# Detailed Analysis

In [232...
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import sweetviz as sv
from scipy import stats
import seaborn as sns
```

In [233...
```
test_cs = pd.read_csv('test_data.csv')
train_cs = pd.read_csv('train_data.csv')
```

In [234...
```
train_cs
```

Out[234...

| | duration | protocol_type | service | flag | src_bytes | dst_bytes | land | wrong_fragment | urgent |
|---|---|---|---|---|---|---|---|---|---|
| **0** | 0 | tcp | ftp_data | SF | 491 | 0 | 0 | 0 | 0 |
| **1** | 0 | udp | other | SF | 146 | 0 | 0 | 0 | 0 |
| **2** | 0 | tcp | private | S0 | 0 | 0 | 0 | 0 | 0 |
| **3** | 0 | tcp | http | SF | 232 | 8153 | 0 | 0 | 0 |
| **4** | 0 | tcp | http | SF | 199 | 420 | 0 | 0 | 0 |
| **...** | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| **25187** | 0 | tcp | exec | RSTO | 0 | 0 | 0 | 0 | 0 |
| **25188** | 0 | tcp | ftp_data | SF | 334 | 0 | 0 | 0 | 0 |
| **25189** | 0 | tcp | private | REJ | 0 | 0 | 0 | 0 | 0 |
| **25190** | 0 | tcp | nnsp | S0 | 0 | 0 | 0 | 0 | 0 |
| **25191** | 0 | tcp | finger | S0 | 0 | 0 | 0 | 0 | 0 |

25192 rows × 42 columns

In [235...
```
train_cs.describe()
```

Out[235...

| | duration | src_bytes | dst_bytes | land | wrong_fragment | urgent | |
|---|---|---|---|---|---|---|---|
| **count** | 25192.000000 | 2.519200e+04 | 2.519200e+04 | 25192.000000 | 25192.000000 | 25192.00000 | 2519 |
| **mean** | 305.054104 | 2.433063e+04 | 3.491847e+03 | 0.000079 | 0.023738 | 0.00004 | |
| **std** | 2686.555640 | 2.410805e+06 | 8.883072e+04 | 0.008910 | 0.260221 | 0.00630 | |
| **min** | 0.000000 | 0.000000e+00 | 0.000000e+00 | 0.000000 | 0.000000 | 0.00000 | |
| **25%** | 0.000000 | 0.000000e+00 | 0.000000e+00 | 0.000000 | 0.000000 | 0.00000 | |
| **50%** | 0.000000 | 4.400000e+01 | 0.000000e+00 | 0.000000 | 0.000000 | 0.00000 | |
| **75%** | 0.000000 | 2.790000e+02 | 5.302500e+02 | 0.000000 | 0.000000 | 0.00000 | |
| **max** | 42862.000000 | 3.817091e+08 | 5.151385e+06 | 1.000000 | 3.000000 | 1.00000 | 7 |

8 rows × 38 columns

In [236…
```
train_cs.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 25192 entries, 0 to 25191
Data columns (total 42 columns):
 #   Column                       Non-Null Count  Dtype  
---  ------                       --------------  -----  
 0   duration                     25192 non-null  int64  
 1   protocol_type                25192 non-null  object 
 2   service                      25192 non-null  object 
 3   flag                         25192 non-null  object 
 4   src_bytes                    25192 non-null  int64  
 5   dst_bytes                    25192 non-null  int64  
 6   land                         25192 non-null  int64  
 7   wrong_fragment               25192 non-null  int64  
 8   urgent                       25192 non-null  int64  
 9   hot                          25192 non-null  int64  
 10  num_failed_logins            25192 non-null  int64  
 11  logged_in                    25192 non-null  int64  
 12  num_compromised              25192 non-null  int64  
 13  root_shell                   25192 non-null  int64  
 14  su_attempted                 25192 non-null  int64  
 15  num_root                     25192 non-null  int64  
 16  num_file_creations           25192 non-null  int64  
 17  num_shells                   25192 non-null  int64  
 18  num_access_files             25192 non-null  int64  
 19  num_outbound_cmds            25192 non-null  int64  
 20  is_host_login                25192 non-null  int64  
 21  is_guest_login               25192 non-null  int64  
 22  count                        25192 non-null  int64  
 23  srv_count                    25192 non-null  int64  
 24  serror_rate                  25192 non-null  float64
 25  srv_serror_rate              25192 non-null  float64
 26  rerror_rate                  25192 non-null  float64
 27  srv_rerror_rate              25192 non-null  float64
 28  same_srv_rate                25192 non-null  float64
 29  diff_srv_rate                25192 non-null  float64
 30  srv_diff_host_rate           25192 non-null  float64
 31  dst_host_count               25192 non-null  int64  
 32  dst_host_srv_count           25192 non-null  int64  
 33  dst_host_same_srv_rate       25192 non-null  float64
 34  dst_host_diff_srv_rate       25192 non-null  float64
 35  dst_host_same_src_port_rate  25192 non-null  float64
 36  dst_host_srv_diff_host_rate  25192 non-null  float64
 37  dst_host_serror_rate         25192 non-null  float64
 38  dst_host_srv_serror_rate     25192 non-null  float64
 39  dst_host_rerror_rate         25192 non-null  float64
 40  dst_host_srv_rerror_rate     25192 non-null  float64
 41  class                        25192 non-null  object 
dtypes: float64(15), int64(23), object(4)
memory usage: 8.1+ MB
```

In [237…
```
#demotrain = sv.analyze(train_cs)
#demotrain.show_html()
```

In [238…
```
train_cs.isnull().sum()
```

Out[238…
```
duration                       0
protocol_type                  0
service                        0
flag                           0
src_bytes                      0
dst_bytes                      0
land                           0
wrong_fragment                 0
urgent                         0
hot                            0
```

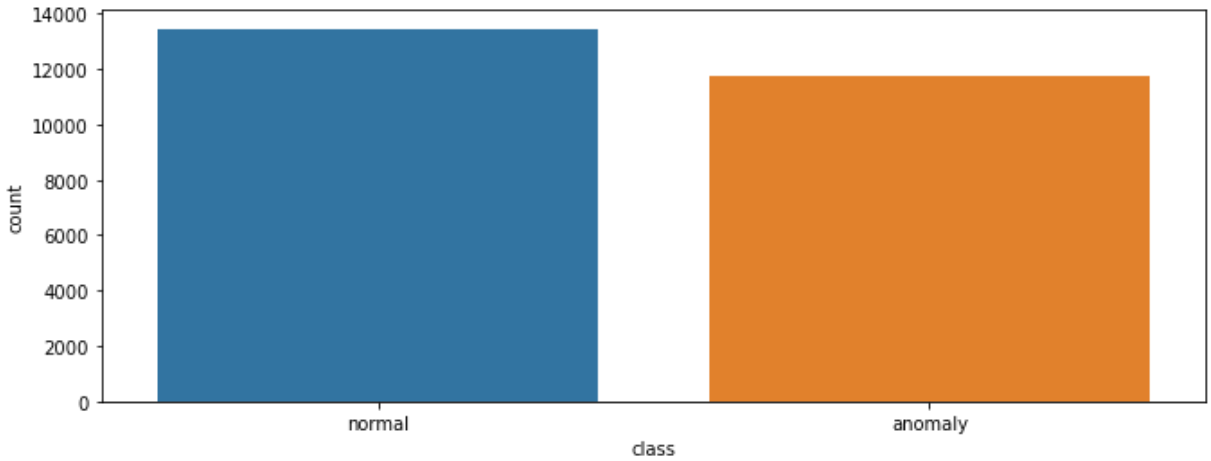
```
num_failed_logins            0
logged_in                    0
num_compromised              0
root_shell                   0
su_attempted                 0
num_root                     0
num_file_creations           0
num_shells                   0
num_access_files             0
num_outbound_cmds            0
is_host_login                0
is_guest_login               0
count                        0
srv_count                    0
serror_rate                  0
srv_serror_rate              0
rerror_rate                  0
srv_rerror_rate              0
same_srv_rate                0
diff_srv_rate                0
srv_diff_host_rate           0
dst_host_count               0
dst_host_srv_count           0
dst_host_same_srv_rate       0
dst_host_diff_srv_rate       0
dst_host_same_src_port_rate  0
dst_host_srv_diff_host_rate  0
dst_host_serror_rate         0
dst_host_srv_serror_rate     0
dst_host_rerror_rate         0
dst_host_srv_rerror_rate     0
class                        0
dtype: int64
```

In [239…
```
train_cs.duplicated().sum()
```

Out[239…
```
0
```

In [240…
```
sns.countplot(data=train_cs, x='class')
```

Out[240…
```
<AxesSubplot:xlabel='class', ylabel='count'>
```

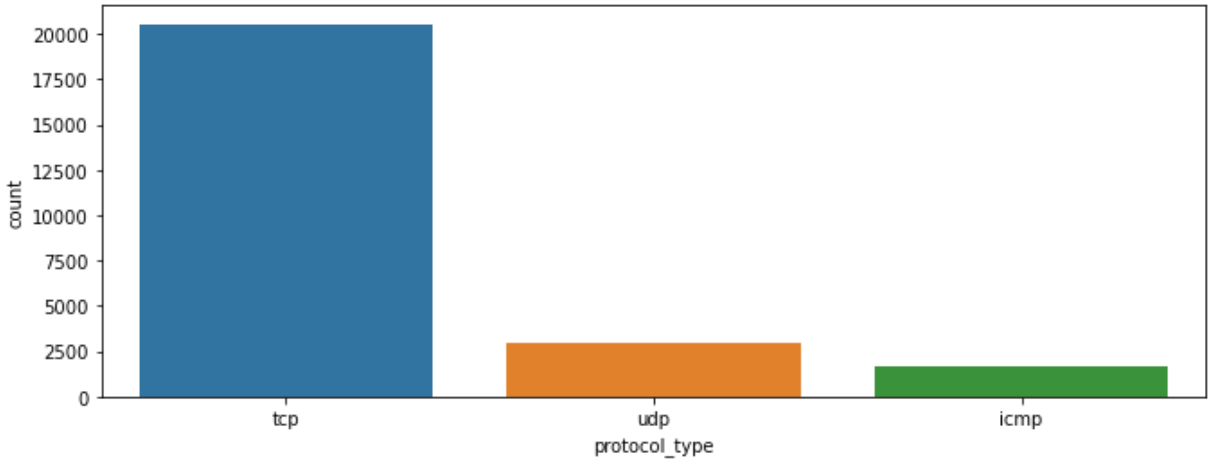



In [241…
```
(train_cs['class'].values == 'anomaly').sum()
```

Out[241…
```
11743
```

In [242…
```
sns.countplot(data=train_cs, x='protocol_type')
```

Out[242…
```
<AxesSubplot:xlabel='protocol_type', ylabel='count'>
```

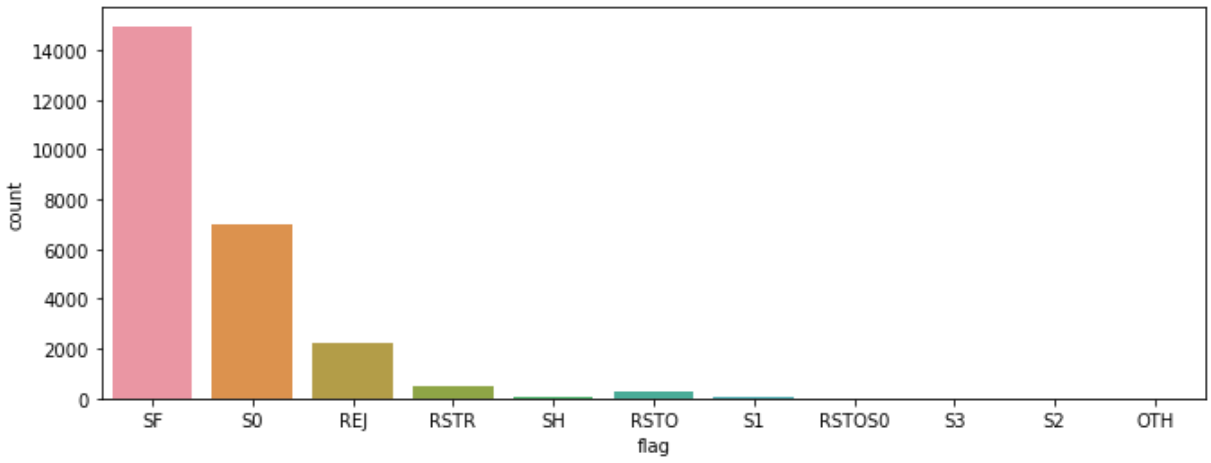



In [243...
```
train_cs['service'].unique()
```

Out[243...
```
array(['ftp_data', 'other', 'private', 'http', 'remote_job', 'name',
       'netbios_ns', 'eco_i', 'mtp', 'telnet', 'finger', 'domain_u',
       'supdup', 'uucp_path', 'Z39_50', 'smtp', 'csnet_ns', 'uucp',
       'netbios_dgm', 'urp_i', 'auth', 'domain', 'ftp', 'bgp', 'ldap',
       'ecr_i', 'gopher', 'vmnet', 'systat', 'http_443', 'efs', 'whois',
       'imap4', 'iso_tsap', 'echo', 'klogin', 'link', 'sunrpc', 'login',
       'kshell', 'sql_net', 'time', 'hostnames', 'exec', 'ntp_u',
       'discard', 'nntp', 'courier', 'ctf', 'ssh', 'daytime', 'shell',
       'netstat', 'pop_3', 'nnsp', 'IRC', 'pop_2', 'printer', 'tim_i',
       'pm_dump', 'red_i', 'netbios_ssn', 'rje', 'X11', 'urh_i',
       'http_8001'], dtype=object)
```

In [244...
```
sns.countplot(data=train_cs, x='flag')
```

Out[244...
```
<AxesSubplot:xlabel='flag', ylabel='count'>
```




In [245...
```
nor_data = train_cs.loc[train_cs['class'] == 'normal']
```

In [246...
```
nor_data #normal data distribution
```

Out[246...

| | duration | protocol_type | service | flag | src_bytes | dst_bytes | land | wrong_fragment | urgent |
|---|---|---|---|---|---|---|---|---|---|
| **0** | 0 | tcp | ftp_data | SF | 491 | 0 | 0 | 0 | 0 |
| **1** | 0 | udp | other | SF | 146 | 0 | 0 | 0 | 0 |
| **3** | 0 | tcp | http | SF | 232 | 8153 | 0 | 0 | 0 |
| **4** | 0 | tcp | http | SF | 199 | 420 | 0 | 0 | 0 |
| **12** | 0 | tcp | http | SF | 287 | 2251 | 0 | 0 | 0 |

| | duration | protocol_type | service | flag | src_bytes | dst_bytes | land | wrong_fragment | urgent |
|---|---|---|---|---|---|---|---|---|---|
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| **25176** | 0 | tcp | ftp_data | SF | 748 | 0 | 0 | 0 | 0 |
| **25177** | 0 | tcp | http | SF | 293 | 2486 | 0 | 0 | 0 |
| **25184** | 29 | tcp | ftp | SF | 329 | 1063 | 0 | 0 | 0 |
| **25185** | 1 | tcp | smtp | SF | 2896 | 333 | 0 | 0 | 0 |
| **25186** | 0 | tcp | http | S1 | 339 | 14600 | 0 | 0 | 0 |

13449 rows × 42 columns

In [247...
```
ano_data = train_cs.loc[train_cs['class'] == 'anomaly']
```

In [248...
```
ano_data #anomaly data distribution
```

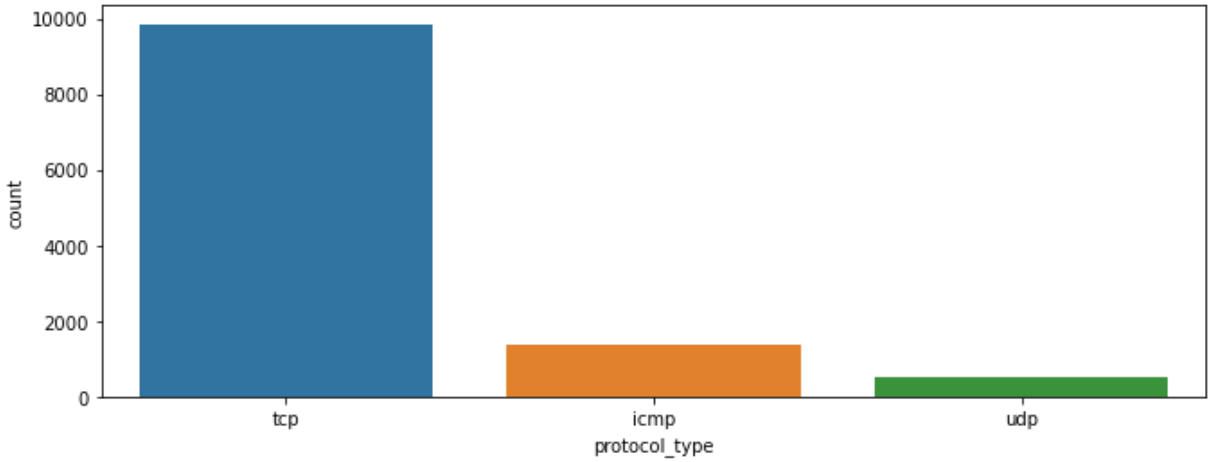
Out[248...

| | duration | protocol_type | service | flag | src_bytes | dst_bytes | land | wrong_fragment | urg |
|---|---|---|---|---|---|---|---|---|---|
| **2** | 0 | tcp | private | S0 | 0 | 0 | 0 | 0 | |
| **5** | 0 | tcp | private | REJ | 0 | 0 | 0 | 0 | |
| **6** | 0 | tcp | private | S0 | 0 | 0 | 0 | 0 | |
| **7** | 0 | tcp | private | S0 | 0 | 0 | 0 | 0 | |
| **8** | 0 | tcp | remote_job | S0 | 0 | 0 | 0 | 0 | |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | |
| **25187** | 0 | tcp | exec | RSTO | 0 | 0 | 0 | 0 | |
| **25188** | 0 | tcp | ftp_data | SF | 334 | 0 | 0 | 0 | |
| **25189** | 0 | tcp | private | REJ | 0 | 0 | 0 | 0 | |
| **25190** | 0 | tcp | nnsp | S0 | 0 | 0 | 0 | 0 | |
| **25191** | 0 | tcp | finger | S0 | 0 | 0 | 0 | 0 | |

11743 rows × 42 columns

In [249...
```
sns.countplot(data=ano_data, x='protocol_type')
```

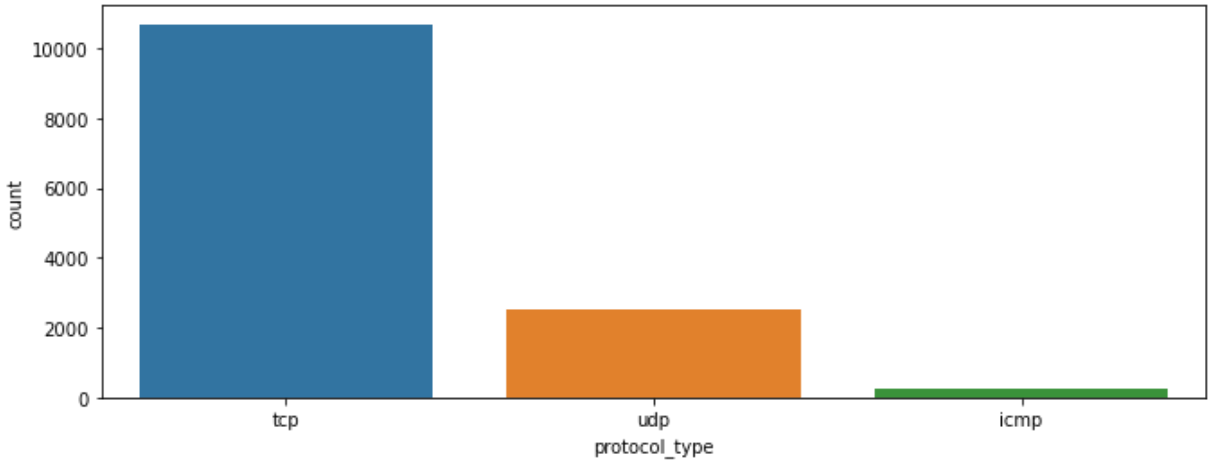
Out[249...
```
<AxesSubplot:xlabel='protocol_type', ylabel='count'>
```




In anomaly data tcp and icmp protocols have higher usages

In [250…
```
sns.countplot(data=nor_data, x='protocol_type')
```

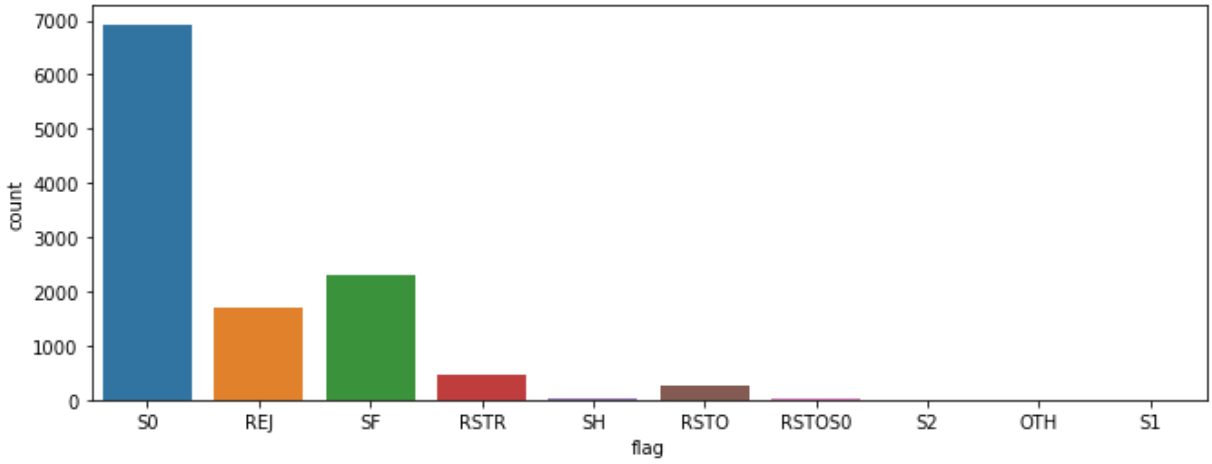
Out[250…
```
<AxesSubplot:xlabel='protocol_type', ylabel='count'>
```




In normal distribution tcp and udp protocols have higher usage

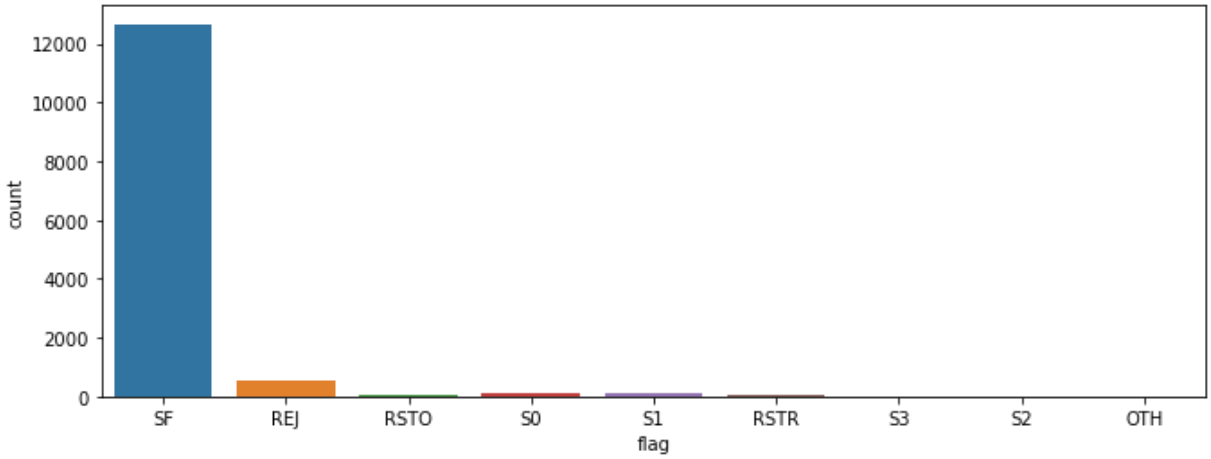
In [251…
```
sns.countplot(data=ano_data, x='flag')
```

Out[251…
```
<AxesSubplot:xlabel='flag', ylabel='count'>
```



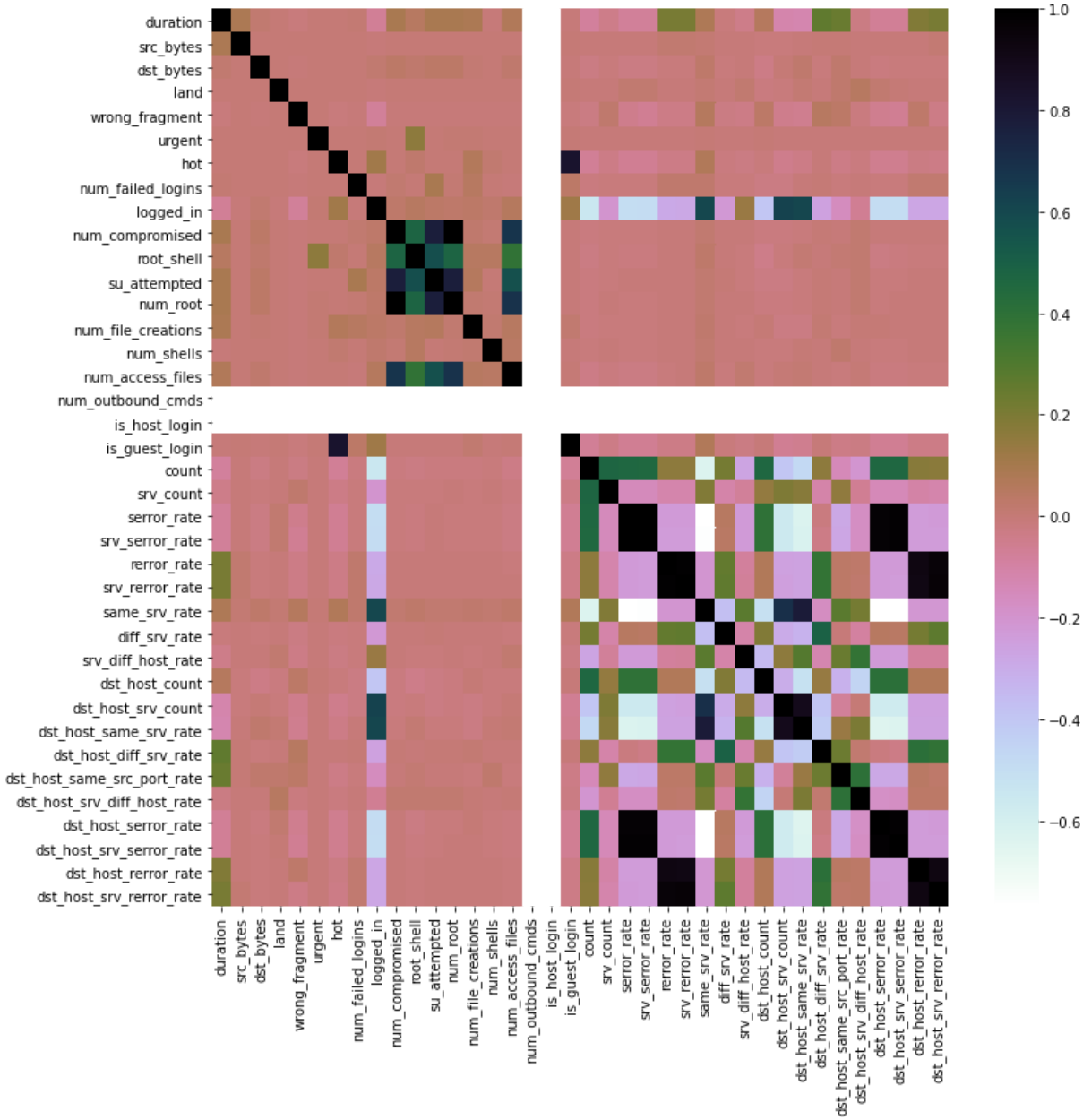

In [252…
```
sns.countplot(data=nor_data, x='flag')
```

Out[252…
```
<AxesSubplot:xlabel='flag', ylabel='count'>
```




In [253…

```
corr = train_cs.corr()
plt.figure(figsize=(12,12))
sns.heatmap(corr, cmap='cubehelix_r');
```




In [254…

```
train_cs.drop(['num_outbound_cmds', 'is_host_login'], axis=1, inplace=True)
test_cs.drop(['num_outbound_cmds', 'is_host_login'], axis=1, inplace=True)
```

# Separating numerical and object columns

Combining all Numerical Columns

In [255…
```
from sklearn.preprocessing import StandardScaler
scaler = StandardScaler()

cols = train_cs.select_dtypes(include=['float64','int64']).columns
sc_train = scaler.fit_transform(train_cs.select_dtypes(include=['float64','int64']))
sc_test = scaler.fit_transform(test_cs.select_dtypes(include=['float64','int64']))

train_num = pd.DataFrame(sc_train, columns = cols)
test_num = pd.DataFrame(sc_test, columns = cols)
```

Finding Object type Columns

In [256…
```
from sklearn.preprocessing import LabelEncoder
encoder = LabelEncoder()

# extract object attributes from both train and test sets
train_obj = train_cs.select_dtypes(include=['object']).copy()
test_obj = test_cs.select_dtypes(include=['object']).copy()

# encode the object attributes
train_a = train_obj.apply(encoder.fit_transform)
test_a = test_obj.apply(encoder.fit_transform)

# separate 'class' column from encoded data
train_noclass = train_a.drop(['class'], axis=1)
Ytrain_class = train_a[['class']].copy()
```

In [257…
```
train_x = pd.concat([train_num,train_noclass],axis=1)
train_y = train_cs['class']
train_x.shape
```

Out[257… (25192, 39)

In [258…
```
test_ = pd.concat([test_num,test_a],axis=1)
test_.shape
```

Out[258… (22544, 39)

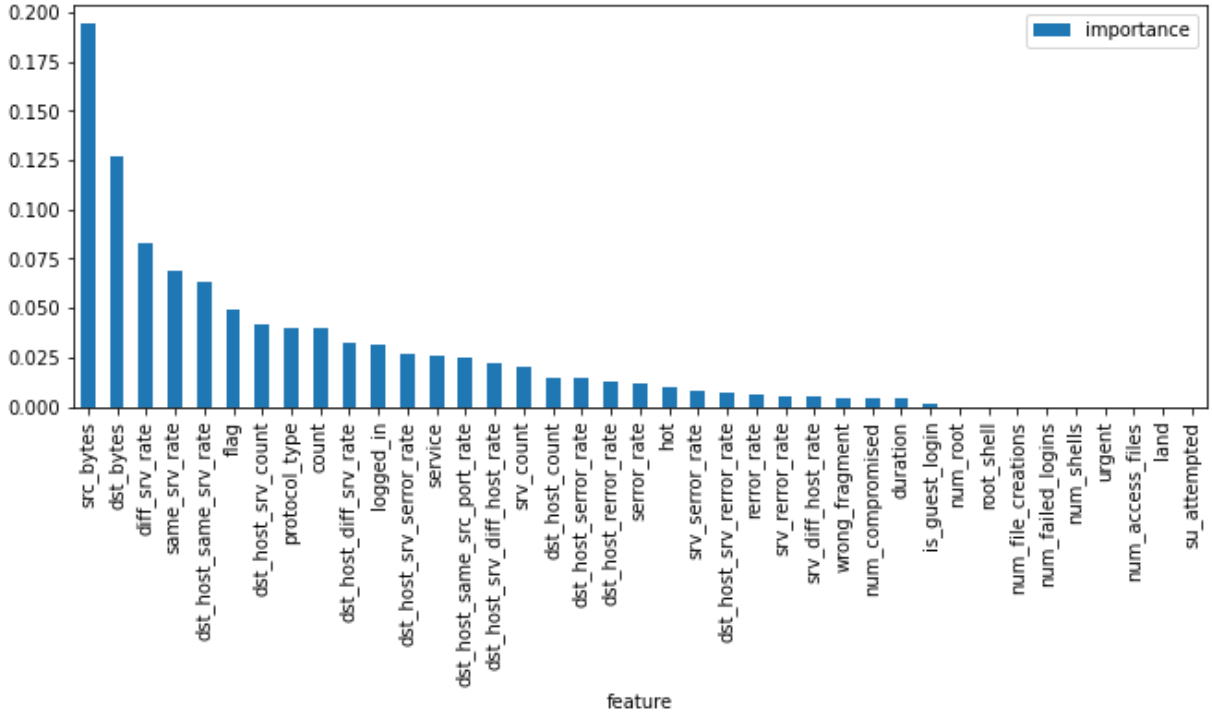
# Feature Selection

In [259…
```
from sklearn.ensemble import RandomForestClassifier
rfc = RandomForestClassifier();

# fit random forest classifier on the training set
rfc.fit(train_x, train_y);

# extract important features
score = np.round(rfc.feature_importances_,3)
imp = pd.DataFrame({'feature':train_x.columns,'importance':score})
imp = imp.sort_values('importance',ascending=False).set_index('feature')

# plot importances
plt.rcParams['figure.figsize'] = (11, 4)
imp.plot.bar();
```




In [260…
```
from sklearn.feature_selection import RFE
import itertools
rfc = RandomForestClassifier()

# create the RFE model and select 15 attributes
rfe = RFE(rfc, n_features_to_select=15)
rfe = rfe.fit(train_x, train_y)

# summarize the selection of the attributes
feature_map = [(i, v) for i, v in itertools.zip_longest(rfe.get_support(), train_x.c
features = [v for i, v in feature_map if i==True]

features
```

Out[260…
```
['src_bytes',
 'dst_bytes',
 'logged_in',
 'count',
 'srv_count',
 'same_srv_rate',
 'diff_srv_rate',
 'dst_host_count',
 'dst_host_srv_count',
 'dst_host_same_srv_rate',
 'dst_host_same_src_port_rate',
 'dst_host_srv_diff_host_rate',
 'protocol_type',
 'service',
 'flag']
```

In [279…
```
#train_feature = train_x[features]
#train_feature
```

Defining Train and Test

In [280…
```
from sklearn.model_selection import train_test_split

X_train, X_test, Y_train, Y_test = train_test_split(train_x,train_y,test_size = 0.25
```

# Applying Logistic Regression

In [281…
```
from sklearn.linear_model import LogisticRegression
from sklearn import metrics
from sklearn.model_selection import cross_val_score
```

In [282…
```
LGR_Classifier = LogisticRegression(n_jobs=-1, random_state=0)
LGR_Classifier.fit(X_train, Y_train);
```

## Evaluating Model

In [283…
```
models = []
models.append(('LogisticRegression', LGR_Classifier))

for i, v in models:
    scores = cross_val_score(v, X_train, Y_train, cv=10)
    accuracy = metrics.accuracy_score(Y_train, v.predict(X_train))
    confusion_matrix = metrics.confusion_matrix(Y_train, v.predict(X_train))
    classification = metrics.classification_report(Y_train, v.predict(X_train))
    print()
    print('============================== {} Model Evaluation ======================
    print()
    print ("Cross Validation Mean Score:" "\n", scores.mean())
    print()
    print ("Model Accuracy:" "\n", accuracy)
    print()
    print("Confusion matrix:" "\n", confusion_matrix)
    print()
    print("Classification report:" "\n", classification)
    print()
```

```
============================== LogisticRegression Model Evaluation ================
=============

Cross Validation Mean Score:
 0.9547470036776546

Model Accuracy:
 0.9556472954377051

Confusion matrix:
 [[8298  516]
 [ 322 9758]]

Classification report:
               precision    recall  f1-score   support

     anomaly       0.96      0.94      0.95      8814
      normal       0.95      0.97      0.96     10080

    accuracy                           0.96     18894
   macro avg       0.96      0.95      0.96     18894
weighted avg       0.96      0.96      0.96     18894
```

## Validating Model

In [284…
```
for i, v in models:
    accuracy = metrics.accuracy_score(Y_test, v.predict(X_test))
    confusion_matrix = metrics.confusion_matrix(Y_test, v.predict(X_test))
    classification = metrics.classification_report(Y_test, v.predict(X_test))
    print()
    print('============================== {} Model Test Results ====================
    print()
    print ("Model Accuracy:" "\n", accuracy)
    print()
```

```
    print("Confusion matrix:" "\n", confusion_matrix)
    print()
    print("Classification report:" "\n", classification)
    print()
```

```
============================== LogisticRegression Model Test Results ==============
===============

Model Accuracy:
 0.9537948555096856

Confusion matrix:
 [[2754  175]
 [ 116 3253]]

Classification report:
               precision    recall  f1-score   support

     anomaly       0.96      0.94      0.95      2929
      normal       0.95      0.97      0.96      3369

    accuracy                           0.95      6298
   macro avg       0.95      0.95      0.95      6298
weighted avg       0.95      0.95      0.95      6298
```

# Predicting normal and anamoly behaviour on Test dataset

In [285…
```
pred_log = LGR_Classifier.predict(test_)
```

In [286…
```
pred_log
```

Out[286…
```
array(['anomaly', 'anomaly', 'normal', ..., 'normal', 'normal', 'anomaly'],
      dtype=object)
```

In [287…
```
test_cs
```

Out[287…

| | duration | protocol_type | service | flag | src_bytes | dst_bytes | land | wrong_fragment | urge |
|---|---|---|---|---|---|---|---|---|---|
| **0** | 0 | tcp | private | REJ | 0 | 0 | 0 | 0 | |
| **1** | 0 | tcp | private | REJ | 0 | 0 | 0 | 0 | |
| **2** | 2 | tcp | ftp_data | SF | 12983 | 0 | 0 | 0 | |
| **3** | 0 | icmp | eco_i | SF | 20 | 0 | 0 | 0 | |
| **4** | 1 | tcp | telnet | RSTO | 0 | 15 | 0 | 0 | |
| **...** | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| **22539** | 0 | tcp | smtp | SF | 794 | 333 | 0 | 0 | |
| **22540** | 0 | tcp | http | SF | 317 | 938 | 0 | 0 | |
| **22541** | 0 | tcp | http | SF | 54540 | 8314 | 0 | 0 | |
| **22542** | 0 | udp | domain_u | SF | 42 | 42 | 0 | 0 | |
| **22543** | 0 | tcp | sunrpc | REJ | 0 | 0 | 0 | 0 | |

22544 rows × 39 columns

In [288…
```
pred_df = pd.DataFrame(pred_log, columns = ['Prediction'])
test_output = pd.concat([test_cs, pred_df],axis=1)
```

In [289…
```
test_output
```

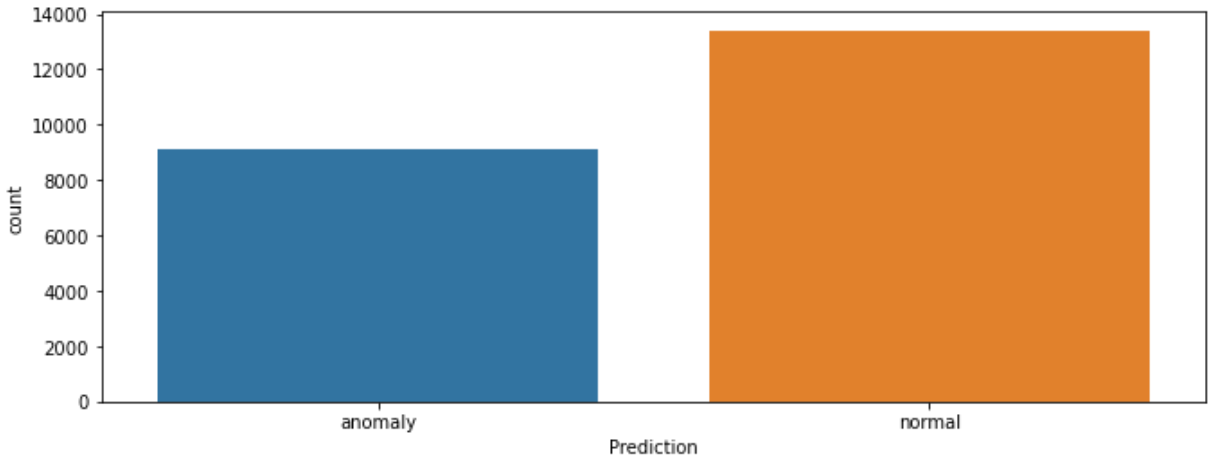
Out[289…

| | duration | protocol_type | service | flag | src_bytes | dst_bytes | land | wrong_fragment | urge |
|---|---|---|---|---|---|---|---|---|---|
| **0** | 0 | tcp | private | REJ | 0 | 0 | 0 | 0 | |
| **1** | 0 | tcp | private | REJ | 0 | 0 | 0 | 0 | |
| **2** | 2 | tcp | ftp_data | SF | 12983 | 0 | 0 | 0 | |
| **3** | 0 | icmp | eco_i | SF | 20 | 0 | 0 | 0 | |
| **4** | 1 | tcp | telnet | RSTO | 0 | 15 | 0 | 0 | |
| **...** | ... | ... | ... | ... | ... | ... | ... | ... | |
| **22539** | 0 | tcp | smtp | SF | 794 | 333 | 0 | 0 | |
| **22540** | 0 | tcp | http | SF | 317 | 938 | 0 | 0 | |
| **22541** | 0 | tcp | http | SF | 54540 | 8314 | 0 | 0 | |
| **22542** | 0 | udp | domain_u | SF | 42 | 42 | 0 | 0 | |
| **22543** | 0 | tcp | sunrpc | REJ | 0 | 0 | 0 | 0 | |

22544 rows × 40 columns

In [290…
```
sns.countplot(data= test_output, x = 'Prediction')
```

Out[290… <AxesSubplot:xlabel='Prediction', ylabel='count'>




In [ ]: