7_Testing_ids2018

June 5, 2024

1 Testing the Models on the IDS-2018 Dataset

In this notebook, the IDS-2018 dataset is loaded and the models trained on the IDS 2017 are tested to check for generalization

This command was used to download the csv files from the ids 2018 dataset: `aws s3 sync --no-sign-request --region us-east-2 "s3://cse-cic-ids2018/" "C:\Users\youss\Downloads" --exclude "*" --include "*.csv"`

1.1 1. Preprocessing

[1]:
```
import numpy as np
import pandas as pd
import os
import re
from notebook_utils import load_processed_dataset_2017, plot_confusion_matrix,␣
 ↪metrics_report
from keras.models import load_model as keras_load_model
%matplotlib inline
%load_ext autoreload
%autoreload 2
import gc

file_path = r"CIC-IDS-2018\Processed Traffic Data for ML Algorithms"
file_path_2017 =␣
 ↪r"CIC-IDS-2017\CSVs\GeneratedLabelledFlows\TrafficLabelling\processed\ids2017_processed.
 ↪csv"
# Load the scaler from the 2017 dataset
X_train, Y_train, X_eval, Y_eval, X_test, Y_test, scaler =␣
 ↪load_processed_dataset_2017(file_path_2017)
gc.collect()
```

[1]:
```
14
```

[2]:
```
import numpy as np
import pandas as pd
import os
import re
```

```python
import gc

# Define the regular expression to match spaces and special characters
column_name_regex = re.compile(r'[^\w\s]')

# Function to trim column names
def trim_column_names(df):
    df.columns = [column_name_regex.sub('_', c.lower()) for c in df.columns]
    return df

# Initialize an empty list to hold the sampled DataFrames
df_list = []

# Fraction to sample
sampling_fraction = 0.1

# Iterate over all CSV files in the folder
for i, file_name in enumerate(os.listdir(file_path)):
    if file_name.endswith(".csv"):
        file_full_path = os.path.join(file_path, file_name)
        # Read the CSV file in chunks
        for chunk in pd.read_csv(file_full_path, chunksize=100000,␣
 ↪low_memory=False):
            # Sample the chunk
            sampled_chunk = chunk.sample(frac=sampling_fraction, random_state=1)
            df_list.append(sampled_chunk)
            # Delete chunk to free memory
            del chunk
        # Print progress
        print(f"Processed {i+1}/{len(os.listdir(file_path))} files.")

# Concatenate the sampled DataFrames
combined_df = pd.concat(df_list, ignore_index=True)

# Apply the function to the column names
combined_df = trim_column_names(combined_df)

# Delete the list of DataFrames to free memory
del df_list
gc.collect()

# Print DataFrame info
print(combined_df.info())
```

```
Processed 1/10 files.
Processed 2/10 files.
Processed 3/10 files.
Processed 4/10 files.
Processed 5/10 files.
Processed 6/10 files.
Processed 7/10 files.
Processed 8/10 files.
Processed 9/10 files.
Processed 10/10 files.
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1623303 entries, 0 to 1623302
Data columns (total 84 columns):
 #   Column             Non-Null Count    Dtype
---  ------             --------------    -----
 0   dst port           1623303 non-null  object
 1   protocol           1623303 non-null  object
 2   timestamp          1623303 non-null  object
 3   flow duration      1623303 non-null  object
 4   tot fwd pkts       1623303 non-null  object
 5   tot bwd pkts       1623303 non-null  object
 6   totlen fwd pkts    1623303 non-null  object
 7   totlen bwd pkts    1623303 non-null  object
 8   fwd pkt len max    1623303 non-null  object
 9   fwd pkt len min    1623303 non-null  object
 10  fwd pkt len mean   1623303 non-null  object
 11  fwd pkt len std    1623303 non-null  object
 12  bwd pkt len max    1623303 non-null  object
 13  bwd pkt len min    1623303 non-null  object
 14  bwd pkt len mean   1623303 non-null  object
 15  bwd pkt len std    1623303 non-null  object
 16  flow byts_s        1617385 non-null  object
 17  flow pkts_s        1623303 non-null  object
 18  flow iat mean      1623303 non-null  object
 19  flow iat std       1623303 non-null  object
 20  flow iat max       1623303 non-null  object
 21  flow iat min       1623303 non-null  object
 22  fwd iat tot        1623303 non-null  object
 23  fwd iat mean       1623303 non-null  object
 24  fwd iat std        1623303 non-null  object
 25  fwd iat max        1623303 non-null  object
 26  fwd iat min        1623303 non-null  object
 27  bwd iat tot        1623303 non-null  object
 28  bwd iat mean       1623303 non-null  object
 29  bwd iat std        1623303 non-null  object
 30  bwd iat max        1623303 non-null  object
 31  bwd iat min        1623303 non-null  object
 32  fwd psh flags      1623303 non-null  object
 33  bwd psh flags      1623303 non-null  object
 34  fwd urg flags      1623303 non-null  object
 35  bwd urg flags      1623303 non-null  object
 36  fwd header len     1623303 non-null  object
 37  bwd header len     1623303 non-null  object
 38  fwd pkts_s         1623303 non-null  object
 39  bwd pkts_s         1623303 non-null  object
 40  pkt len min        1623303 non-null  object
 41  pkt len max        1623303 non-null  object
 42  pkt len mean       1623303 non-null  object
 43  pkt len std        1623303 non-null  object
 44  pkt len var        1623303 non-null  object
 45  fin flag cnt       1623303 non-null  object
 46  syn flag cnt       1623303 non-null  object
 47  rst flag cnt       1623303 non-null  object
 48  psh flag cnt       1623303 non-null  object
 49  ack flag cnt       1623303 non-null  object
 50  urg flag cnt       1623303 non-null  object
 51  cwe flag count     1623303 non-null  object
 52  ece flag cnt       1623303 non-null  object
 53  down_up ratio      1623303 non-null  object
 54  pkt size avg       1623303 non-null  object
 55  fwd seg size avg   1623303 non-null  object
 56  bwd seg size avg   1623303 non-null  object
 57  fwd byts_b avg     1623303 non-null  object
 58  fwd pkts_b avg     1623303 non-null  object
 59  fwd blk rate avg   1623303 non-null  object
 60  bwd byts_b avg     1623303 non-null  object
 61  bwd pkts_b avg     1623303 non-null  object
 62  bwd blk rate avg   1623303 non-null  object
 63  subflow fwd pkts   1623303 non-null  object
 64  subflow fwd byts   1623303 non-null  object
 65  subflow bwd pkts   1623303 non-null  object
 66  subflow bwd byts   1623303 non-null  object
 67  init fwd win byts  1623303 non-null  object
 68  init bwd win byts  1623303 non-null  object
 69  fwd act data pkts  1623303 non-null  object
 70  fwd seg size min   1623303 non-null  object
 71  active mean        1623303 non-null  object
 72  active std         1623303 non-null  object
 73  active max         1623303 non-null  object
 74  active min         1623303 non-null  object
 75  idle mean          1623303 non-null  object
 76  idle std           1623303 non-null  object
 77  idle max           1623303 non-null  object
 78  idle min           1623303 non-null  object
 79  label              1623303 non-null  object
 80  flow id            794875 non-null   object
 81  src ip             794875 non-null   object
 82  src port           794875 non-null   float64
 83  dst ip             794875 non-null   object
dtypes: float64(1), object(83)
```

```
memory usage: 1.0+ GB
None
```

[3]:

```
def replace_spaces_in_column_names(df):
    df.columns = [c.replace(' ', '_').lower() for c in df.columns]
    return df
combined_df = replace_spaces_in_column_names(combined_df)
combined_df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1623303 entries, 0 to 1623302
Data columns (total 84 columns):
 #   Column             Non-Null Count    Dtype
---  ------             --------------    -----
 0   dst_port           1623303 non-null  object
 1   protocol           1623303 non-null  object
 2   timestamp          1623303 non-null  object
 3   flow_duration      1623303 non-null  object
 4   tot_fwd_pkts       1623303 non-null  object
 5   tot_bwd_pkts       1623303 non-null  object
 6   totlen_fwd_pkts    1623303 non-null  object
 7   totlen_bwd_pkts    1623303 non-null  object
 8   fwd_pkt_len_max    1623303 non-null  object
 9   fwd_pkt_len_min    1623303 non-null  object
 10  fwd_pkt_len_mean   1623303 non-null  object
 11  fwd_pkt_len_std    1623303 non-null  object
 12  bwd_pkt_len_max    1623303 non-null  object
 13  bwd_pkt_len_min    1623303 non-null  object
 14  bwd_pkt_len_mean   1623303 non-null  object
 15  bwd_pkt_len_std    1623303 non-null  object
 16  flow_byts_s        1617385 non-null  object
 17  flow_pkts_s        1623303 non-null  object
 18  flow_iat_mean      1623303 non-null  object
 19  flow_iat_std       1623303 non-null  object
 20  flow_iat_max       1623303 non-null  object
 21  flow_iat_min       1623303 non-null  object
 22  fwd_iat_tot        1623303 non-null  object
 23  fwd_iat_mean       1623303 non-null  object
 24  fwd_iat_std        1623303 non-null  object
 25  fwd_iat_max        1623303 non-null  object
 26  fwd_iat_min        1623303 non-null  object
 27  bwd_iat_tot        1623303 non-null  object
 28  bwd_iat_mean       1623303 non-null  object
 29  bwd_iat_std        1623303 non-null  object
 30  bwd_iat_max        1623303 non-null  object
 31  bwd_iat_min        1623303 non-null  object
 32  fwd_psh_flags      1623303 non-null  object
 33  bwd_psh_flags      1623303 non-null  object
```

```
34  fwd_urg_flags      1623303 non-null  object
35  bwd_urg_flags      1623303 non-null  object
36  fwd_header_len     1623303 non-null  object
37  bwd_header_len     1623303 non-null  object
38  fwd_pkts_s         1623303 non-null  object
39  bwd_pkts_s         1623303 non-null  object
40  pkt_len_min        1623303 non-null  object
41  pkt_len_max        1623303 non-null  object
42  pkt_len_mean       1623303 non-null  object
43  pkt_len_std        1623303 non-null  object
44  pkt_len_var        1623303 non-null  object
45  fin_flag_cnt       1623303 non-null  object
46  syn_flag_cnt       1623303 non-null  object
47  rst_flag_cnt       1623303 non-null  object
48  psh_flag_cnt       1623303 non-null  object
49  ack_flag_cnt       1623303 non-null  object
50  urg_flag_cnt       1623303 non-null  object
51  cwe_flag_count     1623303 non-null  object
52  ece_flag_cnt       1623303 non-null  object
53  down_up_ratio      1623303 non-null  object
54  pkt_size_avg       1623303 non-null  object
55  fwd_seg_size_avg   1623303 non-null  object
56  bwd_seg_size_avg   1623303 non-null  object
57  fwd_byts_b_avg     1623303 non-null  object
58  fwd_pkts_b_avg     1623303 non-null  object
59  fwd_blk_rate_avg   1623303 non-null  object
60  bwd_byts_b_avg     1623303 non-null  object
61  bwd_pkts_b_avg     1623303 non-null  object
62  bwd_blk_rate_avg   1623303 non-null  object
63  subflow_fwd_pkts   1623303 non-null  object
64  subflow_fwd_byts   1623303 non-null  object
65  subflow_bwd_pkts   1623303 non-null  object
66  subflow_bwd_byts   1623303 non-null  object
67  init_fwd_win_byts  1623303 non-null  object
68  init_bwd_win_byts  1623303 non-null  object
69  fwd_act_data_pkts  1623303 non-null  object
70  fwd_seg_size_min   1623303 non-null  object
71  active_mean        1623303 non-null  object
72  active_std         1623303 non-null  object
73  active_max         1623303 non-null  object
74  active_min         1623303 non-null  object
75  idle_mean          1623303 non-null  object
76  idle_std           1623303 non-null  object
77  idle_max           1623303 non-null  object
78  idle_min           1623303 non-null  object
79  label              1623303 non-null  object
80  flow_id            794875 non-null   object
81  src_ip             794875 non-null   object
```

```
 82  src_port           794875 non-null   float64
 83  dst_ip             794875 non-null   object
dtypes: float64(1), object(83)
memory usage: 1.0+ GB
```

[4]:

```
print("Mapping columns to match the trained features...")
# Map columns to match the trained features
column_mapping = {
    'protocol': 'protocol',
    'flow_duration': 'flow_duration',
    'tot_fwd_pkts': 'total_fwd_packets',
    'totlen_fwd_pkts': 'total_length_of_fwd_packets',
    'fwd_pkt_len_max': 'fwd_packet_length_max',
    'fwd_pkt_len_min': 'fwd_packet_length_min',
    'fwd_pkt_len_mean': 'fwd_packet_length_mean',
    'bwd_pkt_len_max': 'bwd_packet_length_max',
    'bwd_pkt_len_min': 'bwd_packet_length_min',
    'flow_byts_s': 'flow_bytes_s',
    'flow_pkts_s': 'flow_packets_s',
    'flow_iat_mean': 'flow_iat_mean',
    'flow_iat_std': 'flow_iat_std',
    'flow_iat_min': 'flow_iat_min',
    'fwd_iat_min': 'fwd_iat_min',
    'bwd_iat_tot': 'bwd_iat_total',
    'bwd_iat_mean': 'bwd_iat_mean',
    'bwd_iat_std': 'bwd_iat_std',
    'bwd_iat_max': 'bwd_iat_max',
    'fwd_psh_flags': 'fwd_psh_flags',
    'fwd_urg_flags': 'fwd_urg_flags',
    'fwd_header_len': 'fwd_header_length',
    'bwd_header_len': 'bwd_header_length',
    'bwd_pkts_s': 'bwd_packets_s',
    'pkt_len_min': 'min_packet_length',
    'fin_flag_cnt': 'fin_flag_count',
    'rst_flag_cnt': 'rst_flag_count',
    'psh_flag_cnt': 'psh_flag_count',
    'ack_flag_cnt': 'ack_flag_count',
    'urg_flag_cnt': 'urg_flag_count',
    'down_up_ratio': 'down_up_ratio',
    'init_fwd_win_byts': 'init_win_bytes_forward',
    'init_bwd_win_byts': 'init_win_bytes_backward',
    'fwd_act_data_pkts': 'act_data_pkt_fwd',
    'fwd_seg_size_min': 'min_seg_size_forward',
    'active_mean': 'active_mean',
    'active_std': 'active_std',
    'active_max': 'active_max',
    'idle_std': 'idle_std'
}

print("Renaming columns in the DataFrame...")
# Rename the columns in the new DataFrame to match the trained feature names
combined_df.rename(columns=column_mapping, inplace=True)

# Updated feature columns
feature_columns = list(column_mapping.values())

print("Creating is_attack column...")
# Selecting the necessary columns and creating is_attack
combined_df['is_attack'] = combined_df.label.apply(lambda x: 0 if x == "Benign"␣
 ↪else 1)

print("Ensuring the data types are correct...")
# Ensure the data types are correct
combined_df[feature_columns] = combined_df[feature_columns].apply(pd.
 ↪to_numeric, errors='coerce')

print("Removing rows with null, infinity, and negative values...")
# Remove rows with null, infinity, and negative values
combined_df.replace([np.inf, -np.inf], np.nan, inplace=True)
combined_df.dropna(subset=feature_columns, inplace=True)
combined_df = combined_df[(combined_df[feature_columns] >= 0).all(axis=1)]

print("Data preprocessing completed.")
```

```
Mapping columns to match the trained features…
Renaming columns in the DataFrame…
Creating is_attack column…
Ensuring the data types are correct…
Removing rows with null, infinity, and negative values…
Data preprocessing completed.
```

[5]:

```
combined_df["is_attack"].value_counts()
```

[5]:

```
is_attack
0    670707
1    126692
Name: count, dtype: int64
```

1.2 2. Loading and Testing the Modules

[6]:

```
# Apply the scaler to the selected columns directly in the DataFrame
# print("Scaling the data...")
# combined_df[feature_columns] = scaler.transform(combined_df[feature_columns])
# Separate features and target
```

```
X_new = combined_df[feature_columns]
Y_new = combined_df[['is_attack']]  # Define Y_new as a DataFrame
```

[7]:
```
X_new.head()
X_test.head()
```

[7]:
```
         protocol  flow_duration  total_fwd_packets  \
2326395        17          175.0                  2
2726667         6        16815.0                  5
2517796         6           57.0                  1
212987          6     36117515.0                  7
2427509         6           65.0                  1

         total_length_of_fwd_packets  fwd_packet_length_max  \
2326395                         46.0                   23.0
2726667                      11601.0                 5840.0
2517796                          0.0                    0.0
212987                         460.0                  430.0
2427509                          2.0                    2.0

         fwd_packet_length_min  fwd_packet_length_mean  bwd_packet_length_max  \
2326395                   23.0               23.000000                   23.0
2726667                    0.0             2320.200000                   20.0
2517796                    0.0                0.000000                    6.0
212987                     0.0               65.714286                 1768.0
2427509                    2.0                2.000000                    6.0

         bwd_packet_length_min   flow_bytes_s  …  urg_flag_count  \
2326395                   23.0  525714.285700  …               0
2726667                    6.0  691465.953000  …               0
2517796                    6.0  105263.157900  …               0
212987                     0.0      62.019771  …               0
2427509                    6.0  123076.923100  …               0

         down_up_ratio  init_win_bytes_forward  init_win_bytes_backward  \
2326395            1.0            10815.441693              4054.888799
2726667            0.0             8192.000000               256.000000
2517796            1.0            29200.000000                 0.000000
212987             1.0             8192.000000               946.000000
2427509            1.0             1024.000000                 0.000000

         act_data_pkt_fwd  min_seg_size_forward  active_mean    active_std  \
2326395                 1                  32.0          0.0      0.000000
2726667                 3                  20.0          0.0      0.000000
2517796                 0                  40.0          0.0      0.000000
212987                  6                  20.0      36417.0  22365.124212
2427509                 0                  24.0          0.0      0.000000
```

```
         active_max     idle_std
2326395         0.0     0.000000
2726667         0.0     0.000000
2517796         0.0     0.000000
212987      62237.0  2790.808664
2427509         0.0     0.000000

[5 rows x 39 columns]
```

[8]:

```python
import joblib
from keras.optimizers import Adam
def load_model(model_name):
    file_path = f'models/{model_name}.pkl'
    model = joblib.load(file_path)
    print(f'Model loaded from {file_path}')
    return model

def load_keras_model(model_name):
    file_path = f'models/{model_name}'
    model = keras_load_model(file_path)
    model.compile(optimizer=Adam(), loss='binary_crossentropy',␣
 ↪metrics=['accuracy'])
    print(f'Keras model loaded from {file_path}')
    return model
# Load the models
models = {
    'ID3': load_model('id3_model'),
    'Random Forest': load_model('random_forest'),
    'XGBoost': load_model('xgb_model'),
    'DNN1': load_keras_model('DNN_model1.h5'),
    'DNN2': load_keras_model('DNN_model2.keras'),
    'DNN3': load_keras_model('DNN_model1.keras'),
    'DNN4': load_keras_model('DNN_model3.keras')
}

# Evaluate the models on the training data
for model_name, model in models.items():
    if 'DNN' in model_name:
        y_pred_prob = model.predict(scaler.transform(X_new))
        predictions = (y_pred_prob > 0.5).astype(int).flatten()  # Convert␣
 ↪probabilities to binary predictions and flatten to 1D array
    else:
        predictions = model.predict(scaler.transform(X_new))
    print(f"Evaluating {model_name}...")
    metrics_report("Evaluation", Y_new.is_attack, predictions, print_avg=False)
    plot_confusion_matrix(model_name, Y_new, predictions)
```

```
Model loaded from models/id3_model.pkl
Model loaded from models/random_forest.pkl
Model loaded from models/xgb_model.pkl
```

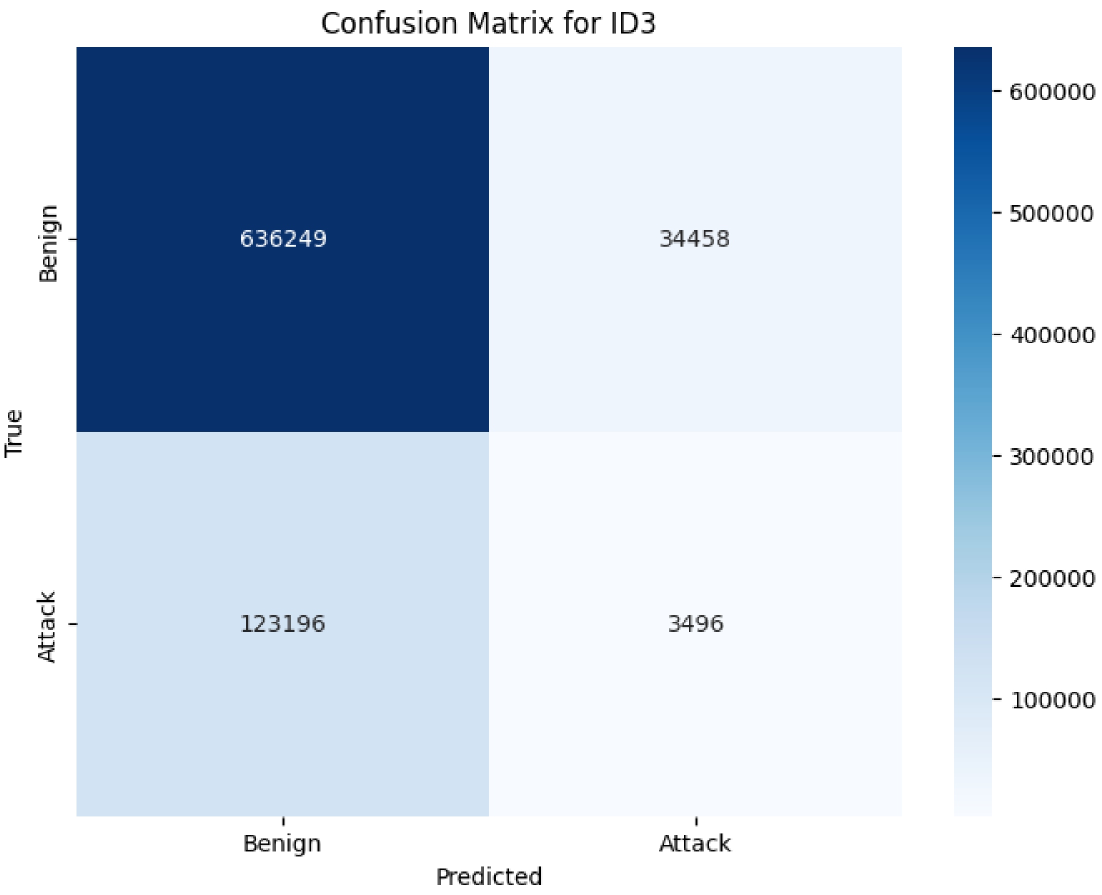
```
WARNING:absl:Compiled the loaded model, but the compiled metrics have yet to be
built. `model.compile_metrics` will be empty until you train or evaluate the
model.
```

```
Keras model loaded from models/DNN_model1.h5
Keras model loaded from models/DNN_model2.keras
Keras model loaded from models/DNN_model1.keras
Keras model loaded from models/DNN_model3.keras
Evaluating ID3…
Classification Report (Evaluation):
              precision    recall  f1-score   support

           0     0.8378    0.9486    0.8898    670707
           1     0.0921    0.0276    0.0425    126692

    accuracy                         0.8023    797399
   macro avg     0.4649    0.4881    0.4661    797399
weighted avg     0.7193    0.8023    0.7551    797399

Accuracy: 0.8022896943688166
```



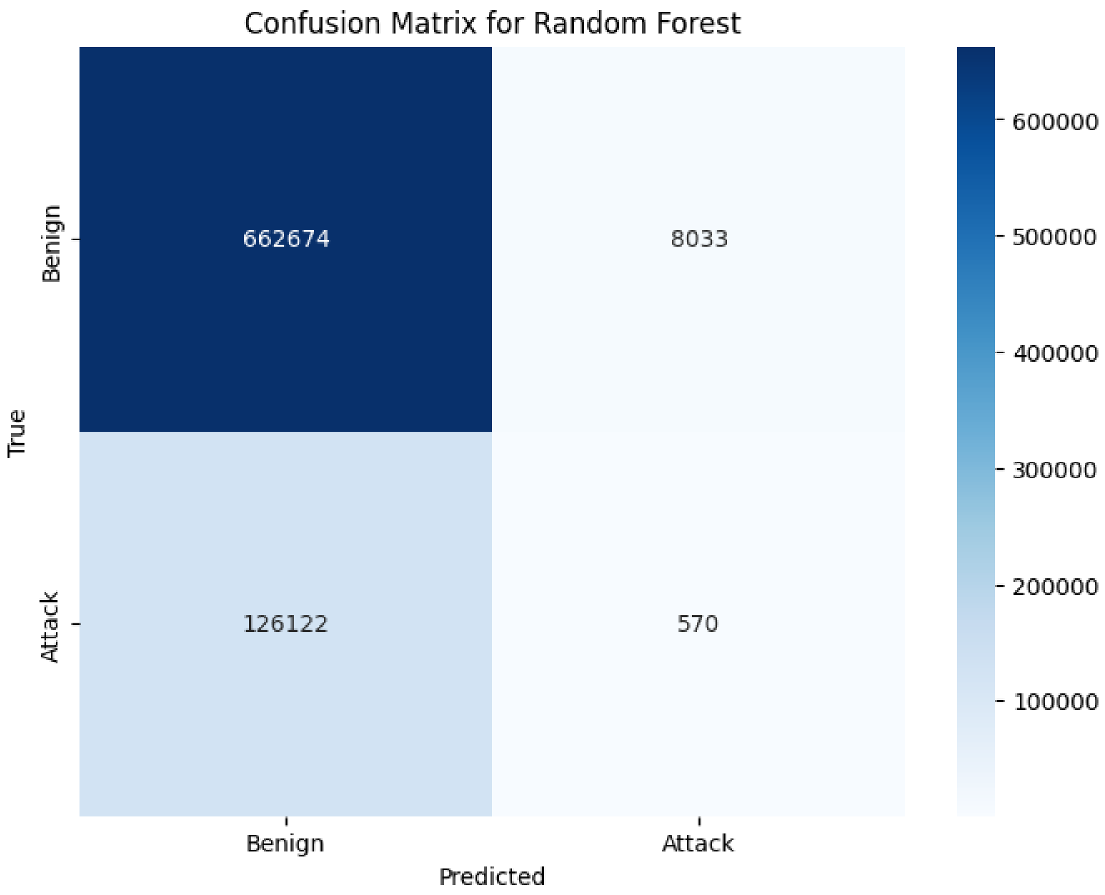
```
[Parallel(n_jobs=16)]: Using backend ThreadingBackend with 16 concurrent
workers.
[Parallel(n_jobs=16)]: Done  18 tasks      | elapsed:    0.1s
[Parallel(n_jobs=16)]: Done 168 tasks      | elapsed:    1.0s
[Parallel(n_jobs=16)]: Done 300 out of 300 | elapsed:    1.9s finished

Evaluating Random Forest…
Classification Report (Evaluation):
              precision    recall  f1-score   support

           0     0.8401    0.9880    0.9081    670707
           1     0.0663    0.0045    0.0084    126692

    accuracy                         0.8318    797399
   macro avg     0.4532    0.4963    0.4583    797399
weighted avg     0.7172    0.8318    0.7651    797399

Accuracy: 0.8317592572852487
```

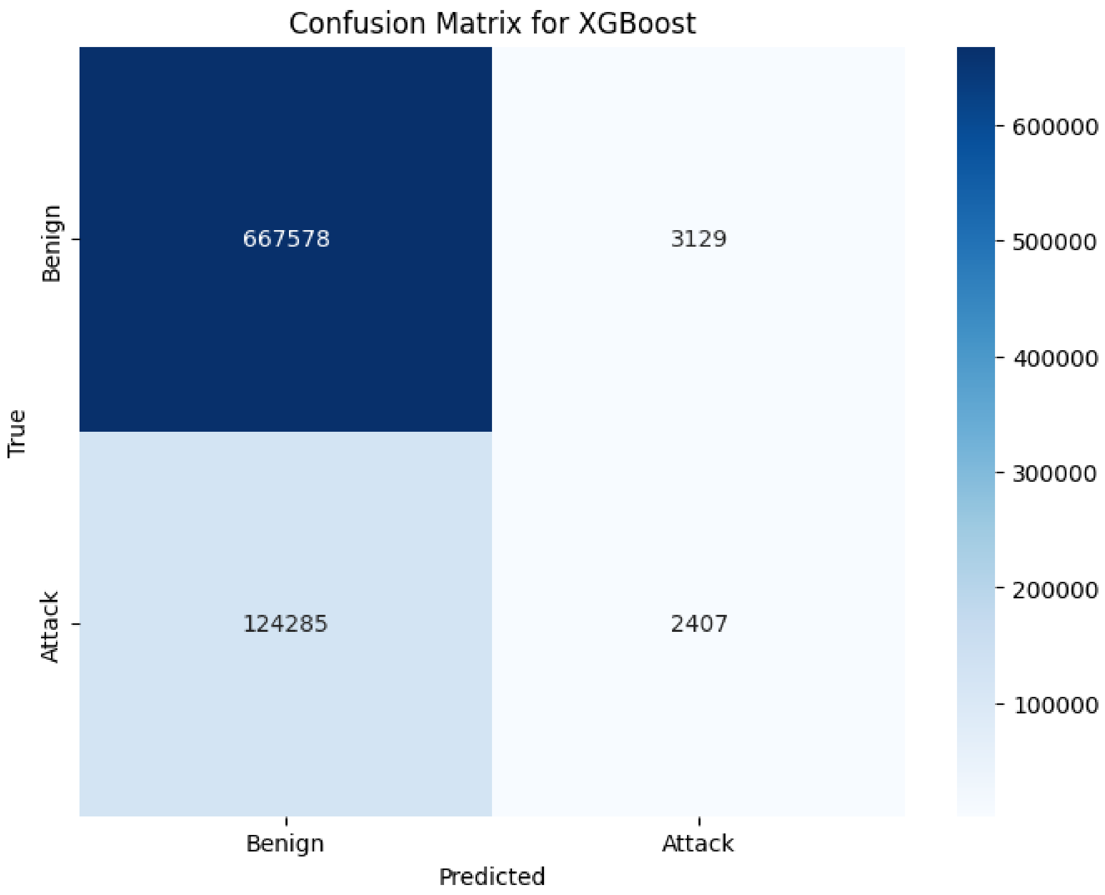


```
Evaluating XGBoost…
Classification Report (Evaluation):
              precision    recall  f1-score   support

           0     0.8430    0.9953    0.9129    670707
           1     0.4348    0.0190    0.0364    126692

    accuracy                         0.8402    797399
   macro avg     0.6389    0.5072    0.4746    797399
weighted avg     0.7782    0.8402    0.7736    797399

Accuracy: 0.8402129924918391
```

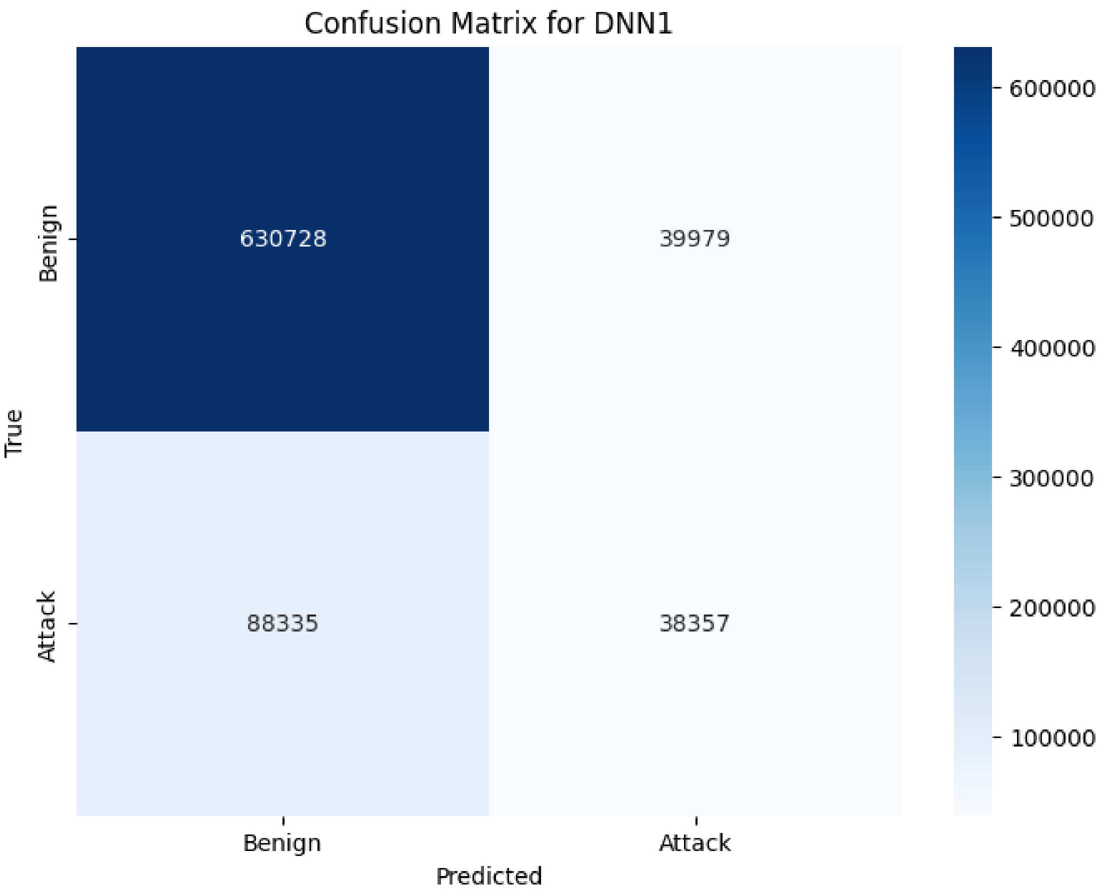


```
24919/24919            11s
434us/step
Evaluating DNN1…
Classification Report (Evaluation):
              precision    recall  f1-score   support

           0     0.8772    0.9404    0.9077    670707
           1     0.4896    0.3028    0.3742    126692

    accuracy                         0.8391    797399
   macro avg     0.6834    0.6216    0.6409    797399
weighted avg     0.8156    0.8391    0.8229    797399

Accuracy: 0.8390843229048444
```

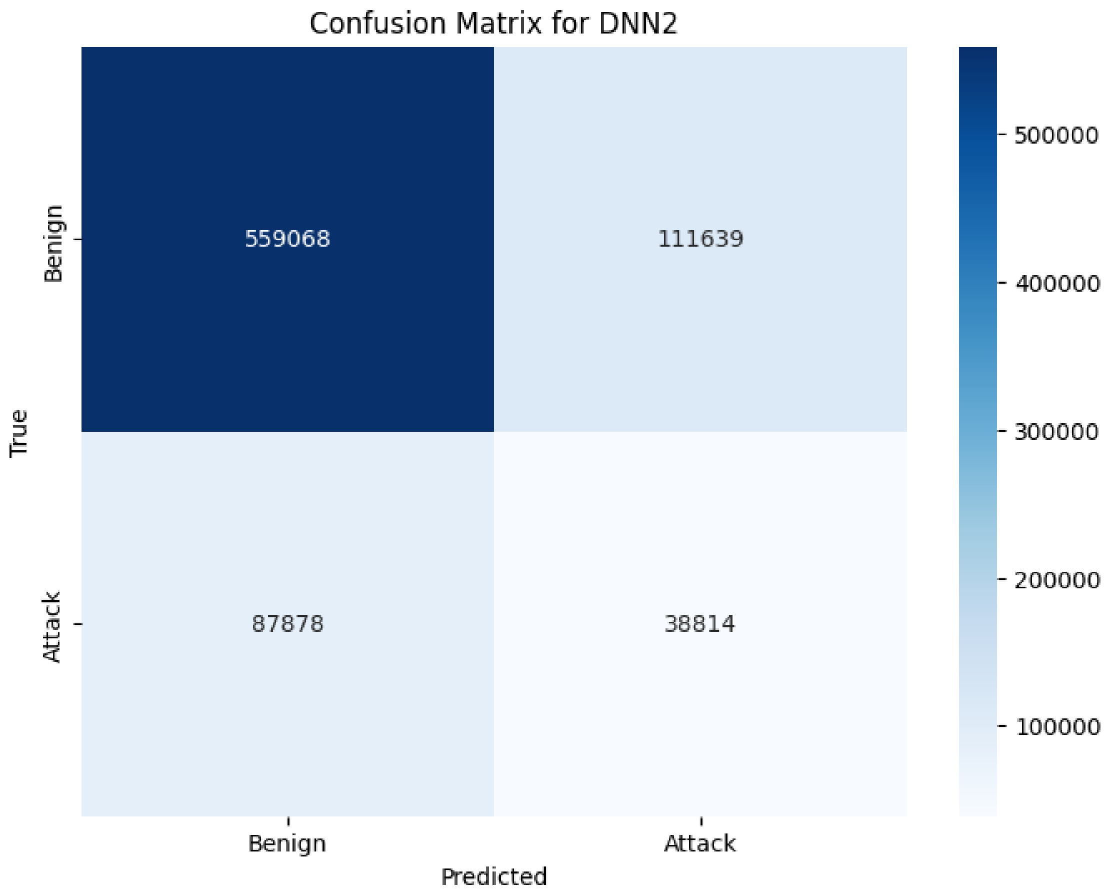


```
24919/24919             11s
424us/step
Evaluating DNN2…
Classification Report (Evaluation):
              precision    recall  f1-score   support

           0     0.8642    0.8336    0.8486    670707
           1     0.2580    0.3064    0.2801    126692

    accuracy                         0.7498    797399
   macro avg     0.5611    0.5700    0.5643    797399
weighted avg     0.7679    0.7498    0.7583    797399

Accuracy: 0.7497902555684168
```

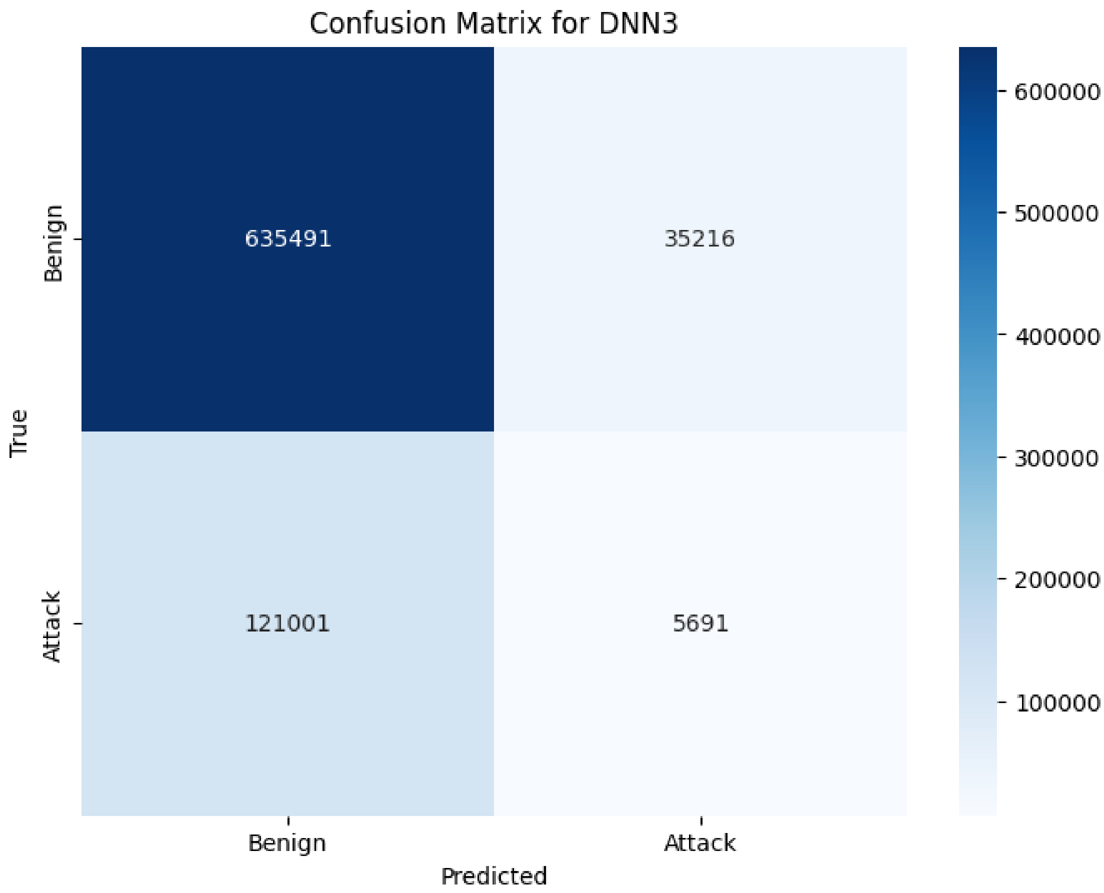


```
24919/24919            20s
781us/step
Evaluating DNN3…
Classification Report (Evaluation):
              precision    recall  f1-score   support

           0     0.8400    0.9475    0.8905    670707
           1     0.1391    0.0449    0.0679    126692

    accuracy                         0.8041    797399
   macro avg     0.4896    0.4962    0.4792    797399
weighted avg     0.7287    0.8041    0.7598    797399

Accuracy: 0.8040918034760515
```

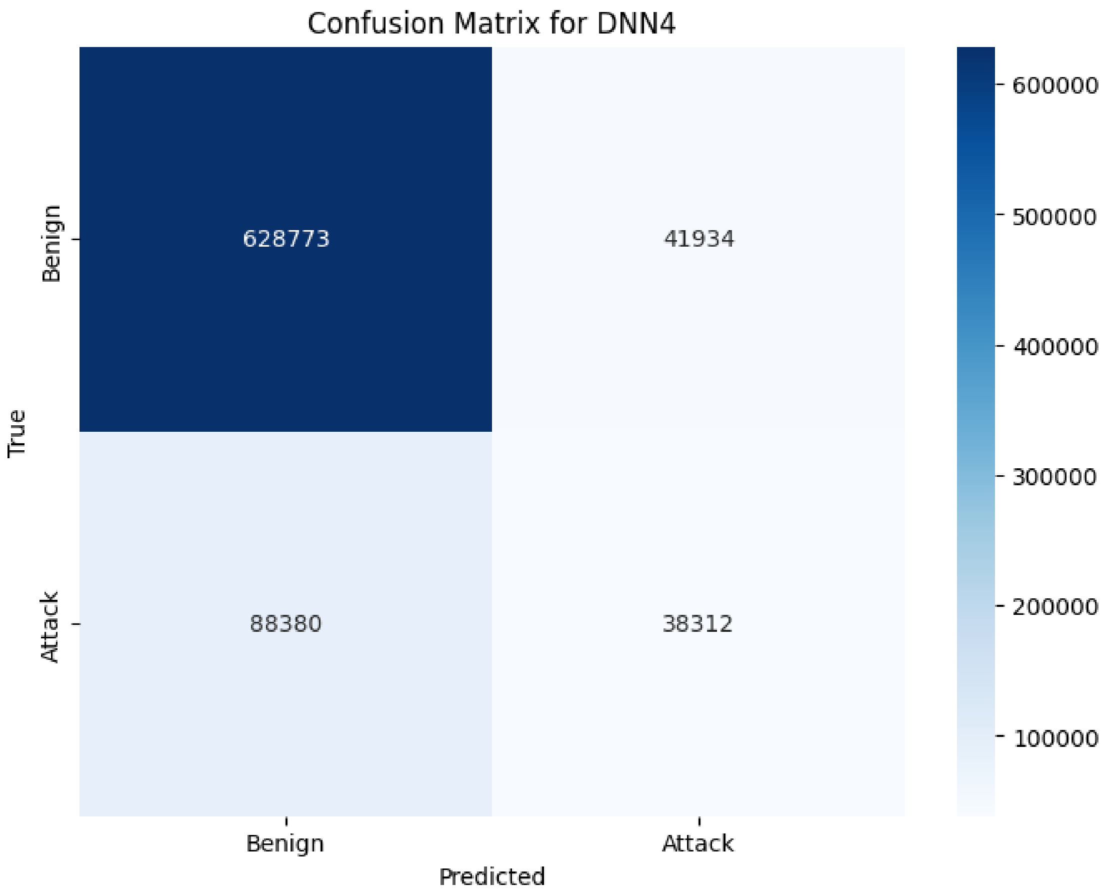


```
24919/24919            12s
488us/step
Evaluating DNN4…
Classification Report (Evaluation):
              precision    recall  f1-score   support

           0     0.8768    0.9375    0.9061    670707
           1     0.4774    0.3024    0.3703    126692

    accuracy                         0.8366    797399
   macro avg     0.6771    0.6199    0.6382    797399
weighted avg     0.8133    0.8366    0.8210    797399

Accuracy: 0.8365761682670784
```



1.3 Conclusion

Given the results, the models don't generalize very well to the IDS-2018 dataset. Another approach is considered, invloving active learning and semi-supervised learning, using both datasets to train the models.