1)]),
           ('A182015000000056921',
            [('A182015000000056921', '2007', '2009', 1),
             ('A182015000000056921', '2010', '2012', 2),
             ('A182015000000056921', '2012', '2012', 3),
             ('A182015000000056921', '2013', '2013', 4)]),
           ('A012015000000121868', [('A012015000000121868', '2010', '2010', 1)]),
           ('A042015000000248418',
            [('A042015000000248418', '1999', '2002', 1),
             ('A042015000000248418', '2002', '2003', 2),
             ('A042015000000248418', '2005', '2007', 3),
             ('A042015000000248418', '2008', '2008', 4),
             ('A042015000000248418', '2010', '2011', 5),
             ('A042015000000248418', '2011', '2011', 6),
             ('A042015000000248418', '2012', '2012', 7)]),
           ('A392015000000022346', [('A392015000000022346', '2009', '2011', 1)])]

In [123]: grp_id = pris_admrel_rdd.map(tuple).groupBy(lambda a: a[0]).mapValues(lambda xs:[(x[3]

In [162]: grp_id.take(5)

Out[162]: [('A062015000002614481',
            [(1, 1993, 1994, 2),
             (2, 1994, 1994, 3),
             (3, 1995, 1995, 4),
             (4, 1996, 1996, 5),
             (5, 1997, 1997, 6),
             (6, 1997, 1998, 7),
             (7, 1999, 2000, 8),
             (8, 2000, 2000, 9),
             (9, 2001, 2001, 10),
             (10, 2002, 2002, 11),
             (11, 2003, 2004, 12),
```

```
  (12, 2004, 2005, 13),
  (13, 2006, 2007, 14)]),
 ('A4920150000000017034', [(1, 1994, 2000, 2), (2, 2000, 2000, 3)]),
 ('A062015000000866760', [(1, 1999, 2002, 2), (2, 2003, 2003, 3)]),
 ('A022015000000108570', [(1, 2006, 2006, 2), (2, 2007, 2007, 3)]),
 ('A292015000000094965',
  [(1, 2011, 2011, 2), (2, 2012, 2012, 3), (3, 2013, 2014, 4)])]
```

```
In [124]: grp_id2= grp_id.mapValues(lambda xs:[(y[1]-x[2]) for x in xs for y in xs  if x[3]==y[0
```

```
In [125]: grp_id2.take(5)
```

```
Out[125]: [('A062015000002614481', [0, 1, 1, 1, 0, 1, 0, 1, 1, 1, 0, 1]),
           ('A4920150000000017034', [0]),
           ('A062015000000866760', [1]),
           ('A022015000000108570', [1]),
           ('A292015000000094965', [1, 1])]
```

2.13 Average

```
In [127]: grp_id2.mapValues(lambda av:sum(av)/len(av) ).map(lambda std:std[1] ).mean()
```

```
Out[127]: 2.1319708309732626
```

2.14 Standard deviation

```
In [126]: grp_id2.mapValues(lambda av:sum(av)/len(av) ).map(lambda std:std[1] ).stdev()
```

```
Out[126]: 2.2951026961337768
```

```
In [ ]:
```