LOAN LENDING CLUB

Report by: Mengqi Zhao (Team 6)

Part1:

CREATE USER ID AND PASSWORD TO DOWNLOAD LOAN DATA FILES

Given user name and password by the user, we will be programmatically generating the URL to download the various data file present on the Loan Lending Club Website. We also do have sample file present on their website which does not require any user login but it consist of only sample data with less number of columns.

In [1]:
```
import luigi
import requests
import sys
import logging
import pandas as pd
import numpy as np
import glob
import os
from bs4 import BeautifulSoup
from zipfile import ZipFile
from io import BytesIO
from luigi.parameter import MissingParameterException
```

In [5]:
```
def extractZip(yearwisedata,path):
    r = requests.get(yearwisedata)
    z = ZipFile(BytesIO(r.content))
    z.extractall(path)

def output(self):
    return luigi.LocalTarget('rejectdictionary.csv')


url = 'https://www.lendingclub.com/account/login.action?'
postUrl = 'https://www.lendingclub.com/info/download-data.action'
payload = {'login_email': 'zhaomengqi8000@gmail.com', 'login_password': 'billy8213198'}
with requests.Session() as s:
            loginRequest = s.post(url, data=payload)
            finalUrl = s.get(postUrl)
            linkhtml = finalUrl.text
            soup = BeautifulSoup(linkhtml, "html.parser")
            ziplist = soup.find_all('div', {"id": 'rejectedLoanStatsFileNamesJS'})
            Borrowerdata = []
            rejectLoandata = []
            rejectloanyearlist = []
            for div in ziplist:
                for d in div:
                    link = d.split('|')
                    Borrowerdata.extend(link)
            for data in Borrowerdata:
                if data != '':
                    rejectLoandata.append('https://resources.lendingclub.com/' + data)
            year_options = soup.findAll('select', {"id": 'rejectStatsDropdown'})[0].findAll("option")
            for year in year_options:
                rejectloanyearlist.append(year.text)
            dictionary = dict(zip(rejectloanyearlist, rejectLoandata))
            # print(dictionary)
            for year in dictionary:
                url = dictionary[year]
                yearpath = str(os.getcwd()) + "/RejectData/" + year
                extractZip(url, yearpath)
            yeardict=pd.DataFrame(list(dictionary.items()),columns=['year','Link'])
            yeardict.to_csv('rejectdictionary.csv', mode='a', encoding='utf-8', index=False)
```

```
year,Link
2007 - 2012,https://resources.lendingclub.com/RejectStatsA.csv.zip
2013 - 2014,https://resources.lendingclub.com/RejectStatsB.csv.zip
2015,https://resources.lendingclub.com/RejectStatsD.csv.zip
2016 Q1,https://resources.lendingclub.com/RejectStats_2016Q1.csv.zip
2016 Q2,https://resources.lendingclub.com/RejectStats_2016Q2.csv.zip
2016 Q3,https://resources.lendingclub.com/RejectStats_2016Q3.csv.zip
2016 Q4,https://resources.lendingclub.com/RejectStats_2016Q4.csv.zip
2017 Q1,https://resources.lendingclub.com/RejectStats_2017Q1.csv.zip
2017 Q2,https://resources.lendingclub.com/RejectStats_2017Q2.csv.zip
2017 Q3,https://resources.lendingclub.com/RejectStats_2017Q3.csv.zip
year,Link
2007 - 2012,https://resources.lendingclub.com/RejectStatsA.csv.zip
2013 - 2014,https://resources.lendingclub.com/RejectStatsB.csv.zip
2015,https://resources.lendingclub.com/RejectStatsD.csv.zip
2016 Q1,https://resources.lendingclub.com/RejectStats_2016Q1.csv.zip
2016 Q2,https://resources.lendingclub.com/RejectStats_2016Q2.csv.zip
2016 Q3,https://resources.lendingclub.com/RejectStats_2016Q3.csv.zip
2016 Q4,https://resources.lendingclub.com/RejectStats_2016Q4.csv.zip
2017 Q1,https://resources.lendingclub.com/RejectStats_2017Q1.csv.zip
2017 Q2,https://resources.lendingclub.com/RejectStats_2017Q2.csv.zip
2017 Q3,https://resources.lendingclub.com/RejectStats_2017Q3.csv.zip

```

In [3]:
```
writeHeader2 = True
for year in dictionary:
        # for year in customyear:
            yearpath = str(os.getcwd()) + "\\" + year
            for filename in os.listdir(yearpath):
                print(filename)
                newFile = "ModifiedData.csv"
                for f in glob.glob(yearpath + '\\' + filename):
                    datadf = pd.read_csv(f, skiprows=1, skipfooter=2, engine='python')
                    with open(newFile, 'a', encoding='utf-8', newline="") as file:
                        for f in glob.glob(str(os.getcwd()) + '\\' + newFile):
                            if writeHeader2 is True:
                                datadf.to_csv(f, mode='w', header=True, index=False, skipinitial
                                writeHeader2 = False
                            else:
                                datadf.to_csv(f, mode='a', header=False, index=False, skipiniti
```

```
LoanStats3a_securev1.csv
LoanStats3b_securev1.csv
LoanStats3c_securev1.csv
LoanStats3d_securev1.csv
LoanStats_securev1_2016Q1.csv
LoanStats_securev1_2016Q2.csv
LoanStats_securev1_2016Q3.csv
LoanStats_securev1_2016Q4.csv
LoanStats_securev1_2017Q1.csv
LoanStats_securev1_2017Q2.csv
LoanStats_securev1_2017Q3.csv
```

In [5]:
```
def extractZip(yearwisedata,path):
    r = requests.get(yearwisedata)
    z = ZipFile(BytesIO(r.content))
    z.extractall(path)



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            linkhtml = finalUrl.text
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                for d in div:
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            year_options = soup.findAll('select', {"id": 'rejectStatsDropdown'})[0].findAll("opt
            for year in year_options:
                rejectloanyearlist.append(year.text)
            dictionary = dict(zip(rejectloanyearlist, rejectLoandata))
            # print(dictionary)
            for year in dictionary:
                url = dictionary[year]
                yearpath = str(os.getcwd()) + "\\RejectData\\" + year
                extractZip(url, yearpath)
            yeardict=pd.DataFrame(list(dictionary.items()),columns=['year','Link'])
            yeardict.to_csv('rejectdictionary.csv', mode='a', encoding='utf-8', index=False)
```

In [40]:
```
# consolidate date
writeHeader2 = True
for year in dictionary:
    yearpath = str(os.getcwd()) + "\\RejectData\\" + year

    for filename in os.listdir(yearpath):
        print(filename)
        newFile = "RejectModifiedData.csv"

        for f in glob.glob(yearpath + '\\' + filename):

            datadf = pd.read_csv(f, skiprows=1, skipfooter=2, engine='python')
            with open(newFile, 'a', encoding='utf-8', newline="")as file:
                for f in glob.glob(str(os.getcwd()) + '\\' + newFile):
                    datadf.to_csv('RejectModifiedData.csv', mode='a', encoding='utf-8')
```

```
RejectStatsA.csv
RejectStatsB.csv
RejectStatsD.csv
RejectStats_2016Q1.csv
RejectStats_2016Q2.csv
RejectStats_2016Q3.csv
RejectStats_2016Q4.csv
RejectStats_2017Q1.csv
RejectStats_2017Q2.csv
RejectStats_2017Q3.csv
```

DATA CLEANING & HANDLING MISSING VALUE

Once we have all the data downloaded as a single csv file, we will load the resultant dataset in pandas data frame for data cleaning and handling missing value.

```
loan_df = pd.read_csv('ModifiedData.csv',low_memory=False,encoding='ISO-8859-1',skipinitialspace=True)
loan_df.shape
```

```
(1321848, 115)
```

```
loan_df.columns
```

```
Index(['id', 'member_id', 'loan_amnt', 'funded_amnt', 'funded_amnt_inv',
       'term', 'int_rate', 'installment', 'grade', 'sub_grade',
       ...
       'num_tl_90g_dpd_24m', 'num_tl_op_past_12m', 'pct_tl_nvr_dlq',
       'percent_bc_gt_75', 'pub_rec_bankruptcies', 'tax_liens',
       'tot_hi_cred_lim', 'total_bal_ex_mort', 'total_bc_limit',
       'total_il_high_credit_limit'],
      dtype='object', length=115)
```

Out[6]:

```
Amount Requested        0
Application Date        0
Loan Title              0
Risk_Score              0
Debt-To-Income Ratio    0
State                   0
Employment Length       0
Policy Code             0
dtype: int64
```

In [8]:

```
reject_df.shape
```

Out[8]:

```
(11079386, 8)
```

We will now remove all the unused columns which are not useful for the loan data analysis or consist of data which is insignificant. Also, we drop all the column having Null value more than 80% in our data set.

```
print ('Removing unused columns')
loan_df = loan_df[loan_df.id != 'Loans that do not meet the credit policy']
loan_df.drop(['id', 'member_id', 'emp_title','pymnt_plan','url','desc','title' ],axis=1, inplace=True)
column_naper_dict = {}
print ('Removing columns with nan% > 80%')
for column in loan_df:
    if loan_df[column].isnull().sum()>0:
        column_naper_dict[column] = loan_df[column].isnull().sum()/ 1321847
        if column_naper_dict[column] > 0.80:
            loan_df.drop(column, axis=1,inplace='True')
```

```
Removing unused columns
Removing columns with nan% > 80%
```

```
#Handling missing data
print ('Handling missing data')
loan_df.term = pd.to_numeric(loan_df.term.str[:3])
loan_df["int_rate"]= pd.Series(loan_df.int_rate).str.replace('%','')
loan_df["revol_util"]= pd.Series(loan_df.revol_util).str.replace('%','')
loan_df.replace('n/a', np.nan,inplace=True)
loan_df.emp_length.fillna(value=0,inplace=True)
loan_df['emp_length'].replace(to_replace='[^0-9]+', value='', inplace=True, regex=True)
loan_df['emp_length'] = loan_df['emp_length'].astype(int)
loan_df["annual_inc"].fillna(loan_df["annual_inc"].median(), inplace=True)
loan_df["issue_d"] = loan_df["issue_d"].str.split("-")
loan_df["issue_month"] = loan_df["issue_d"].str[0]
loan_df["issue_year"] = loan_df["issue_d"].str[1]
m = loan_df['mths_since_last_delinq'].max() #max is 188 so this will be our imputed value.
loan_df['mths_since_last_delinq'] = np.where(loan_df['mths_since_last_delinq'].isnull(), m, loan_df['mths_since_last_del
#Revol_util will involve a median value imputation.
loan_df['revol_util'] = loan_df['revol_util'].fillna(loan_df['revol_util'].median())
loan_df['tot_coll_amt'] = loan_df['tot_coll_amt'].fillna(loan_df['tot_coll_amt'].median())
#tot_cur_bal will be fixed in similar manner.
loan_df['tot_cur_bal'] = loan_df['tot_cur_bal'].fillna(loan_df['tot_cur_bal'].median())
#total_rev_hi_lim will also contain median imputation
loan_df['total_rev_hi_lim'] = loan_df['total_rev_hi_lim'].fillna(loan_df['total_rev_hi_lim'].median())
loan_df['earliest_cr_line'] = loan_df['earliest_cr_line'].fillna('Unknown')
loan_df['last_pymnt_d'] = loan_df['last_pymnt_d'].fillna('Unknown')
loan_df['next_pymnt_d'] = loan_df['next_pymnt_d'].fillna('Unknown')
loan_df['last_credit_pull_d'] = loan_df['last_credit_pull_d'].fillna('Unknown')
loan_df['last_fico_range'] = loan_df.last_fico_range_low.astype('str') + '-' + loan_df.last_fico_range_high.astype('str'
loan_df['last_meanfico'] = (loan_df.last_fico_range_low + loan_df.last_fico_range_high)/2
loan_df = loan_df.fillna(0)
loan_df = changedatatype(loan_df)
print ('Creating Cleaned CSV file')
loan_df.to_csv('Final.csv', header=True,index=False,skipinitialspace=True)
```

Changing the data types of the columns:

```
def changedatatype(df):
    #Change the data types for all column
    df[['loan_amnt','funded_amnt','funded_amnt_inv','annual_inc','delinq_2yrs','fico_range_low','fico_range_high','inq_l
    df[['mths_since_last_delinq','open_acc','pub_rec','revol_bal','total_acc','last_meanfico']] = df[['mths_since_last_d
    df[['int_rate','revol_util']] = df[['int_rate','revol_util']].astype('float64')
    return df
```

Cleaned Loan Data Set:

```
loan_df.head()
```

	loan_amnt	funded_amnt	funded_amnt_inv	term	int_rate	installment	grade	sub_grade	emp_length	home_ownership	...	pub_rec_bankruptc
0	10400	10400	10400	36	6.99	321.08	A	A3	8	MORTGAGE	...	0.0
1	15000	15000	15000	60	12.39	336.64	C	C1	10	RENT	...	0.0
2	21425	21425	21425	60	15.59	516.36	D	D1	6	RENT	...	0.0
3	7650	7650	7650	36	13.66	260.20	C	C3	1	RENT	...	0.0
4	12800	12800	12800	60	17.14	319.08	D	D4	10	MORTGAGE	...	0.0

5 rows × 108 columns

Similarly, all the operation was performed on the Rejected loan data sets:

```
def changedatatype(df):
    #Change the data types for all column
    df[['Amount Requested','Risk_Score']] = df[['Amount Requested','Risk_Score']].astype('int64')
    df[['Debt-To-Income Ratio']] = df[['Debt-To-Income Ratio']].astype('float64')
    return df

def handleMissingData(reject_df):
    print ('Removing unused columns')

    reject_df.drop(['Zip Code'],axis=1, inplace=True)
    column_naper_dict = {}
    print ('Removing columns with nan% > 80%')
    for column in reject_df:
        if reject_df[column].isnull().sum()>0:
            column_naper_dict[column] = reject_df[column].isnull().sum()/ 11079372
            if column_naper_dict[column] > 0.80:
                reject_df.drop(column, axis=1,inplace='True')
    #Handling missing data
    print ('Handling missing data')
    reject_df["Debt-To-Income Ratio"]= pd.Series(reject_df['Debt-To-Income Ratio']).str.replace('%','')
    reject_df.replace('n/a', np.nan,inplace=True)
    reject_df['Employment Length'].fillna(value=0,inplace=True)
    reject_df['Employment Length'].replace(to_replace='[^0-9]+', value='', inplace=True, regex=True)
    reject_df['Employment Length'] = reject_df['Employment Length'].astype(int)
    reject_df["Risk_Score"].fillna(0, inplace=True)
    reject_df['Loan Title'] = reject_df['Loan Title'].fillna('other')
    reject_df['State'] = reject_df['State'].fillna('NA')
    reject_df = changedatatype(reject_df)
    print ('Creating Cleaned CSV file')
    reject_df.to_csv('RejectLoan.csv', header=True,index=False,skipinitialspace=True)
    return reject_df
```

```
file='RejectModifiedData.csv'
reject_df = pd.read_csv(file,low_memory=False,encoding='ISO-8859-1',skipinitialspace=True)
reject_df=handleMissingData(reject_df)
reject_df.head()
```

```
Removing unused columns
Removing columns with nan% > 80%
Handling missing data
Creating Cleaned CSV file
```

	Amount Requested	Application Date	Loan Title	Risk_Score	Debt-To-Income Ratio	State	Employment Length	Policy Code
0	30000	2013-01-01	debt_consolidation	754	32.01	MN	1	0
1	15000	2013-01-01	medical	728	27.01	CA	1	0
2	2500	2013-01-01	other	723	0.92	PA	7	0
3	4000	2013-01-01	car	563	24.92	SC	1	0
4	22000	2013-01-01	debt_consolidation	0	26.91	OK	1	0

FEATURE ENGINEERING

```
#Feature Engineering
import warnings
from sklearn.linear_model import (LinearRegression, Ridge,
                                  Lasso, RandomizedLasso)
from sklearn.feature_selection import RFE, f_regression
from sklearn.preprocessing import MinMaxScaler
from sklearn.ensemble import RandomForestRegressor
from sklearn.feature_selection import SelectKBest
from sklearn.feature_selection import chi2
```

```
#Loading dataset for feature engineering
print("Training Data")
loanfreature_df=pd.read_csv('Final.csv',low_memory=False,encoding='ISO-8859-1',skipinitialspace=True)
```

```
Training Data
```

```
#Creating dummy Variables
def createDummies(df):
    dummies1 = pd.get_dummies(df['purpose']).rename(columns=lambda x: 'purpose' + str(x))
    df=pd.concat([df, dummies1], axis=1)
    dummies2 = pd.get_dummies(df['application_type']).rename(columns=lambda x: 'application_type' + str(x))
    df=pd.concat([df, dummies2], axis=1)
    return df
```

We have changed some of the category columns into numeric.

```
#Dropping interest rate (target to predict)
Y =loanfreature_df.int_rate
loanfreature_df.drop('int_rate',axis=1,inplace=True)
#Creating Categorical Variables
home_positive = ['OWN', 'MORTGAGE']
home_negative = ['RENT','NONE','OTHER','ANY']
# filter out any word that is not within home_positive & home_negative
loanfreature_df = loanfreature_df[loanfreature_df['home_ownership'].isin(home_positive + home_negative)].copy()
loanfreature_df['home_ownership_category']=loanfreature_df['home_ownership'].isin(home_positive).astype(int)
# Make "verified" and "Source Verified" in the "verification_status" column as 1 and non-verified as 0
verification_positive = ['Verified', 'Source Verified']
verification_negative = ['Not Verified']
loanfreature_df = loanfreature_df[loanfreature_df['verification_status'].isin(verification_positive + verification_negat
loanfreature_df['verification_status_category']=loanfreature_df['verification_status'].isin(verification_positive).astyp
```

Our analysis suggests that FICO score is not the only parameter predicting Interest Rate and using statistical methods such as multivariate linear regression we show that there is obvious relationship between Interest Rate and the following parameters: Loan length, amount of money funded by investors, debt to income ratio and inquiries in the last 6 months

```
print ('Removing unused column for feature engineering')
cols_to_keep=['loan_amnt','term','emp_length','home_ownership_category','annual_inc',
              'verification_status_category','purpose','addr_state','dti','delinq_2yrs',
              'last_meanfico','inq_last_6mths','open_acc','revol_bal','revol_util','total_acc',
              'mths_since_last_major_derog','funded_amnt_inv','installment','application_type','pub_rec']
loanfreature_df = loanfreature_df[cols_to_keep]
loanfreature_df = createDummies(loanfreature_df)
X = loanfreature_df._get_numeric_data()
```

```
Removing unused column for feature engineering
```

```
def rank_to_dict(ranks, names, order=1):
    minmax = MinMaxScaler()
    ranks = minmax.fit_transform(order*np.array([ranks]).T).T[0]
    ranks = map(lambda x: round(x, 2), ranks)
    return dict(zip(names, ranks ))
```

```
#Comapring models for feature selection
names = ["%s" % i for i in X]
ranks = {}

lr = LinearRegression(normalize=True)
with warnings.catch_warnings():
    warnings.simplefilter("ignore", category=DeprecationWarning)
    lr.fit(X, Y)
    ranks["Linear reg"] = rank_to_dict((lr.coef_), names)

ridge = Ridge(alpha=7)
with warnings.catch_warnings():
    warnings.simplefilter("ignore", category=DeprecationWarning)
    ridge.fit(X, Y)
    ranks["Ridge"] = rank_to_dict((ridge.coef_), names)

lasso = Lasso(alpha=.05)
with warnings.catch_warnings():
    warnings.simplefilter("ignore", category=DeprecationWarning)
    lasso.fit(X, Y)
    ranks["Lasso"] = rank_to_dict(np.abs(lasso.coef_), names)

rlasso = RandomizedLasso(alpha=0.00)
with warnings.catch_warnings():
    warnings.simplefilter("ignore", category=DeprecationWarning)
    rlasso.fit(X, Y)
    ranks["Stability"] = rank_to_dict((rlasso.scores_), names)
```

```
rf = RandomForestRegressor()
with warnings.catch_warnings():
    warnings.simplefilter("ignore", category=DeprecationWarning)
    rf.fit(X,Y)
    ranks["RF"] = rank_to_dict(rf.feature_importances_, names)

# stop the search when 5 features are left (they will get equal scores)
rfe = RFE(lr, n_features_to_select=15)
with warnings.catch_warnings():
    warnings.simplefilter("ignore", category=DeprecationWarning)
    rfe.fit(X,Y)
    ranks["RFE"] = rank_to_dict(rfe.ranking_,X.columns, order=-1)


f, pval  = f_regression(X, Y, center=True)
ranks["Corr."] = rank_to_dict(f, names)

r = {}
for name in names:
    r[name] = round(np.mean([ranks[method][name]
                             for method in ranks.keys()]), 2)
methods = sorted(ranks.keys())
ranks["Mean"] = r
methods.append("Mean")

#     f_rank = pd.DataFrame()
print ("\t%s" % "\t".join(methods))
temp= "\t".join(methods)
f=open("testing.txt", 'w')
f.write(temp)
f.write("\n")
for name in names:
    temp=name+"\t"+" \t".join(map(str,
                          [ranks[method][name] for method in methods]))
    f.write(temp)
    f.write("\n")
```

Result :

The analyzed data contains information on the following parameters:

- Amount of requested money in dollars (Amount.Requested)
- Amount of money that was loaned to the individual(Amount.Funded.By.Investors)
- Length of time of the loan in months (Loan.Length)
- Purpose of a loan as stated by the applicant (Loan.Purpose)
- The percentage of customer gross income that goes toward paying debt (Debt.To.Income.Ratio)
- The abbreviation for the U.S. state of residence of (State)
- A variable indicationg whether the applicant owns, rents or has a mortgage on his home (Home.ownership)
- The monthly income of the applicant in dollars (Monthly.income)
- A measure of the creditworthiness of the applicant, FICO Score (FICO.Range)
- The number of open lines of credit the applicant had at the
- time of application (Open.CREDIT.Lines)
- The total amount outstanding all lines of credit (Revolving.CREDIT.Balance)
- The number of authorized queries about the applicant's creditworthness in the 6 months before the credit was issued (Inquiries.in.the.Last.6.Months)
- Length of time employed at current job (Employment.Length)

	Corr.	Lasso	Linear r	RF	RFE	Ridge	Stability	Mean
term	1	0.63	0.02	0.59	0.55	0.53	1	0.62
last_meanfico	0.53	0.01	0.02	0.38	0.32	0.42	1	0.38
revol_util	0.31	0.03	0.02	0.14	0.41	0.42	1	0.33
verification_status_category	0.26	0.84	0.02	0.04	0.77	0.61	1	0.51
inq_last_6mths	0.24	0.75	0.02	0.1	0.73	0.57	1	0.49
purposecredit_card	0.15	1	0.04	0.05	0.91	0	1	0.45
installment	0.11	0.06	0.02	1	0.23	0.43	1	0.41
loan_amnt	0.1	0	0.02	0.48	0.18	0.42	1	0.31
funded_amnt_inv	0.1	0	0.02	0.28	0.09	0.42	0.98	0.27
purposedebt_consolidation	0.05	0.01	0.04	0.01	1	0.22	0.55	0.27
annual_inc	0.03	0	0.02	0.14	0	0.42	1	0.23
purposeother	0.03	0.56	0.04	0.01	1	0.58	0.99	0.46
home_ownership_category	0.02	0.21	0.02	0.01	0.68	0.33	1	0.32

Correlation analysis showed high negative correlation between Interest rate and FICO score and moderate positive correlation between interest rate and loan length and amount of money funded by investors.

There also is slight positive correlation between interest rate and inquires in the last six months and quantity of open credit lines.

Rejected Loan Data Files:

As we don't have target variable to predict, we choose to see the correlation between the variable.

```
correction_df
```

```
Amount Requested      Amount Requested        0.000000
                      Risk_Score              0.000000
                      Debt-To-Income Ratio    0.000000
                      Employment Length       0.000000
                      Policy Code             0.000000
Risk_Score            Amount Requested       -0.000399
                      Risk_Score              0.000000
                      Debt-To-Income Ratio    0.000000
                      Employment Length       0.000000
                      Policy Code             0.000000
Debt-To-Income Ratio  Amount Requested        0.000243
                      Risk_Score              0.001839
                      Debt-To-Income Ratio    0.000000
                      Employment Length       0.000000
                      Policy Code             0.000000
Employment Length     Amount Requested        0.005622
                      Risk_Score             -0.039622
                      Debt-To-Income Ratio   -0.000886
                      Employment Length       0.000000
                      Policy Code             0.000000
Policy Code           Amount Requested        0.042160
                      Risk_Score             -0.026878
                      Debt-To-Income Ratio   -0.000579
                      Employment Length       0.063920
                      Policy Code             0.000000
dtype: float64
```

Also, these were the entries which were provided by the requester while requesting a loan from Lending Loan club.

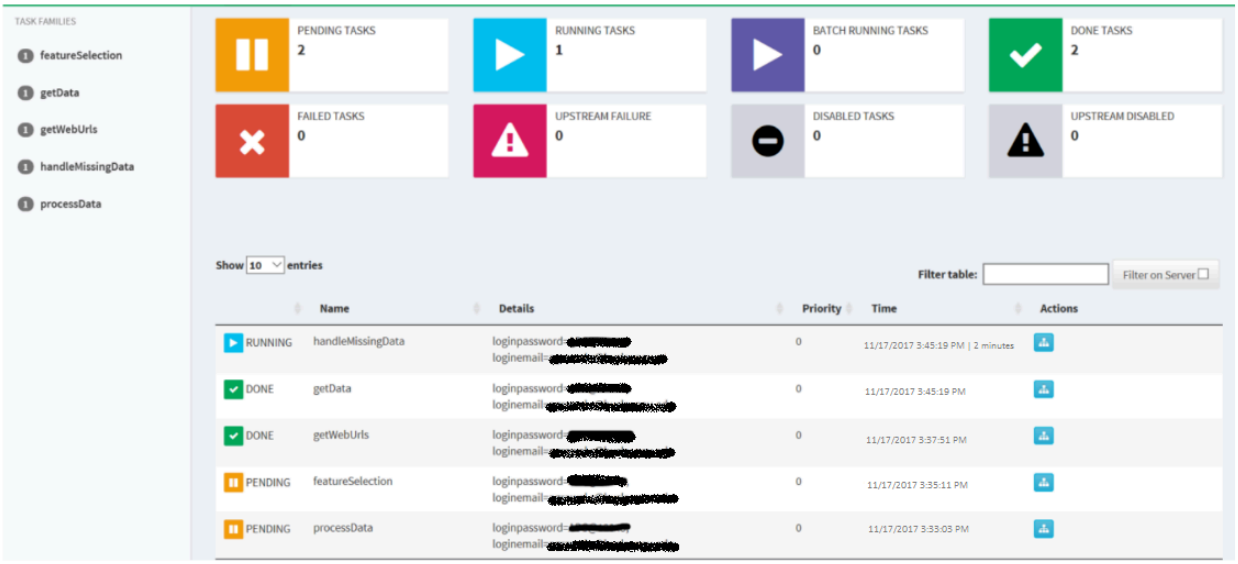
- **Amount Requested**
- **Fico_Score**
- **Annual Income**
- **Employment Length**

PIPELINING PROCESS USING LUIGI

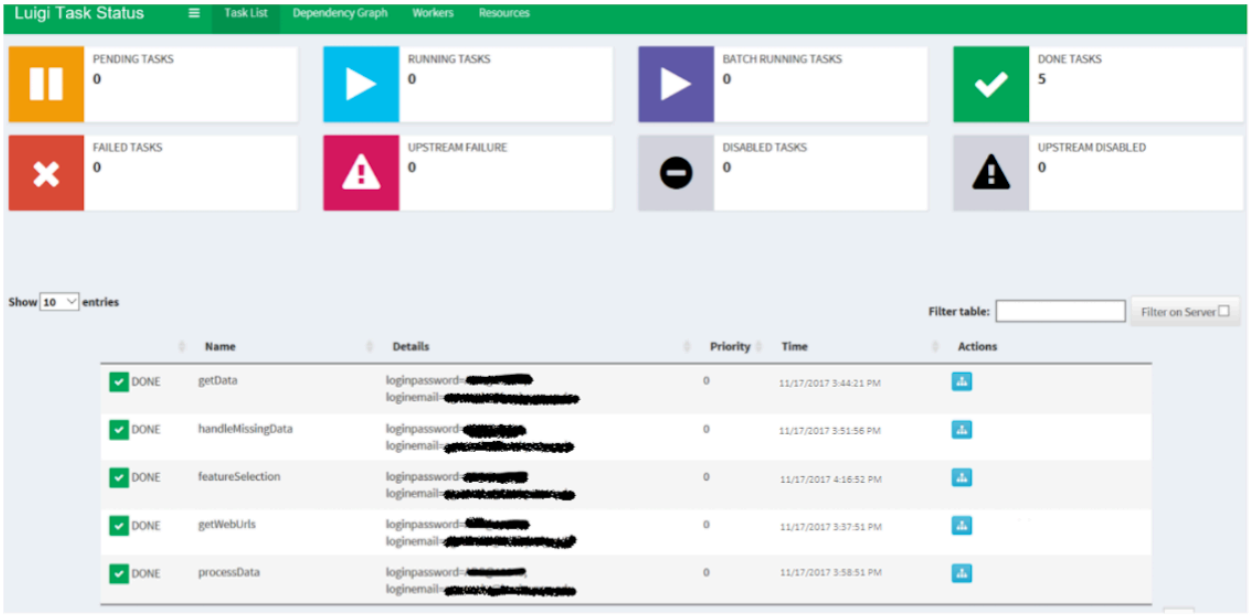
Luigi is a Python-based framework for expressing data pipelines. Everything in Luigi is in Python.

Luigi performs following functions in a pipeline for Loan data which is approved:

1. getWebUrls-Fetching urls for file download
2. getData-Merging the data from all downloaded file into a single file
3. handleMissingData-Managed missing data in the file
4. processData-Intermediate step for featureselection
5. featureSelection –Selects relevant features by applying several feature selection techniqiues.



Pipeline is completed when all the tasks into it are completed i.e. green status.



Similarly, we implemented Luigi pipeline for rejected data:

DATA EXPLORATION

In [1]:
```
%matplotlib inline
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import matplotlib as m
import seaborn as sns
```

In [2]:
```
loan=pd.read_csv('CleanedFile.csv',low_memory=False,encoding='ISO-8859-1',skipinitialspace=True)
loanfreature_df=loan
```

In [3]:
```
reject=pd.read_csv('RejectLoan.csv',low_memory=False,encoding='ISO-8859-1',skipinitialspace=True)
rejectData_df=reject
```

In [4]:
```
loan.head()
```

Out[4]:

	loan_amnt	funded_amnt	funded_amnt_inv	term	int_rate	installment	grade	sub_grade	emp_length	home_ownership
0	32000	32000	32000	36	13.99	1093.53	C	C3	10	MORTGAGE
1	35000	35000	35000	36	23.99	1372.97	E	E2	10	RENT
2	24000	24000	24000	60	13.99	558.32	C	C3	10	RENT
3	21000	21000	21000	36	13.49	712.54	C	C2	10	MORTGAGE
4	11000	11000	11000	36	9.49	352.32	B	B2	10	RENT

5 rows × 108 columns

In [5]:
```
reject.head()
```

Out[5]:

	Amount Requested	Application Date	Loan Title	Risk_Score	Debt-To-Income Ratio	State	Employment Length	Policy Code
0	30000	2015-01-01	debt_consolidation	681	35.65	CA	1	0
1	5000	2015-01-01	debt_consolidation	648	10.62	CA	1	0
2	10000	2015-01-01	Debt consolidation	721	10.02	TX	7	0
3	10000	2015-01-01	major_purchase	659	19.05	AZ	1	0
4	5000	2015-01-01	debt_consolidation	501	10.73	IN	1	0

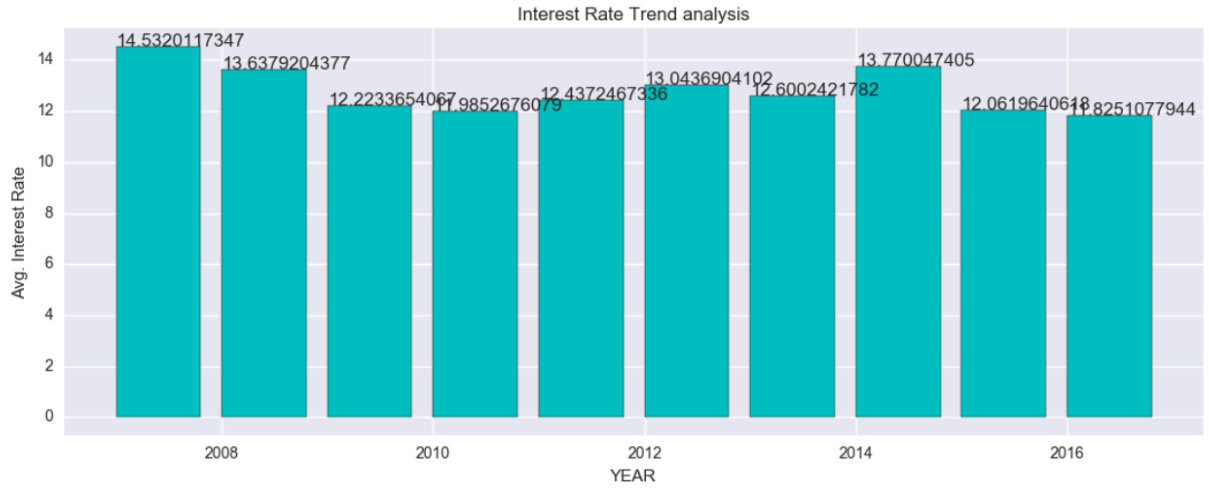
In [6]:
```
summ_df = pd.DataFrame()
grouped = loan.groupby('issue_year')
summ_df = summ_df.append(grouped.aggregate(np.mean))
summ_df['loancount']=loan['loan_amnt'].groupby(loan['issue_year']).count()
summ_df['year']=summ_df.index
summ_df
```

Out[6]:

	loan_amnt	funded_amnt	funded_amnt_inv	term	int_rate	installment	emp_length	annual_inc
issue_year								
2007	8254.519071	7946.185738	1325.519071	36.000000	11.825108	264.842090	3.109453	64743.955224
2008	8825.428333	8347.273297	3179.903051	36.000000	12.061964	278.829465	4.326786	65241.740493
2009	9833.033516	9811.541375	8668.199773	36.000000	12.437247	329.842043	4.238023	69192.281954
2010	10528.240408	10078.262343	9817.588418	42.472362	11.985268	303.322235	4.884342	69512.984765
2011	12047.503568	11848.609640	11694.905161	44.419502	12.223365	338.436839	5.209060	69456.000506
2012	13461.709015	13452.932055	13429.753893	40.450840	13.637920	421.866695	5.638353	69720.227481
2013	14707.413733	14707.371267	14699.791847	42.122569	14.532012	452.393052	6.011334	73228.081364
2014	14870.156793	14870.156793	14865.334169	43.441427	13.770047	442.468144	5.877995	74854.143212
2015	15240.285862	15240.285862	15234.156411	43.860763	12.600242	441.857881	5.766651	76965.604424
2016	14734.039046	14733.974591	14727.754074	42.127636	13.043690	444.116471	5.739682	79498.270180

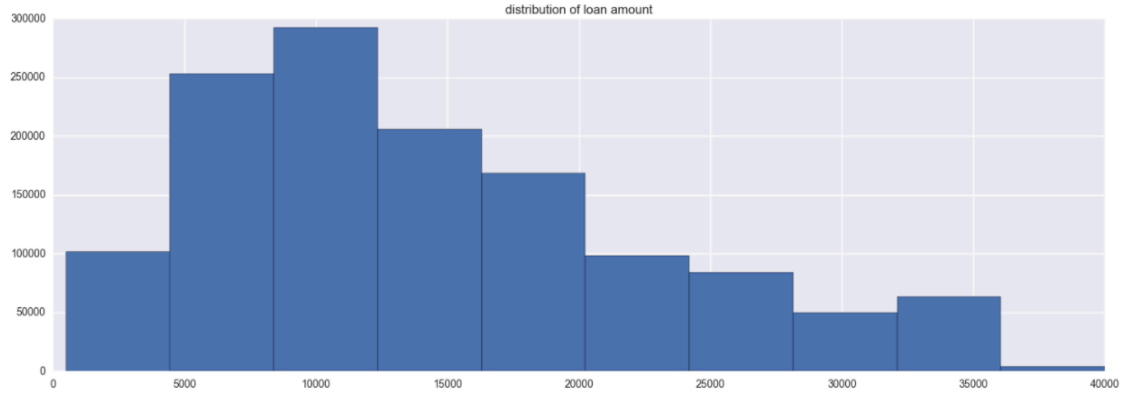
10 rows × 92 columns

In [7]:
```
from __future__ import unicode_literals
import math

def plot_time_trends_1():
    year=loan['issue_year'].drop_duplicates()
    fico=loan['last_meanfico']
    dti=summ_df['dti']

    plt.figure(num=None, figsize=(12, 10), dpi=80, facecolor='w', edgecolor='b')

    ax1=plt.subplot(211)
    plt.plot(['07','08','09','10','11','12','13','14','15','16'],dti,'r--')
    plt.xlabel('YEAR in 2000s')
    plt.ylabel('Avg. Debt to Income %')
    plt.legend(['DTI'])
    plt.grid(True)

    plt.title('Debt to Income Time Series')

    ax2=plt.subplot(212)
    bins=[650,660,670,680,690,700,710,720,730,740,750,760,770,780,790,800]
    plt.hist(fico, bins=bins, histtype='bar', rwidth=0.8 ,color='m')
    plt.xlabel('FICO')
    plt.ylabel('Counts')
    plt.title('FICO Distribution')

    ax2.margins(0.05)
    plt.subplots_adjust(top=0.92, bottom=0.08, left=0.10, right=0.95, hspace=0.25,
                        wspace=0.35)
    plt.show()

def plot_time_trends_2():
    int_rt=summ_df['int_rate']
    year=loan['issue_year'].drop_duplicates()
    dti=summ_df['dti']

    plt.figure(num=None, figsize=(12, 10), dpi=80, facecolor='w', edgecolor='b')


    ax4=plt.subplot(212)
    plt.bar(year,int_rt,color='c')
    plt.xlabel('YEAR')
    plt.ylabel('Avg. Interest Rate')
    plt.title('Interest Rate Trend analysis')
    for a,b in zip(year, int_rt):
        plt.text(a, b, str(b))

    ax4.margins(0.05)
    plt.subplots_adjust(top=0.92, bottom=0.08, left=0.10, right=0.95, hspace=0.25,
                        wspace=0.35)
    plt.show()
```



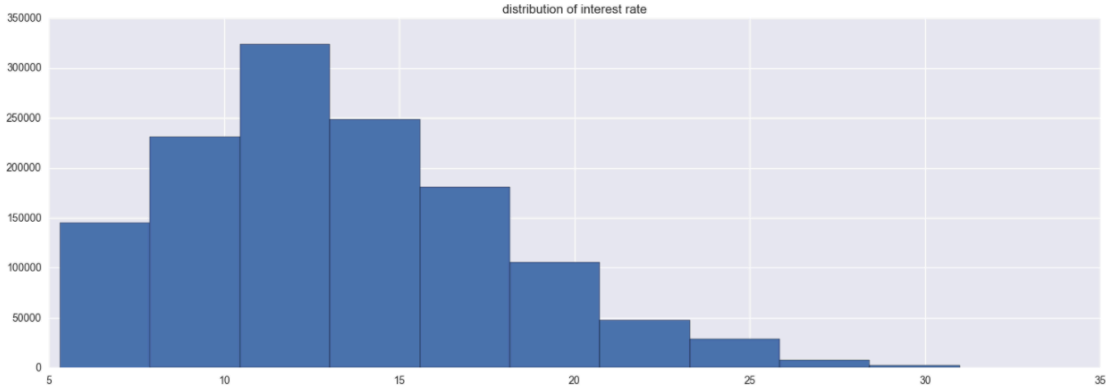
In [8]:
```
plt.rc("figure", figsize=(18, 6))
loan["loan_amnt"].hist()
plt.title("distribution of loan amount")
```

Out[8]: <matplotlib.text.Text at 0x2018760ff60>



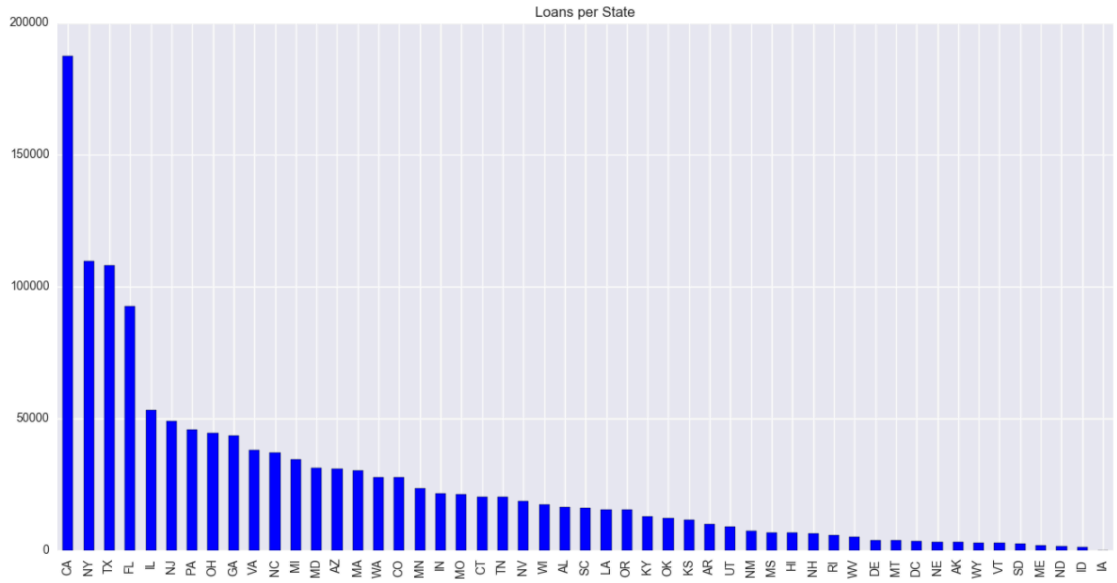
In [9]:
```
plt.rc("figure", figsize=(18, 6))
loan["int_rate"].hist()
plt.title("distribution of interest rate")
```

Out[9]: <matplotlib.text.Text at 0x201878a0710>



In [10]:
```
state_count = loan.addr_state.value_counts()
state_count.plot(kind = 'bar',figsize=(16,8),color='blue', title = 'Loans per State')
```

Out[10]: <matplotlib.axes._subplots.AxesSubplot at 0x20187885978>



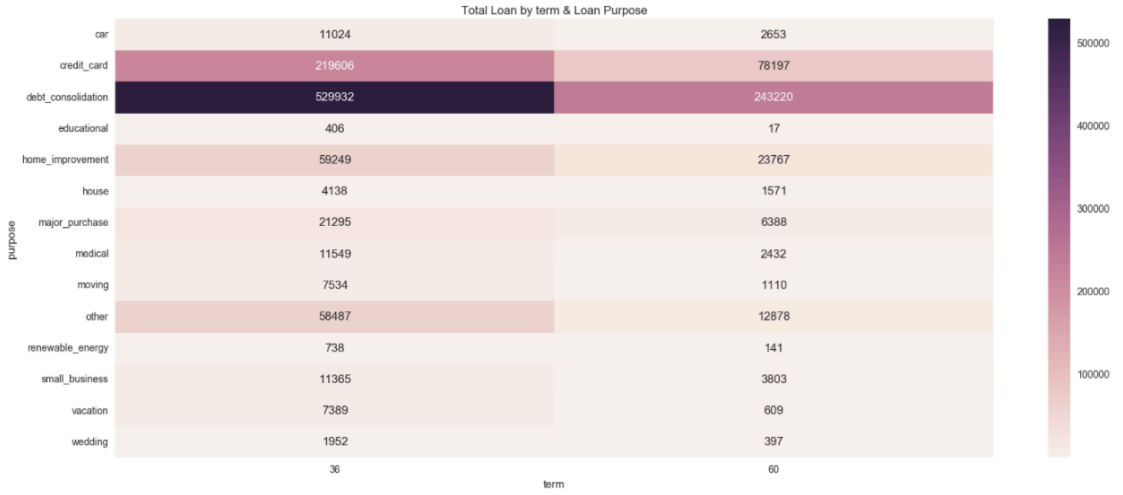
In [11]:
```
loanpurp = pd.DataFrame()
loanpurp = loan.groupby(['term','purpose']).size().sort_values()
loanp = loanpurp.unstack()
loanp
```

Out[11]:

purpose	car	credit_card	debt_consolidation	educational	home_improvement	house	major_purchase	medical	movi
term									
36	11024	219606	529932	406	59249	4138	21295	11549	7534
60	2653	78197	243220	17	23767	1571	6388	2432	1110

In [12]:
```
import seaborn as sns
sns.set(style='white')

plt.figure(figsize=(20, 8))
plt.title('Total Loan by term & Loan Purpose')
ax =sns.heatmap(loanp.T,mask= loanp.T.isnull(),annot=True,fmt='g');
ax
```

Out[12]: <matplotlib.axes._subplots.AxesSubplot at 0x20187898f28>

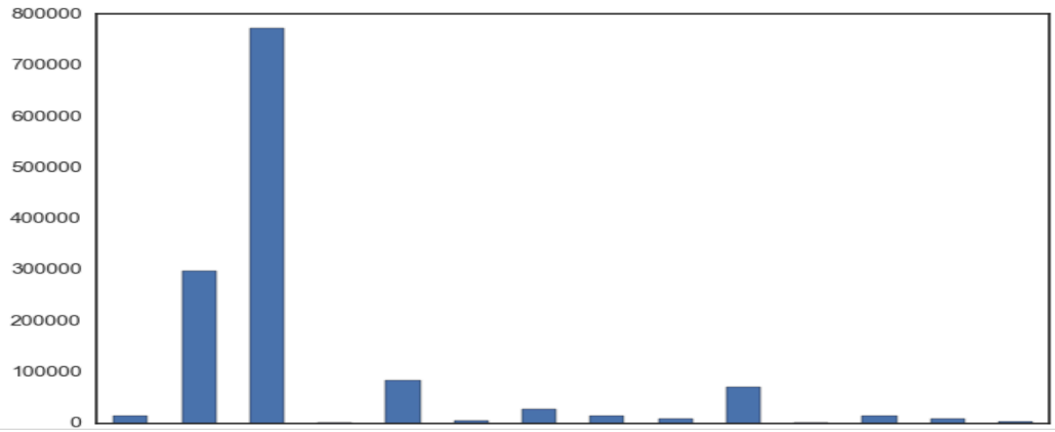


In [13]:
```
# What is the distribution of loans by purpose?
loans_by_purpose = loan.groupby('purpose')
print(loans_by_purpose['purpose'].count())
loans_by_purpose['purpose'].count().plot(kind='bar')
```

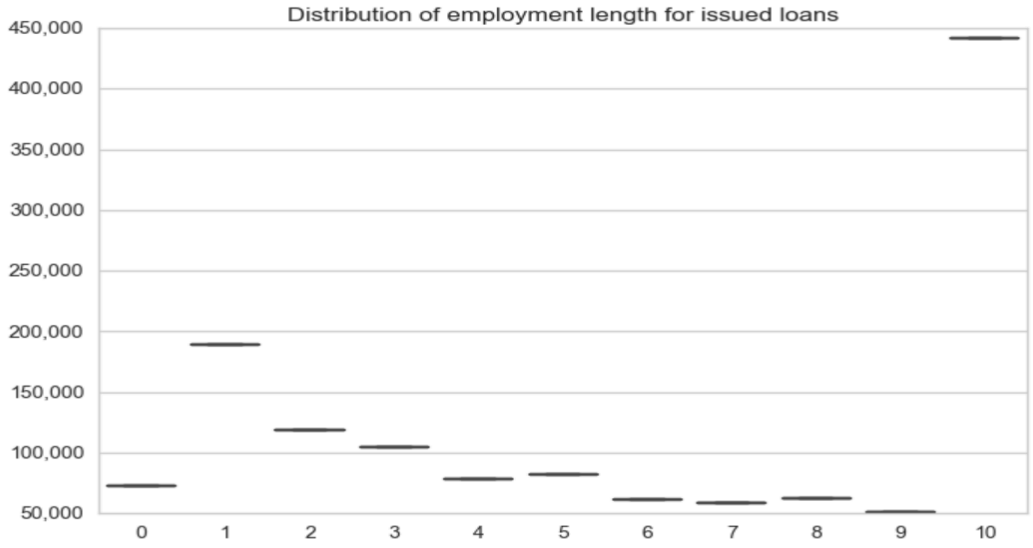
In [13]:
```
# What is the distribution of loans by purpose?
loans_by_purpose = loan.groupby('purpose')
print(loans_by_purpose['purpose'].count())
loans_by_purpose['purpose'].count().plot(kind='bar')
```

```
purpose
car                    13677
credit_card           297803
debt_consolidation    773152
educational              423
home_improvement       83016
house                   5709
major_purchase         27683
medical                13981
moving                  8644
other                  71365
renewable_energy         879
small_business         15168
vacation                7998
wedding                 2349
Name: purpose, dtype: int64
```

Out[13]: <matplotlib.axes._subplots.AxesSubplot at 0x201875d5240>



In [14]:
```
s = pd.value_counts(loan['emp_length']).to_frame().reset_index()
s.columns = ['type', 'count']
def emp_dur_graph(graph_title):

    sns.set(style="whitegrid", color_codes=True)
    ax = sns.boxplot(y = "count", x = 'type', data=s)
    ax.set(xlabel = '', ylabel = '', title = graph_title)
    ax.get_yaxis().set_major_formatter(
    m.ticker.FuncFormatter(lambda x, p: format(int(x), ',')))
    _ = ax.set_xticklabels(ax.get_xticklabels(), rotation=0)

emp_dur_graph('Distribution of employment length for issued loans')
```

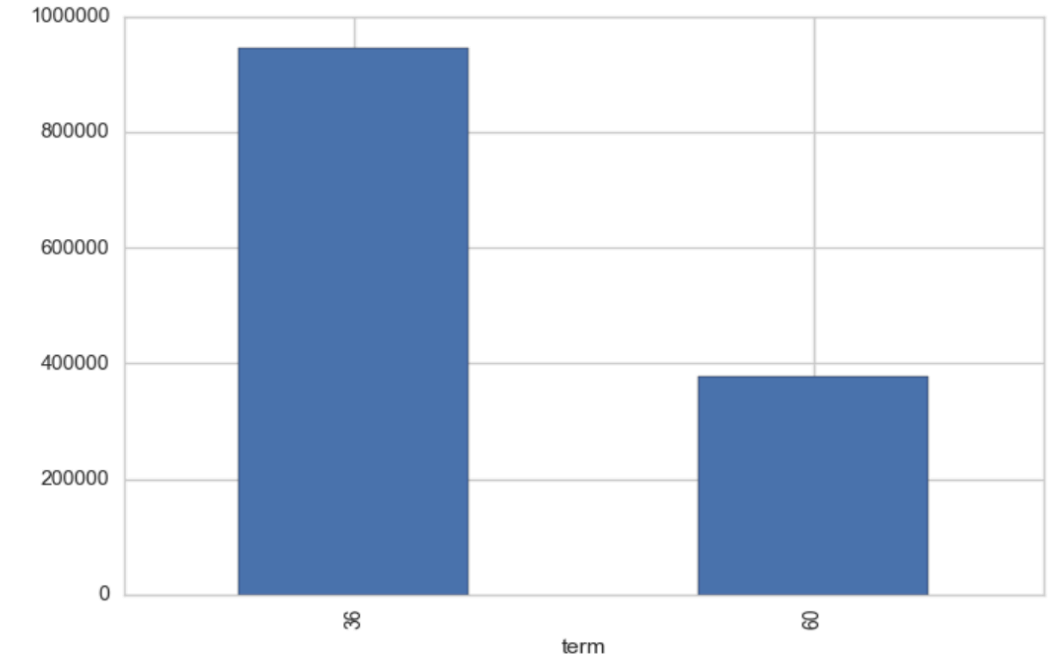


In [ ]:
```
#Total interest rate ByYear
import pylab
import numpy as np
import seaborn as sns
import matplotlib.pyplot as plt

pylab.rcParams['figure.figsize'] = (30.0, 10.0)

sns.set_style("darkgrid")

year=np.sort(loan["issue_year"].unique().tolist())

with plt.style.context('fivethirtyeight'):
    ax1 = plt.subplot2grid((4,2), (0,0), colspan=3)
    order=loan["purpose"].drop_duplicates().tolist()
    ax1 = sns.barplot(x='purpose',y="int_rate",data = loan, order = order)
    ax1 = plt.xticks(size = 10,rotation = 80)
    ax1 = plt.title("'purpose' v/s 'interest rate'")

    ax2 = plt.subplot2grid((4,2), (1, 0))
    ax2 = plt.rc("figure", figsize=(10, 8))
    ax2 = sns.barplot(x='term',y="int_rate",data = loan)
    ax2 = plt.title("'term' v/s 'interest rate'")

    ax3 = plt.subplot2grid((4,2), (1, 1))
    ax3 = plt.rc("figure", figsize=(6, 4))
    ax3 = sns.barplot(x='home_ownership',y="int_rate",data = loan)
    ax3 = plt.title("'home_ownership' v/s 'int_rate'")

    ax4 = plt.subplot2grid((4,2), (2, 0))
    ax4 = plt.rc("figure", figsize=(10, 8))
    ax4 = sns.barplot(x='emp_length',y="int_rate",data = loan)
    ax4 = plt.title("'employee length' v/s 'interest rate'")
    ax4 = plt.xticks(size = 10,rotation = 80)

    ax5 = plt.subplot2grid((4,2), (2, 1))
    ax5 = plt.rc("figure", figsize=(10, 8))
    order = np.sort(loan["issue_year"].unique().tolist())
    ax5 = sns.barplot(x='issue_year',y="int_rate",data = loan, order = order)
    ax5 = plt.title("'issue_year' v/s 'interest rate'")
    ax5 = plt.xticks(size = 10,rotation = 80)

    ax6 = plt.subplot2grid((4,2), (3, 0))
    ax6 = plt.rc("figure", figsize=(10, 8))
    ax6 = sns.barplot(x='application_type',y="int_rate",data = loan)
    ax6 = plt.title("'application type' v/s 'interest rate'")



plt.tight_layout(2)
```

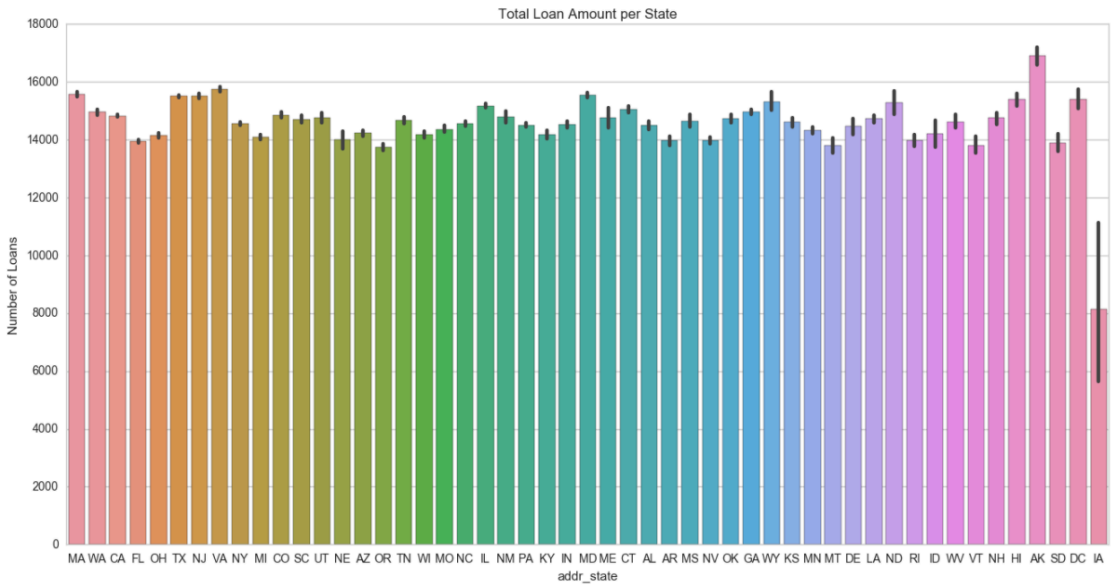
In [15]:
```
# What is the distribution of loans by term?
loans_by_term = loan.groupby('term')
print(loans_by_term['term'].count())
loans_by_term['term'].count().plot(kind='bar')
```

```
term
36    944664
60    377183
Name: term, dtype: int64
```

Out[15]: <matplotlib.axes._subplots.AxesSubplot at 0x201875f5f60>

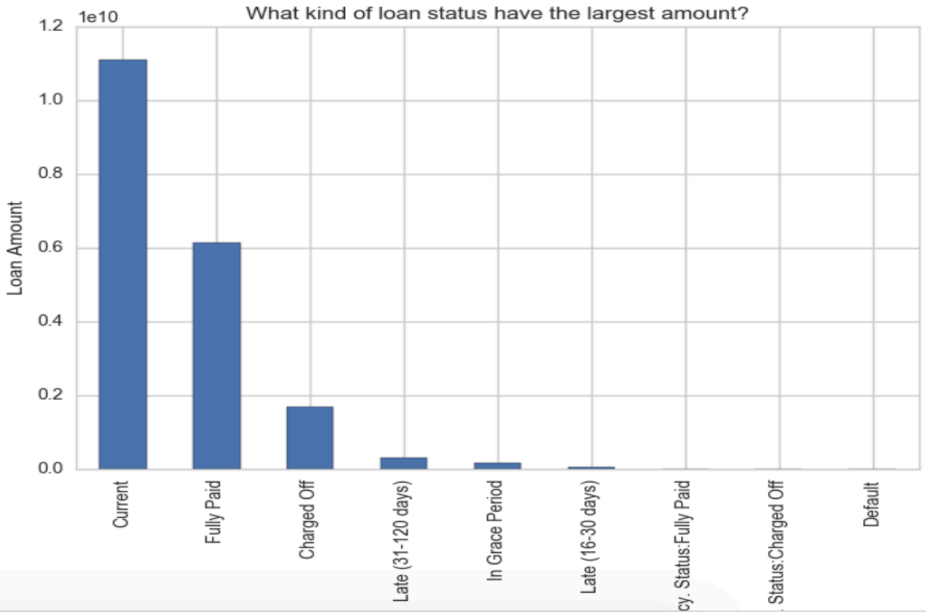


In [16]:
```
fig, ax = plt.subplots(figsize = (16,8))
ax = sns.barplot(x='addr_state', y='loan_amnt', data=loan)
ax.set(ylabel = 'Number of Loans', title = 'Total Loan Amount per State')
plt.show()
```



In [17]:
```
loan.groupby('loan_status')['loan_amnt'].sum().sort_values(ascending=0).plot(kind='bar')
plt.xlabel('Loan Status')
plt.ylabel('Loan Amount')
plt.title('What kind of loan status have the largest amount?')
```

Out[17]: <matplotlib.text.Text at 0x20188c772b0>



In [18]:
```
rejectData_df['issue_d'] = rejectData_df['Application Date'].str.split("-")
rejectData_df['Issue_year']=rejectData_df['issue_d'].str[0]
reject_cols_to_keep=['Amount Requested', 'Employment Length', 'Risk_Score', 'Debt-To-Income Ratio'
,'Issue_year']
rejectData_df=rejectData_df[reject_cols_to_keep]
rejectData_df['Approval_status']=0
rejectData_df.head()
```

```
C:\Users\vishakha\Anaconda3\lib\site-packages\ipykernel\__main__.py:5: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: http://pandas.pydata.org/pandas-docs/stable/indexing.html#in
dexing-view-versus-copy
```

Out[18]:

	Amount Requested	Employment Length	Risk_Score	Debt-To-Income Ratio	Issue_year	Approval_status
0	30000	1	681	35.65	2015	0
1	5000	1	648	10.62	2015	0
2	10000	7	721	10.02	2015	0
3	10000	1	659	19.05	2015	0
4	5000	1	501	10.73	2015	0

In [19]:
```
cols_to_keep=['loan_amnt', 'emp_length', 'last_meanfico', 'dti','issue_year']
loanfreature_df=loanfreature_df[cols_to_keep]
loanfreature_df['Approval_status']=1
loanfreature_df.columns=['Amount Requested', 'Employment Length', 'Risk_Score', 'Debt-To-Income Ra
tio','Issue_year','Approval_status']
loanfreature_df.head()
```

```
C:\Users\vishakha\Anaconda3\lib\site-packages\ipykernel\__main__.py:3: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: http://pandas.pydata.org/pandas-docs/stable/indexing.html#in
dexing-view-versus-copy
  app.launch_new_instance()
```

Out[19]:

	Amount Requested	Employment Length	Risk_Score	Debt-To-Income Ratio	Issue_year	Approval_status
0	32000	10	712.0	17.30	2016	1
1	35000	10	672.0	15.61	2016	1
2	24000	10	697.0	19.30	2016	1
3	21000	10	697.0	25.00	2016	1
4	11000	10	682.0	11.90	2016	1

In [20]:
```
x_train1=loanfreature_df
x_test1=rejectData_df
frames=[x_train1,x_test1]
result = pd.concat(frames)
result.head()
```

Out[20]:

	Amount Requested	Employment Length	Risk_Score	Debt-To-Income Ratio	Issue_year	Approval_status
0	32000	10	712.0	17.30	2016	1
1	35000	10	672.0	15.61	2016	1
2	24000	10	697.0	19.30	2016	1
3	21000	10	697.0	25.00	2016	1
4	11000	10	682.0	11.90	2016	1

In [ ]:
```
# Analysis of Yearly approved and rejected loans
y=result
y=pd.DataFrame({'count' : y.groupby( ['Issue_year','Approval_status'] ).size()}).reset_index()
y
```

In [ ]:
```
# Barplot to show yearwise approval status
g = sns.factorplot(x="Issue_year", y="count", hue="Approval_status", data=y,
                   size=10, kind="bar", palette="muted")
g.despine(left=True)
g.set_ylabels("Count")
```

In [ ]:
```
# Barplot to show yearwise approval status
g = sns.factorplot(x="Issue_year", y="count", hue="Approval_status", data=y,
                   size=10, kind="bar", palette="muted")
g.despine(left=True)
g.set_ylabels("Count")
```

In [ ]:
```
# Analysis of approval status
X=result.groupby(['Approval_status']).count()

X['status']=X.index
# print(X)

# Barplot to show categorization of approval status
g=sns.factorplot(x="status",y='Issue_year',data=X,size=6, kind="bar", palette="muted")
g.despine(left=True)
g.set_ylabels("Count")
```

In [ ]:
```
# Plot to show Risk_Score analysis as per the approval status
z=result
g = sns.FacetGrid(z,col="Approval_status",col_order=[0,1])
g = g.map(plt.hist, "Risk_Score",color="m")
```

Part2:

CLASSIFICATION

In [1]:
```
# Package imports
%matplotlib inline
from IPython.display import Image
import matplotlib as mlp
import matplotlib.pyplot as plt
import numpy as np
import pandas as pd
import sklearn
import warnings
from sklearn.metrics import roc_curve
from sklearn.utils import ConvergenceWarning
from sklearn.linear_model import LogisticRegression
from sklearn.ensemble import RandomForestClassifier
from sklearn.metrics import confusion_matrix
from sklearn import cross_validation
from sklearn import tree
from sklearn import svm
from sklearn import ensemble
from sklearn import neighbors
from sklearn import linear_model
from sklearn import metrics
from sklearn import preprocessing
import matplotlib.pyplot as plt
import numpy as np
from sklearn.linear_model import LinearRegression
from sklearn.linear_model import LogisticRegression
import pandas as pd
import statsmodels.formula.api as smf
from sklearn.preprocessing import LabelEncoder
from sklearn.preprocessing import StandardScaler
from sklearn.cross_validation import train_test_split, KFold, StratifiedShuffleSplit,StratifiedKFo
ld
from sklearn.ensemble import RandomForestClassifier
from sklearn.svm import SVC
from sklearn import metrics
from sklearn.metrics import confusion_matrix
from sklearn.metrics import roc_curve
from sklearn.metrics import accuracy_score
import matplotlib.pyplot as plt
from sklearn.feature_selection import RFE
import warnings
warnings.filterwarnings('ignore')
```

In [2]:
```
from io import StringIO
import requests
import json
import pandas as pd

# @hidden_cell
# This function accesses a file in your Object Storage. The definition contains your credentials.
# You might want to remove those credentials before you share your notebook.
def get_object_storage_file_with_credentials_14d326a3558e4fc0bfeb2361ed8fd35c(container, filename
):
    """This functions returns a StringIO object containing
    the file content from Bluemix Object Storage."""

    url1 = ''.join(['https://identity.open.softlayer.com', '/v3/auth/tokens'])
    data = {'auth': {'identity': {'methods': ['password'],
            'password': {'user': {'name': 'member_3c25b61fef62727472d70bdd15a6ecc3b9af4f3b','domai
n': {'id': 'fcf7d2f57ba04101a6ee7e43c6b09dc5'},
            'password': 'VW28-eGxM{X-!mji'}}}}}
    headers1 = {'Content-Type': 'application/json'}
    resp1 = requests.post(url=url1, data=json.dumps(data), headers=headers1)
    resp1_body = resp1.json()
    for e1 in resp1_body['token']['catalog']:
        if(e1['type']=='object-store'):
            for e2 in e1['endpoints']:
                        if(e2['interface']=='public'and e2['region']=='dallas'):
                            url2 = ''.join([e2['url'],'/', container, '/', filename])
    s_subject_token = resp1.headers['x-subject-token']
    headers2 = {'X-Auth-Token': s_subject_token, 'accept': 'application/json'}
    resp2 = requests.get(url=url2, headers=headers2)
    return StringIO(resp2.text)

df_data_1 = pd.read_csv(get_object_storage_file_with_credentials_14d326a3558e4fc0bfeb2361ed8fd35c(
'ADSAssignment2', 'Final_loan.csv'))
df_data_1.head()
```

Out[2]:

	loan_amnt	last_meanfico	dti	addr_state	emp_length	policy_code	purpose	issue_month	issue_year	status
0	5000	737	27.65	AZ	10	1	credit_card	12	2011	1
1	2500	742	1.00	GA	1	1	car	12	2011	1
2	2400	737	8.72	IL	10	1	small_business	12	2011	1
3	10000	692	20.00	CA	10	1	other	12	2011	1
4	3000	697	17.94	OR	1	1	other	12	2011	1

In [3]:
```
#Keep the following 6 features (variables) which are important
cols_to_keep = ['loan_amnt', 'last_meanfico', 'dti','addr_state','emp_length','purpose']
train, test = sklearn.cross_validation.train_test_split(df_data_1, train_size = 0.7)
train_y = train['status']
test_y = test['status']
train_x = train[cols_to_keep]
test_x = test[cols_to_keep]
```

In [4]:
```
from sklearn import preprocessing
# Discreet value integer encoder
label_encoder = preprocessing.LabelEncoder()
# State is string and we want discre integer values
train_x['state'] = label_encoder.fit_transform(train_x['addr_state'])
test_x['state'] = label_encoder.fit_transform(test_x['addr_state'])
train_x['purp'] = label_encoder.fit_transform(train_x['purpose'])
test_x['purp'] = label_encoder.fit_transform(test_x['purpose'])
```

In [5]:
```
train_x = train_x._get_numeric_data()
test_x = test_x._get_numeric_data()
```

In [6]:
```
train_x.head()
```

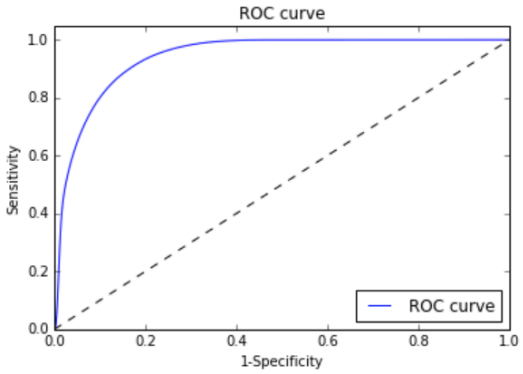
Out[6]:

	loan_amnt	last_meanfico	dti	emp_length	state	purp
6666991	5000	501	13.97	1	37	55
460892	10000	697	3.72	10	5	49
6289137	7000	304	10.60	1	20	45
12054109	25000	304	69.76	1	2	45
11516824	1500	304	319.24	1	36	52

In [8]:
```
def calculate_roc_curve(Y_test, y_pred, pos_label):
    fpr, tpr, _ = roc_curve(Y_test, preds)
    #Plot ROC curve
    plt.figure()
    plt.plot(fpr, tpr, label='ROC curve')
    plt.plot([0, 1], [0, 1], 'k--')
    plt.xlim([0.0, 1.0])
    plt.ylim([0.0, 1.05])
    plt.xlabel('1-Specificity')
    plt.ylabel('Sensitivity')
    plt.title('ROC curve')
    plt.legend(loc="lower right")
    plt.show()

def calculate_confusion_matrix(y_true, y_pred):
    cm=confusion_matrix(y_true, y_pred)
    print(cm)
```

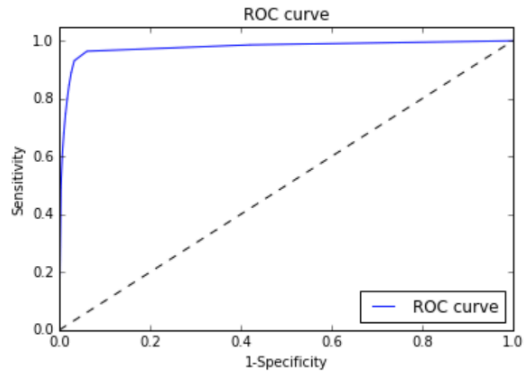
In [9]:
```
#logistic regression
log_reg = LogisticRegression()
log_reg.fit(train_x, train_y)
print ("Intercept is ",log_reg.intercept_)
print("Coefficient is ",log_reg.coef_)
y_pred=log_reg.predict(test_x)

#calculate ROC curve
preds = log_reg.predict_proba(test_x)[:,1]
calculate_roc_curve(test_y, preds,2)

#calculate Confusion Matrix
calculate_confusion_matrix(test_y, y_pred)

print(accuracy_score(test_y, y_pred))
```

```
('Intercept is ', array([-4.35235659]))
('Coefficient is ', array([[ -2.07088278e-05,   6.27878832e-03,  -2.32898171e-02,
          3.20780048e-01,  -1.67046429e-02,  -2.21743219e-02]]))
```




```
[[3256338   67854]
 [ 213655  182523]]
0.924333063647
```

In [10]:
```
#Random Forest
rf = RandomForestClassifier(n_jobs=2)
rf.fit(train_x, train_y)
preds = rf.predict_proba(test_x)[:,1]
y_pred=rf.predict(test_x)
#calculate ROC curve
calculate_roc_curve(test_y, y_pred,2)
 #calculate Confusion Matrix

calculate_confusion_matrix(test_y, y_pred)
print(accuracy_score(test_y, y_pred))
```




```
[[3266240   57952]
 [  79249  316929]]
0.963121678758
```

In [ ]:
```
print("Staring Support Vector Machine")
clf = SVC()
clf.fit(train_x, train_y)
y_pred=clf.predict(test_x)

#calculate ROC curve
preds = clf.predict_proba(test_x)[:,1]
calculate_roc_curve(test_y, preds,2)
 #calculate Confusion Matrix

calculate_confusion_matrix(Y_test, y_pred)
print(accuracy_score(Y_test, y_pred))
```

In [12]:
```
# RFE Code to extract features
model = LogisticRegression()
rfe = RFE(model, 5)
fit = rfe.fit(train_x, train_y)
print("Num Features:", fit.n_features_)
print("Selected Features" , fit.support_)
print("Feature Ranking: ", fit.ranking_)
```

```
('Num Features:', 5)
('Selected Features', array([False,  True,  True,  True,  True,  True], dtype=bool))
('Feature Ranking: ', array([2, 1, 1, 1, 1, 1]))
```

In [13]:
```
#stats model for feature extraction
import statsmodels.api as sm
from statsmodels.formula.api import logit, probit, poisson, ols
logit = sm.Logit(train_y, train_x)
affair_mod = logit.fit()
print(affair_mod.summary())
```

```
Optimization terminated successfully.
         Current function value: 0.266703
         Iterations 13
                           Logit Regression Results
==============================================================================
Dep. Variable:                 status   No. Observations:              8680863
Model:                          Logit   Df Residuals:                  8680857
Method:                           MLE   Df Model:                            5
Date:                Fri, 14 Apr 2017   Pseudo R-squ.:                  0.2142
Time:                        02:12:54   Log-Likelihood:            -2.3152e+06
converged:                       True   LL-Null:                   -2.9464e+06
                                        LLR p-value:                     0.000
==============================================================================
                 coef    std err          z      P>|z|      [95.0% Conf. Int.]
------------------------------------------------------------------------------
loan_amnt  -4.056e-05   1.29e-07   -315.473      0.000     -4.08e-05 -4.03e-05
last_meanfico     0.0032   6.23e-06    516.059      0.000         0.003     0.003
dti           -0.0336   9.24e-05   -363.547      0.000        -0.034    -0.033
emp_length        0.3261      0.000    840.105      0.000         0.325     0.327
state         -0.0316   8.06e-05   -392.551      0.000        -0.032    -0.031
purp          -0.0644   6.83e-05   -943.143      0.000        -0.065    -0.064
==============================================================================
```

In [ ]:
```
# build a neural network

#Calculating rows and columns for input dfs
trn_rows,trn_cols=train_x.shape
tst_rows,tst_cols=test_x.shape

# build train dataset
train_data = ClassificationDataSet(trn_cols, 1 , nb_classes=2)
for k in range(len(train_x)):
    train_data.addSample(train_x.iloc[k],train_y.iloc[k])

# build test dataset
test_data = ClassificationDataSet(tst_cols, 1 , nb_classes=2)
for k in range(len(test_x)):
    test_data.addSample(test_x.iloc[k],test_y.iloc[k])


print("Train Dataset input length: {}".format(len(train_data['input'])))
print("Train Dataset output length: {}".format(len(train_data['target'])))
print("Train Dataset input|output dimensions are {}|{}".format(train_data.indim, train_data.outdim
))

print("Train Data length: {}".format(len(train_data)))
print("Test Data length: {}".format(len(test_data)))

# encode with one output neuron per class
train_data._convertToOneOfMany()
test_data._convertToOneOfMany()

print("Train Data input|output dimensions are {}|{}".format(train_data.indim, train_data.outdim))
print("Test Data input|output dimensions are {}|{}".format(test_data.indim, test_data.outdim))

# build network (INPUT=10,HIDDEN=5,CLASSES=2,outclass=SoftmaxLayer)
print("Building Neural network with 5 hidden layer")
network = buildNetwork(train_data.indim,5,train_data.outdim,outclass=SoftmaxLayer)

# train network
print("Training the network, it may take a while...")
trainer = BackpropTrainer(network,dataset=train_data,momentum=0.1,verbose=True,weightdecay=0.01)
trainer.trainOnDataset(train_data, 1) #training model on One epoch

print("Total epochs: {}".format(trainer.totalepochs))

# test network
print("Predicting the output array with the trained model")
output = network.activateOnDataset(test_data).argmax(axis=1)

#Neural network Percent error and accuracy
print("Percent error: {}".format(percentError(output, test_data['class'])))
print("Model Accuracy: {}".Validator.classificationPerformance(output, test_y))

#Compute confusion metrics
calculate_confusion_matrix(test_y,output)
```

AZUAR ML

1. Importing Dataset

1. Click 'Datasets' on the left menu of the studio.

2. Now click on the '+' to import the dataset from the local storage.

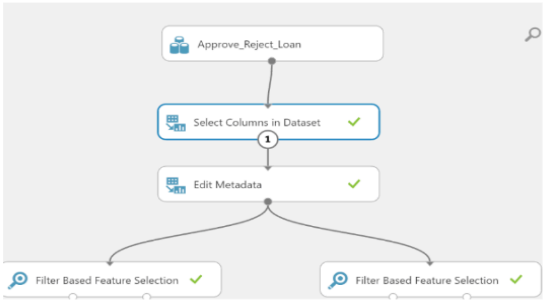
3. When NEW is click it will give following option:

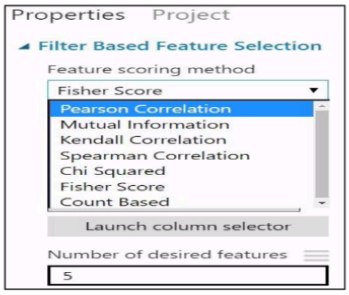
4. choose your dataset and follow the instructions to finish import.

2. Feature selection experiment

Before we proceed with our experiment, we have done feature selection in a separate experiment.

Since we have 10 different features which consist of 5 Main features and 3 derived feature, we apply the feature selection technique to come up with the best feature used to classify the applicant Loan request.





We used 2 different method to find the best feature for our model:

- Pearson Correlation
- Chi-Squared

emp_length	last_meanfico	purpose	dti	loan_amnt
5178164.458377	3979911.756731	1328207.627503	810644.177579	542349.419562

So, we shortlist the above features to use it in our clustering experiment.

3. Drag dataset to classification experiment

```
In [3]: #Keep the following 6 features (variables) which are important
cols_to_keep = ['loan_amnt', 'last_meanfico', 'dti','addr_state','emp_length','purpose']
train, test = sklearn.cross_validation.train_test_split(df_data_1, train_size = 0.7)
train_y = train['status']
test_y = test['status']
train_x = train[cols_to_keep]
test_x = test[cols_to_keep]
```

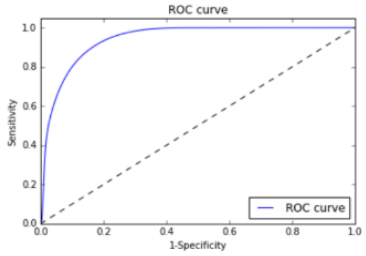
```
In [4]: from sklearn import preprocessing
# Discreet value integer encoder
label_encoder = preprocessing.LabelEncoder()
# State is string and we want discre integer values
train_x['state'] = label_encoder.fit_transform(train_x['addr_state'])
test_x['state'] = label_encoder.fit_transform(test_x['addr_state'])
train_x['purp'] = label_encoder.fit_transform(train_x['purpose'])
test_x['purp'] = label_encoder.fit_transform(test_x['purpose'])
```

```
In [5]: train_x = train_x._get_numeric_data()
test_x = test_x._get_numeric_data()
```

Logistic Regression:

```
#Logistic regression
log_reg = LogisticRegression()
log_reg.fit(train_x, train_y)
print ("Intercept is ",log_reg.intercept_)
print("Coefficient is ",log_reg.coef_)
y_pred=log_reg.predict(test_x)

#calculate ROC curve
preds = log_reg.predict_proba(test_x)[:,1]
calculate_roc_curve(test_y, preds,2)

#calculate Confusion Matrix
calculate_confusion_matrix(test_y, y_pred)

print(accuracy_score(test_y, y_pred))
```

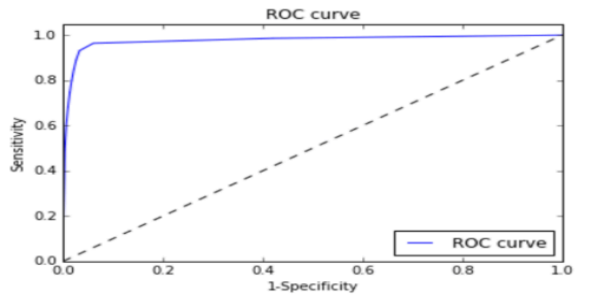
```
('Intercept is ', array([-4.35235659]))
('Coefficient is ', array([[ -2.07088278e-05,   6.27878832e-03,  -2.32898171e-02,
         3.20780048e-01,  -1.67046429e-02,  -2.21743219e-02]]))
```




```
[[3256338   67854]
 [ 213655  182523]]
0.924333063647
```

Random Dense Forest:

```
#Random Forest
rf = RandomForestClassifier(n_jobs=2)
rf.fit(train_x, train_y)
preds = rf.predict_proba(test_x)[:,1]
y_pred=rf.predict(test_x)
#calculate ROC curve
calculate_roc_curve(test_y, y_pred,2)
 #calculate Confusion Matrix

calculate_confusion_matrix(test_y, y_pred)
print(accuracy_score(test_y, y_pred))
```




```
[[3266240   57952]
 [  79249  316929]]
0.963121678758
```

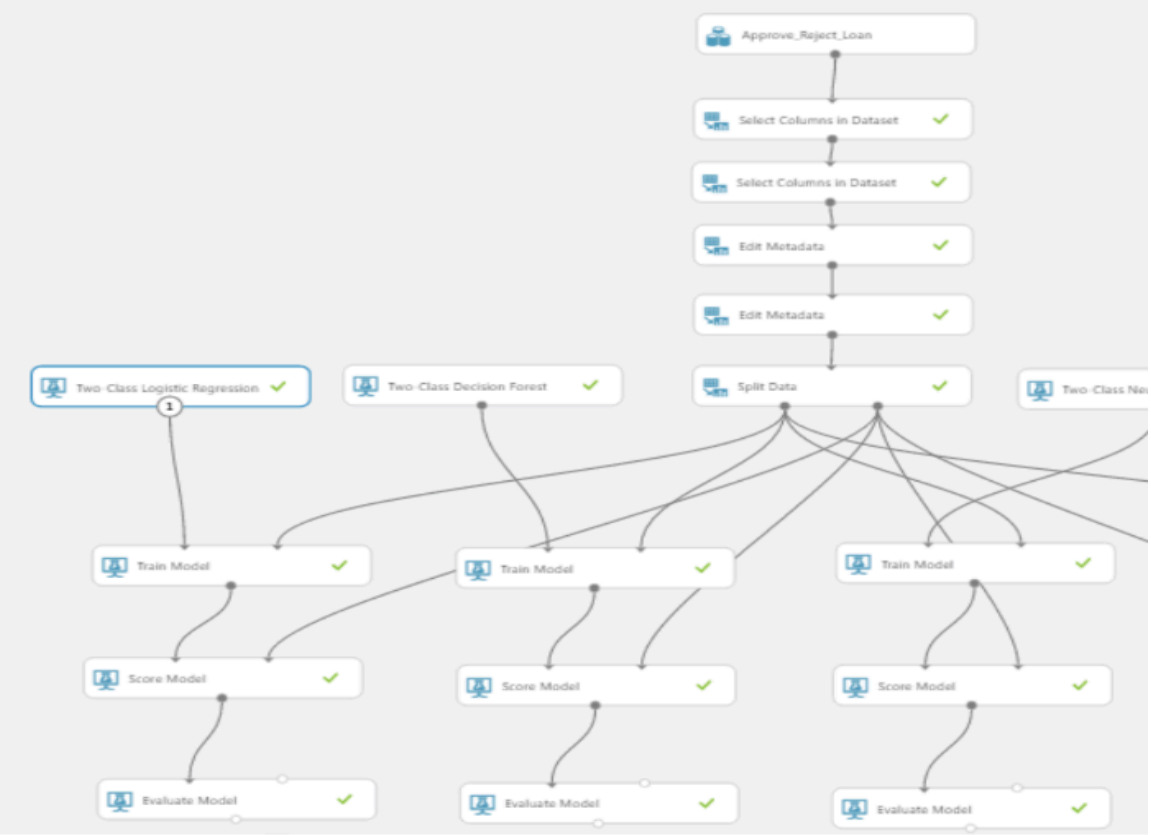
Neural Network models:

In [ ]:
```
# build a neural network

#Calculating rows and columns for input dfs
trn_rows,trn_cols=train_x.shape
tst_rows,tst_cols=test_x.shape

# build train dataset
train_data = ClassificationDataSet(trn_cols, 1 , nb_classes=2)
for k in range(len(train_x)):
    train_data.addSample(train_x.iloc[k],train_y.iloc[k])

# build test dataset
test_data = ClassificationDataSet(tst_cols, 1 , nb_classes=2)
for k in range(len(test_x)):
    test_data.addSample(test_x.iloc[k],test_y.iloc[k])


print("Train Dataset input length: {}".format(len(train_data['input'])))
print("Train Dataset output length: {}".format(len(train_data['target'])))
print("Train Dataset input|output dimensions are {}|{}".format(train_data.indim, train_data.outdim
))

print("Train Data length: {}".format(len(train_data)))
print("Test Data length: {}".format(len(test_data)))

# encode with one output neuron per class
train_data._convertToOneOfMany()
test_data._convertToOneOfMany()

print("Train Data input|output dimensions are {}|{}".format(train_data.indim, train_data.outdim))
print("Test Data input|output dimensions are {}|{}".format(test_data.indim, test_data.outdim))

# build network (INPUT=10,HIDDEN=5,CLASSES=2,outclass=SoftmaxLayer)
print("Building Neural network with 5 hidden layer")
network = buildNetwork(train_data.indim,5,train_data.outdim,outclass=SoftmaxLayer)

# train network
print("Training the network, it may take a while...")
trainer = BackpropTrainer(network,dataset=train_data,momentum=0.1,verbose=True,weightdecay=0.01)
trainer.trainOnDataset(train_data, 1) #training model on One epoch

print("Total epochs: {}".format(trainer.totalepochs))

# test network
print("Predicting the output array with the trained model")
output = network.activateOnDataset(test_data).argmax(axis=1)

#Neural network Percent error and accuracy
print("Percent error: {}".format(percentError(output, test_data['class'])))
print("Model Accuracy: {}".Validator.classificationPerformance(output, test_y))

#Compute confusion metrics
calculate_confusion_matrix(test_y,output)
```

After performing our analysis on Jupyter notebook, we move to Azure ML platform to run Neural network following Dense Random Forest and Logistic classification.

4. Select Columns in dataset

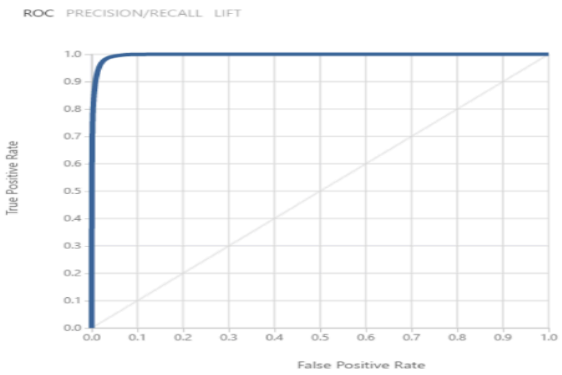
5. Split data: testing and validation



We implemented the following four classification algorithm for classifying user request:

- Logistic Regression
- Random Dense Forest
- Neural Network

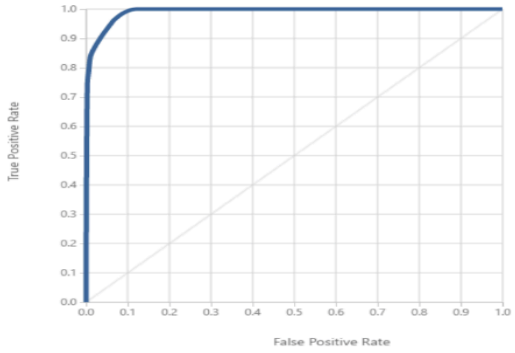
Two Class Decision Forest:



True Positive	False Negative	Accuracy	Precision
358318	38879	0.982	0.926
False Positive	**True Negative**	**Recall**	**F1 Score**
28807	3294366	0.902	0.914

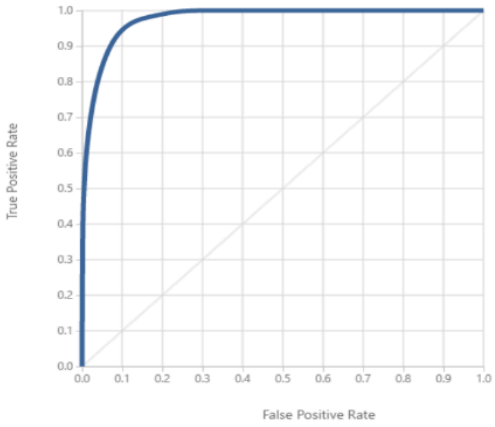
Neural Network:

The ROC curve is shown is visualized as below, having a good accuracy of 97%.



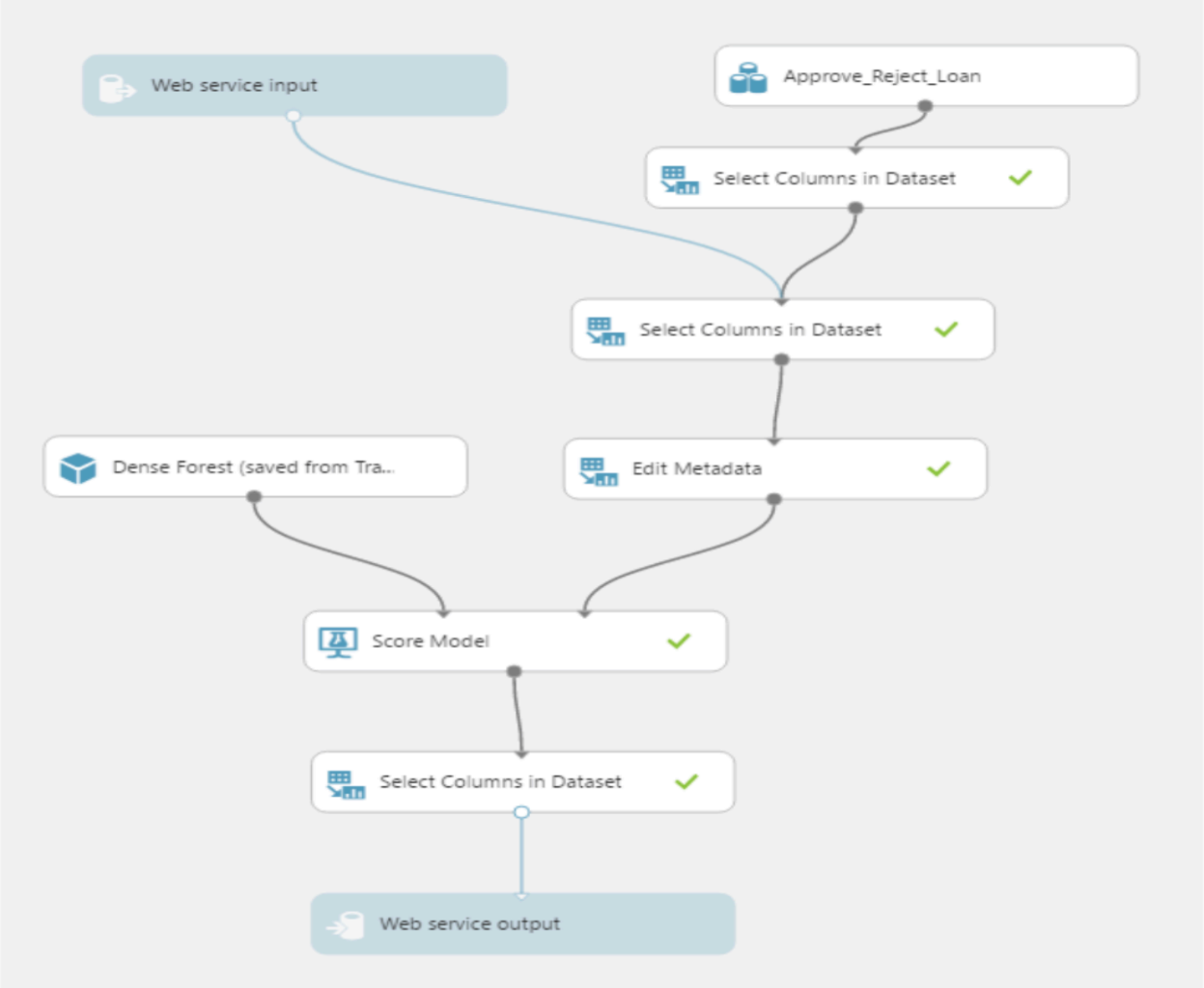
True Positive	False Negative	Accuracy	Precision
306973	90224	0.971	0.950
False Positive	**True Negative**	**Recall**	**F1 Score**
16295	3306867	0.773	0.852

Logistic Regression:



True Positive	False Negative	Accuracy	Precision
262769	134428	0.949	0.825
False Positive	**True Negative**	**Recall**	**F1 Score**
55759	3267403	0.662	0.734

6. Setup web service: classification



When we visualize the Score Model component we get scored labels and scored probabilities along with other features.

loan_amnt	last_meanfico	dti	addr_state	emp_length	purpose	Scored Labels	Scored Probabilities
5000	737	27.65	AZ	10	credit_card	1	0.994397
2500	742	1	GA	1	car	0	0.28303
2400	737	8.72	IL	10	small_business	1	0.924646
10000	692	20	CA	10	other	1	0.677337
3000	697	17.94	OR	1	other	0	0.339034
5000	732	11.2	AZ	3	wedding	1	0.835878

```
from multiprocessing import Process, Manager
from sklearn.feature_selection import RFE
from sklearn.metrics import *
from sklearn import linear_model
lm=linear_model.LinearRegression()
import statsmodels.formula.api as sm
import pandas as pd
import os
import math
from sklearn.neighbors import KNeighborsRegressor
from sklearn import preprocessing
from sklearn import cross_validation
```

```
# Recursive feature elimination
def RFElimination1(X_train1,train1_y,X_test1,test1_y, return_score_p1,name):
    print("in "+str(name))
    org = lm
    selector = RFE(org, 18, step=1)
    selector = selector.fit(X_train1, train1_y)
    #     print(selector.ranking_)
    rankingdf = pd.DataFrame(list(zip(X_train1.columns, selector.ranking_)),
columns=["features", "ranking"])
```

```
    file="Features"+ str(name)
    rankingdf.to_csv(file+".csv")
    # print(rankingdf)
    result = sm.OLS(train1_y, X_train1).fit()
    # print(result.summary())
    pred = selector.predict(X_train1)
    sc = r2_score(train1_y, pred)
    # print("RFElimination:" + str(sc))
    # print(sc)
    return_score_p1[name] = sc
    print("Training Dataset")
    computations(selector,X_train1,train1_y)
    print("Testing Dataset")
    computations(selector,X_test1,test1_y)


#KNN
def KNNAnalysis(x_train1,y_train1,x_test1,y_test1):
    org=lm
    neigh = KNeighborsRegressor(n_neighbors=6)
    neigh.fit(x_train1,y_train1)
    print("KNN---------------")
    print("Testing Data:")
    computations(neigh,x_test1,y_test1)



def computations(org,x,y):
    testlr=org.predict(x)
    #Mean Absolute Error
    mae=mean_absolute_error(y,testlr);
    print("MAE:"+str(mae))
    #RMSE
    rmse=math.sqrt(mean_squared_error(y,testlr))
    print("RMSE:"+str(rmse))
    #Median Absolute error
    Medae=median_absolute_error(y,testlr)
    print("Median Absolute Error:"+str(Medae))


def createDummies(df):
```

```
    dummies1 = pd.get_dummies(df['purpose']).rename(columns=lambda x:
'purpose' + str(x))
    df=pd.concat([df, dummies1], axis=1)
    dummies2 = pd.get_dummies(df['application_type']).rename(columns=lambda
x: 'application_type' + str(x))
    df=pd.concat([df, dummies2], axis=1)
    home_positive = ['OWN', 'MORTGAGE']
    home_negative = ['RENT', 'NONE', 'OTHER', 'ANY']


    # filter out any word that is not within home_positive & home_negative


    df = df[df['home_ownership'].isin(home_positive + home_negative)].copy()


    df['home_ownership_category'] =
df['home_ownership'].isin(home_positive).astype(int)


    # Make "verified" and "Source Verified" in the "verification_status"
column as 1 and non-verified as 0


    verification_positive = ['Verified', 'Source Verified']


    verification_negative = ['Not Verified']


    df = df[df['verification_status'].isin(verification_positive +
verification_negative)].copy()
    label_encoder = preprocessing.LabelEncoder()
    df['addr_state'] = label_encoder.fit_transform(df['addr_state'])


    return df


if __name__ == '__main__':
    #     global score
    # Keep the following 10 features (variables) which are important
```

```
    cols_to_keep = ['term', 'purpose', 'dti', 'loan_amnt', 'annual_inc',
'home_ownership', 'addr_state',
                    'fico_range_high', 'emp_length', 'application_type',
'verification_status', 'revol_util',
                    'inq_last_6mths', 'open_acc_6m', 'pub_rec',
'pub_rec_bankruptcies', 'delinq_2yrs', 'open_acc',
                    'total_acc', 'mths_since_last_delinq',
'mths_since_last_major_derog']
    filename1 = str(os.getcwd()) + "\\Clusters\\cluster0.csv"
    df1 = pd.read_csv(filename1, skipinitialspace=True)
    train1, test1 = cross_validation.train_test_split(df1, train_size=0.7)
    train1_y = train1['int_rate']
    test1_y = test1['int_rate']
    train1_x = train1[cols_to_keep]
    train1_x=createDummies(train1_x)
    X_train1=train1_x._get_numeric_data()
    test1_x = test1[cols_to_keep]
    test1_x=createDummies(test1_x)
    X_test1=test1_x._get_numeric_data()


    filename2=str(os.getcwd())+"\\Clusters\\cluster1.csv"
    df2=pd.read_csv(filename2,skipinitialspace=True)
    train2, test2 = cross_validation.train_test_split(df2, train_size=0.7)
    train2_y = train2['int_rate']
    test2_y = test2['int_rate']
    train2_x = train2[cols_to_keep]
    train2_x=createDummies(train2_x)
    X_train2=train2_x._get_numeric_data()
    test2_x = test2[cols_to_keep]
    test2_x=createDummies(test2_x)
    X_test2=test2_x._get_numeric_data()


    filename3=str(os.getcwd())+"\\Clusters\\cluster2.csv"
    df3=pd.read_csv(filename3,skipinitialspace=True)
    train3, test3 = cross_validation.train_test_split(df3, train_size=0.7)
    train3_y = train3['int_rate']
    test3_y = test3['int_rate']
    train3_x = train3[cols_to_keep]
    train3_x=createDummies(train3_x)
    X_train3=train3_x._get_numeric_data()
    test3_x = test3[cols_to_keep]
```

```
test3_x=createDummies(test3_x)
X_test3=test3_x._get_numeric_data()


filename4=str(os.getcwd())+"\\Clusters\\cluster3.csv"
df4=pd.read_csv(filename4,skipinitialspace=True)
train4, test4 = cross_validation.train_test_split(df4, train_size=0.7)
train4_y = train4['int_rate']
test4_y = test4['int_rate']
train4_x = train4[cols_to_keep]
train4_x=createDummies(train4_x)
X_train4=train4_x._get_numeric_data()
test4_x = test4[cols_to_keep]
test4_x=createDummies(test4_x)
X_test4=test4_x._get_numeric_data()


filename5=str(os.getcwd())+"\\Clusters\\cluster4.csv"
df5=pd.read_csv(filename5,skipinitialspace=True)
train5, test5 = cross_validation.train_test_split(df5, train_size=0.7)
train5_y = train5['int_rate']
test5_y = test5['int_rate']
train5_x = train5[cols_to_keep]
train5_x=createDummies(train5_x)
X_train5=train5_x._get_numeric_data()
test5_x = test5[cols_to_keep]
test5_x=createDummies(test5_x)
X_test5=test5_x._get_numeric_data()


manager = Manager()
return_score_p1 = manager.dict()




fileknn = str(os.getcwd()) + "\\CleanedFile.csv"
dfknn = pd.read_csv(fileknn, skipinitialspace=True)
train, test = cross_validation.train_test_split(dfknn, train_size=0.7)
train_y = train['int_rate']
test_y = test['int_rate']
```

```
    train_x = train[cols_to_keep]
    train_x=createDummies(train_x)
    X_trainknn=train_x._get_numeric_data()
    test_x = test[cols_to_keep]
    test_x=createDummies(test_x)
    X_testknn=test_x._get_numeric_data()


    p1 = Process(target=RFElimination1,
args=(X_train1,train1_y,X_test1,test1_y,return_score_p1,"cluster0"))
    p2 =
Process(target=RFElimination1,args=(X_train2,train2_y,X_test2,test2_y,return
_score_p1,"cluster1"))
    p3 =
Process(target=RFElimination1,args=(X_train3,train3_y,X_test3,test3_y,return
_score_p1,"cluster2"))
    p4 =
Process(target=RFElimination1,args=(X_train4,train4_y,X_test4,test4_y,return
_score_p1,"cluster3"))
    p5 =
Process(target=RFElimination1,args=(X_train5,train5_y,X_test5,test5_y,return
_score_p1,"cluster4"))
    p6=
Process(target=KNNAnalysis,args=(X_trainknn,train_y,X_testknn,test_y))


    p1.start()
    p2.start()
    p3.start()
    p4.start()
    p5.start()
    p6.start()


    p1.join()
    p2.join()
    p3.join()
    p4.join()
    p5.join()
    p6.join()


    print(return_score_p1)
```

```
# KNNAnalysis(X_trainknn,train_y,X_testknn,test_y)
```