CS3315 Project: Random Forest Classifier

In [1]:
```
import numpy as np
import pandas as pd
from sklearn.linear_model import Perceptron
```

In [2]:
```
# import data
filename = 'data/2020.06.19.csv'
df = pd.read_csv(filename)

# sample small subset
# df = df.sample(500000, random_state=78)
df.info()
df.head(2)
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 765360 entries, 0 to 765359
Data columns (total 16 columns):
 #   Column         Non-Null Count   Dtype  
---  ------         --------------   -----  
 0   avg_ipt        765360 non-null  float64
 1   bytes_in       765360 non-null  int64  
 2   bytes_out      765360 non-null  int64  
 3   dest_ip        765360 non-null  int64  
 4   dest_port      740863 non-null  float64
 5   entropy        765360 non-null  float64
 6   num_pkts_out   765360 non-null  int64  
 7   num_pkts_in    765360 non-null  int64  
 8   proto          765360 non-null  int64  
 9   src_ip         765360 non-null  int64  
 10  src_port       740863 non-null  float64
 11  time_end       765360 non-null  int64  
 12  time_start     765360 non-null  int64  
 13  total_entropy  765360 non-null  float64
 14  label          765360 non-null  object 
 15  duration       765360 non-null  float64
dtypes: float64(6), int64(9), object(1)
memory usage: 93.4+ MB
```

Out[2]:

	avg_ipt	bytes_in	bytes_out	dest_ip	dest_port	entropy	num_pkts_out	num_pkts_in	proto
0	7.5	342	3679	786	9200.0	5.436687	2	2	6
1	0.0	0	0	786	55972.0	0.000000	1	1	6

In [3]:
```
# clean data
df.dropna(inplace=True)
df.isna().sum()

# need to clean for features that are 0 and don't make sense (bytes = 0
```

Out[3]:
```
avg_ipt          0
bytes_in         0
bytes_out        0
dest_ip          0
dest_port        0
entropy          0
num_pkts_out     0
num_pkts_in      0
proto            0
src_ip           0
src_port         0
time_end         0
time_start       0
total_entropy    0
label            0
duration         0
dtype: int64
```

In [4]:
```
print('label values:', df['label'].unique())

def ordinal_encoder(category):
    dict = {'benign':0, 'outlier':1, 'malicious':2}
    return dict[category]

print('benign', ordinal_encoder('benign'))
print('outlier', ordinal_encoder('outlier'))
print('malicious', ordinal_encoder('malicious'))
df['label'] = df['label'].apply(ordinal_encoder)
```

```
label values: ['benign' 'outlier' 'malicious']
benign 0
outlier 1
malicious 2
```

In [5]:
```
features = ['avg_ipt',
            'bytes_in',
            'bytes_out',
            'dest_ip',
            'dest_port',
            'entropy',
            'num_pkts_in',
            'num_pkts_out',
            'proto',
            'src_ip',
            'src_port',
            'time_end',
            'time_start',
            'total_entropy',
            'duration']

X = df.loc[:, features]
y = df.loc[:,'label']
```

In [6]:
```
# test/train split

from sklearn.model_selection import train_test_split

# 80/20 training/validation split
X_train, X_val, y_train, y_val = train_test_split(X,y, train_size=.8, t

y_train = y_train.to_numpy()
y_val = y_val.to_numpy()

# should print number of shape: (num features, num entries)
print('Training set: ', 'X: ', X_train.shape, 'y: ', y_train.shape, 'Va
```

```
Training set:  X:  (592690, 15) y:  (592690,) Validation set:  X:  (14
8173, 15) printy:  (148173,)
```

In [21]:
```
from sklearn.ensemble import RandomForestClassifier

rfc = RandomForestClassifier(n_estimators=5000,
                                    max_depth=30,
                                    max_leaf_nodes=16,
                                    n_jobs=-1,
                                    min_samples_leaf=100,
                                    min_samples_split=100)

rfc.fit(X_train, y_train)
```

Out[21]:
```
RandomForestClassifier(max_depth=30, max_leaf_nodes=16, min_samples_l
eaf=100,
                       min_samples_split=100, n_estimators=5000, n_jo
bs=-1)
```

In [22]:
```
y_pred = rfc.predict(X_val)
```

In [23]:
```
from sklearn.tree import export_graphviz

export_graphviz(rfc.estimators_[900], out_file='rfctree.dot',
                feature_names = features,
                class_names = ['benign', 'outlier', 'malicious'],
                rounded = True, proportion = False,
                precision = 2, filled = True)
from subprocess import call
call(['dot', '-Tpng', 'rfctree.dot', '-o', 'tree.png', '-Gdpi=600'])

# Display in jupyter notebook
from IPython.display import Image
Image(filename = 'tree.png')
```

Out[23]:

In [24]:
```
# plot loss vs. accuracy (HOML p. 305)
#import matplotlib.pyplot as plt
#pd.DataFrame(history.history).plot()
#plt.grid(True)
#plt.gca().set_ylim(0,1)
#plt.show()
```

In [25]:
```
from sklearn.metrics import *
print("Predicted labels:\t", y_pred)
print("Actual labels:\t\t", y_val)
print(classification_report(y_val, y_pred))
```

```
Predicted labels:        [0 1 0 ... 2 2 2]
Actual labels:           [0 1 0 ... 2 2 1]
              precision    recall  f1-score   support

           0       0.99      1.00      1.00     75511
           1       1.00      0.42      0.59     24572
           2       0.77      0.99      0.87     48090

    accuracy                           0.90    148173
   macro avg       0.92      0.80      0.82    148173
weighted avg       0.92      0.90      0.89    148173
```

Validate Model with Data from June 2022

In [26]:
```
# import data
filename = 'data/2020.06.20.csv'
df2 = pd.read_csv(filename)

# sample small subset
#df2 = df2.sample(n=100000, random_state=78)
df2.info()
df2.head(2)
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 770853 entries, 0 to 770852
Data columns (total 16 columns):
 #   Column          Non-Null Count   Dtype  
---  ------          --------------   -----  
 0   avg_ipt         770853 non-null  float64
 1   bytes_in        770853 non-null  int64  
 2   bytes_out       770853 non-null  int64  
 3   dest_ip         770853 non-null  int64  
 4   dest_port       770853 non-null  int64  
 5   entropy         770853 non-null  float64
 6   num_pkts_out    770853 non-null  int64  
 7   num_pkts_in     770853 non-null  int64  
 8   proto           770853 non-null  int64  
 9   src_ip          770853 non-null  int64  
 10  src_port        770853 non-null  int64  
 11  time_end        770853 non-null  int64  
 12  time_start      770853 non-null  int64  
 13  total_entropy   770853 non-null  float64
 14  label           770853 non-null  object 
 15  duration        770853 non-null  float64
dtypes: float64(4), int64(11), object(1)
memory usage: 94.1+ MB
```

Out[26]:

	avg_ipt	bytes_in	bytes_out	dest_ip	dest_port	entropy	num_pkts_out	num_pkts_in	pro
0	34.57143	34	29	786	5900	5.040459	7	10	
1	37.00000	34	29	786	5900	5.127916	7	10	

In [27]:
```
# clean data
df2.dropna(inplace=True)
df2.isna().sum()
```

Out[27]:
```
avg_ipt          0
bytes_in         0
bytes_out        0
dest_ip          0
dest_port        0
entropy          0
num_pkts_out     0
num_pkts_in      0
proto            0
src_ip           0
src_port         0
time_end         0
time_start       0
total_entropy    0
label            0
duration         0
dtype: int64
```

In [28]:
```
print('label values:', df2['label'].unique())

def ordinal_encoder(category):
    dict = {'benign':0, 'outlier':1, 'malicious':2}
    return dict[category]

print('benign', ordinal_encoder('benign'))
print('outlier', ordinal_encoder('outlier'))
print('malicious', ordinal_encoder('malicious'))
df2['label'] = df2['label'].apply(ordinal_encoder)
```

```
label values: ['malicious' 'benign' 'outlier']
benign 0
outlier 1
malicious 2
```

In [29]:
```
features = ['avg_ipt',
            'bytes_in',
            'bytes_out',
            'dest_ip',
            'dest_port',
            'entropy',
            'num_pkts_in',
            'num_pkts_out',
            'proto',
            'src_ip',
            'src_port',
            'time_end',
            'time_start',
            'total_entropy',
            'duration']

X_22 = df2.loc[:, features]
y_22 = df2.loc[:,'label']
```

In [30]:
```
# change labels to numpy
y_22 = y_22.to_numpy()
```

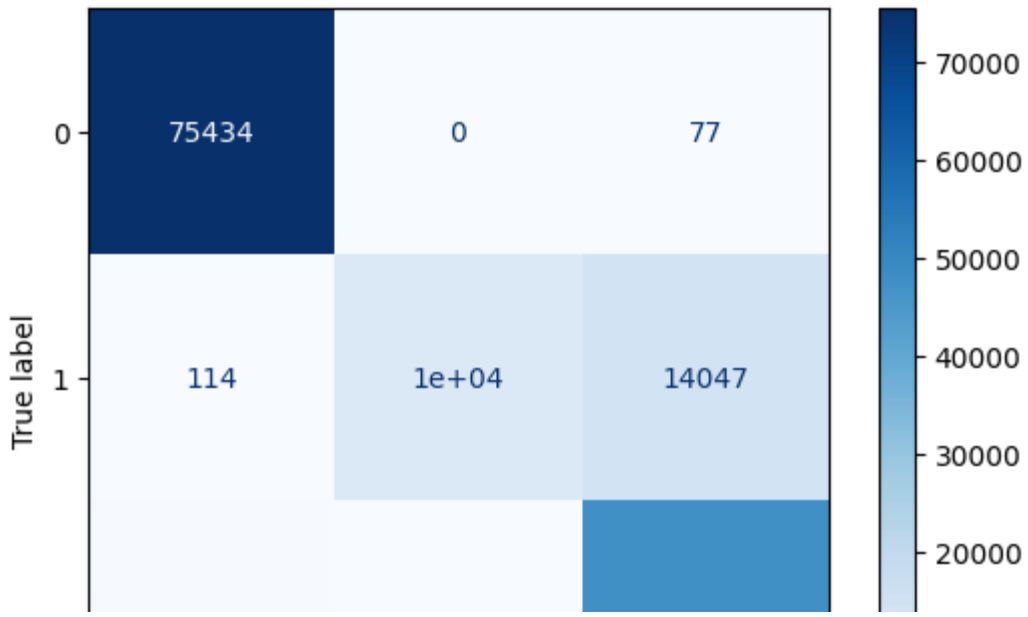
In [31]:
```
# test predictions
X_test_new = X_22
test_pred_22 = rfc.predict(X_test_new)
```

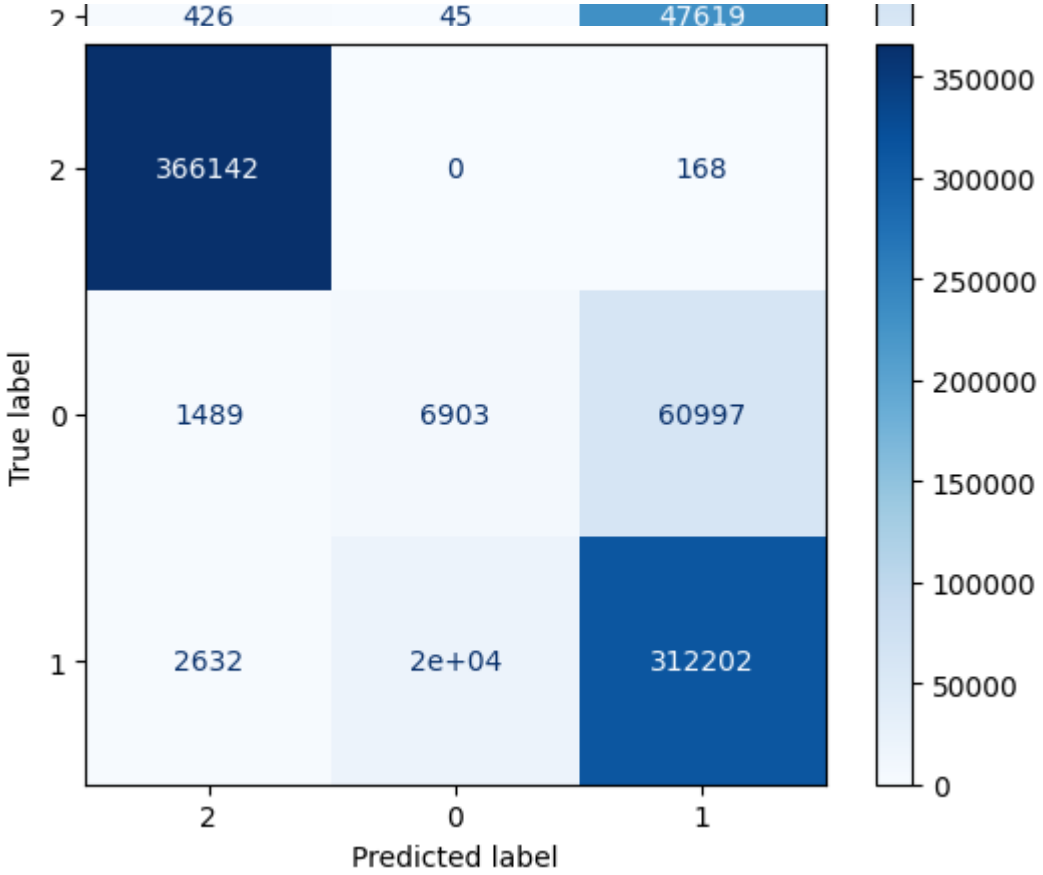
In [32]:
```
print("Predicted labels:\t", test_pred_22)
print("Actual labels:\t\t", y_22)
print(classification_report(y_22, test_pred_22))
```

```
Predicted labels:        [2 2 2 ... 2 2 2]
Actual labels:           [2 2 2 ... 1 1 2]
              precision    recall  f1-score   support

           0       0.99      1.00      0.99    366310
           1       0.25      0.10      0.14     69389
           2       0.84      0.93      0.88    335154

    accuracy                           0.89    770853
   macro avg       0.69      0.68      0.67    770853
weighted avg       0.86      0.89      0.87    770853
```

In [37]:
```
from sklearn.metrics import confusion_matrix

from sklearn.metrics import ConfusionMatrixDisplay
import matplotlib.pyplot as plt


cm = confusion_matrix(y_val, y_pred)

classes = df['label'].unique()
disp = ConfusionMatrixDisplay.from_estimator(
        rfc,
        X_val,
        y_val,
        display_labels= classes,
        cmap=plt.cm.Blues,
    )

print(disp.confusion_matrix)

cm22 = confusion_matrix(y_22, test_pred_22)

classes = df2['label'].unique()
disp = ConfusionMatrixDisplay.from_estimator(
        rfc,
        X_22,
        y_22,
        display_labels= classes,
        cmap=plt.cm.Blues,
    )
print(disp.confusion_matrix)
```

```
[[75434     0    77]
 [  114 10411 14047]
 [  426    45 47619]]
[[366142      0    168]
 [  1489   6903  60997]
 [  2632  20320 312202]]
```




426
45
47619
2
366142
0
168
0
1489
6903
60997
1
2632
2e+04
312202
True label
2
0
1
Predicted label
350000
300000
250000
200000
150000
100000
50000
0

In [ ]: