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 [13]:
```
# 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, test_s

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, 'Validat
```

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

In [33]:
```
from sklearn.ensemble import RandomForestClassifier

rfc = RandomForestClassifier(n_estimators=1000,
                                    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[33]:
```
▾                          RandomForestClassifier

RandomForestClassifier(max_depth=30, max_leaf_nodes=16, min_samples
_leaf=100,
                       min_samples_split=100, n_estimators=1000, n_
jobs=-1)
```

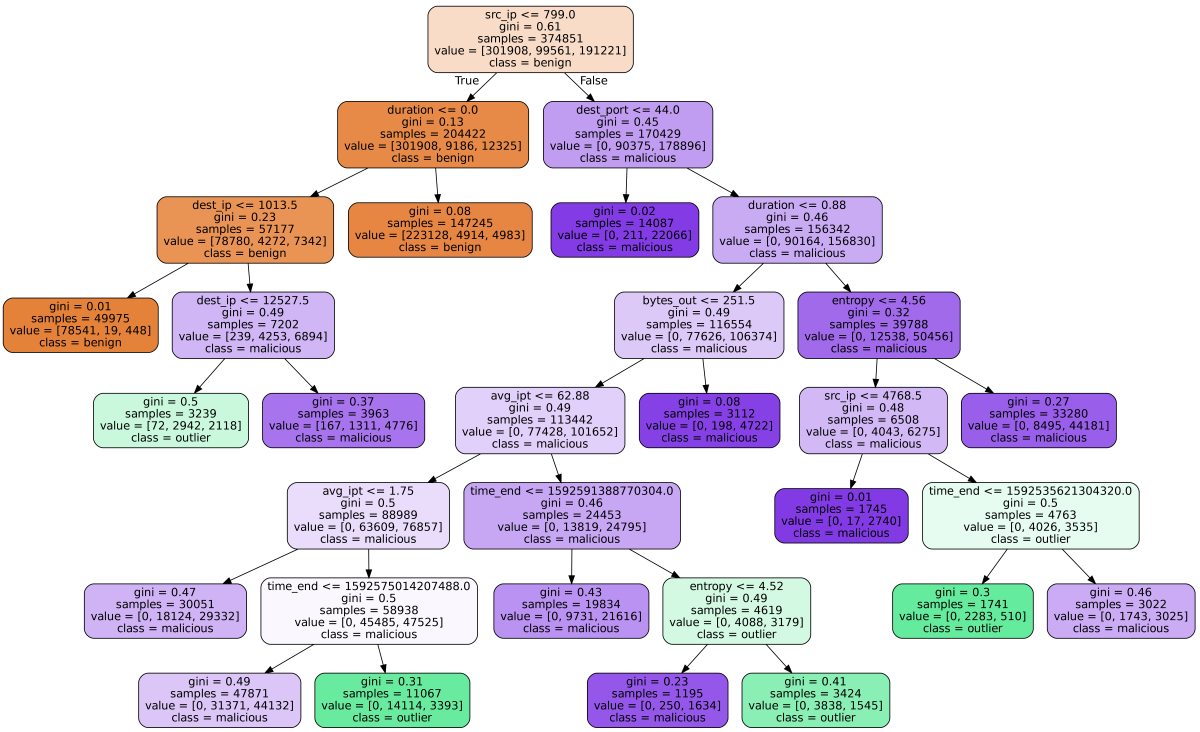
In [34]:
```
y_pred = rfc.predict(X_val)
```

In [35]:
```
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[35]:



In [36]:
```
# 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 [37]:
```
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 [38]:
```
# 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[38]:

	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 [39]:
```
# clean data
df2.dropna(inplace=True)
df2.isna().sum()
```

Out[39]:
```
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 [40]:
```
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 [41]:
```
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 [42]:
```
# change labels to numpy
y_22 = y_22.to_numpy()
```

In [43]:
```
# test predictions
X_test_new = X_22
test_pred_22 = rfc.predict(X_test_new)
```

In [44]:
```
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       0.30      0.13      0.18     69389
           2       0.84      0.93      0.88    335154

    accuracy                           0.89    770853
   macro avg       0.71      0.69      0.69    770853
weighted avg       0.86      0.89      0.87    770853
```

In [ ]: