4_Data_Analysis_IDS2018

June 17, 2024

1 Analyzing the IDS 2018 Dataset

In this notebook, a 10% sample of the IDS-2018 dataset is loaded to analyze basic information about the traffic before applying the same machine learning algorithms applied to the IDS2017.

[13]:
```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import os
import re
import gc
import seaborn as sns

%matplotlib inline
%load_ext autoreload
%autoreload 2
file_path = r"..\CIC-IDS-2018\Processed Traffic Data for ML Algorithms"
```

```
The autoreload extension is already loaded. To reload it, use:
  %reload_ext autoreload
```

[2]:
```
# 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()
```

```
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.
```

[2]:
```
0
```

[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)

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)
combined_df.info()
```

```
Creating is_attack column…
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1623303 entries, 0 to 1623302
Data columns (total 85 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
 84  is_attack          1623303 non-null  int64
dtypes: float64(1), int64(1), object(83)
memory usage: 1.0+ GB
```

[21]:
```
convert_dict = {'label': 'category'}
combined_df = combined_df.astype(convert_dict)
```

[24]:
```
# Convert all object columns to numeric values
```

```
combined_df = combined_df.apply(lambda x: pd.to_numeric(x, errors='coerce') if␣
 ↪x.dtype == 'object' else x)
# Verify the conversion
print(combined_df.info())
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1623303 entries, 0 to 1623302
Data columns (total 85 columns):
 #   Column              Non-Null Count    Dtype
---  ------              --------------    -----
 0   dst_port            1623295 non-null  float64
 1   protocol            1623295 non-null  float64
 2   timestamp           0 non-null        float64
 3   flow_duration       1623295 non-null  float64
 4   tot_fwd_pkts        1623295 non-null  float64
 5   tot_bwd_pkts        1623295 non-null  float64
 6   totlen_fwd_pkts     1623295 non-null  float64
 7   totlen_bwd_pkts     1623295 non-null  float64
 8   fwd_pkt_len_max     1623295 non-null  float64
 9   fwd_pkt_len_min     1623295 non-null  float64
 10  fwd_pkt_len_mean    1623295 non-null  float64
 11  fwd_pkt_len_std     1623295 non-null  float64
 12  bwd_pkt_len_max     1623295 non-null  float64
 13  bwd_pkt_len_min     1623295 non-null  float64
 14  bwd_pkt_len_mean    1623295 non-null  float64
 15  bwd_pkt_len_std     1623295 non-null  float64
 16  flow_byts_s         1617377 non-null  float64
 17  flow_pkts_s         1623295 non-null  float64
 18  flow_iat_mean       1623295 non-null  float64
 19  flow_iat_std        1623295 non-null  float64
 20  flow_iat_max        1623295 non-null  float64
 21  flow_iat_min        1623295 non-null  float64
 22  fwd_iat_tot         1623295 non-null  float64
 23  fwd_iat_mean        1623295 non-null  float64
 24  fwd_iat_std         1623295 non-null  float64
 25  fwd_iat_max         1623295 non-null  float64
 26  fwd_iat_min         1623295 non-null  float64
 27  bwd_iat_tot         1623295 non-null  float64
 28  bwd_iat_mean        1623295 non-null  float64
 29  bwd_iat_std         1623295 non-null  float64
 30  bwd_iat_max         1623295 non-null  float64
 31  bwd_iat_min         1623295 non-null  float64
 32  fwd_psh_flags       1623295 non-null  float64
 33  bwd_psh_flags       1623295 non-null  float64
 34  fwd_urg_flags       1623295 non-null  float64
 35  bwd_urg_flags       1623295 non-null  float64
 36  fwd_header_len      1623295 non-null  float64
 37  bwd_header_len      1623295 non-null  float64
```

```
 38  fwd_pkts_s          1623295 non-null  float64
 39  bwd_pkts_s          1623295 non-null  float64
 40  pkt_len_min         1623295 non-null  float64
 41  pkt_len_max         1623295 non-null  float64
 42  pkt_len_mean        1623295 non-null  float64
 43  pkt_len_std         1623295 non-null  float64
 44  pkt_len_var         1623295 non-null  float64
 45  fin_flag_cnt        1623295 non-null  float64
 46  syn_flag_cnt        1623295 non-null  float64
 47  rst_flag_cnt        1623295 non-null  float64
 48  psh_flag_cnt        1623295 non-null  float64
 49  ack_flag_cnt        1623295 non-null  float64
 50  urg_flag_cnt        1623295 non-null  float64
 51  cwe_flag_count      1623295 non-null  float64
 52  ece_flag_cnt        1623295 non-null  float64
 53  down_up_ratio       1623295 non-null  float64
 54  pkt_size_avg        1623295 non-null  float64
 55  fwd_seg_size_avg    1623295 non-null  float64
 56  bwd_seg_size_avg    1623295 non-null  float64
 57  fwd_byts_b_avg      1623295 non-null  float64
 58  fwd_pkts_b_avg      1623295 non-null  float64
 59  fwd_blk_rate_avg    1623295 non-null  float64
 60  bwd_byts_b_avg      1623295 non-null  float64
 61  bwd_pkts_b_avg      1623295 non-null  float64
 62  bwd_blk_rate_avg    1623295 non-null  float64
 63  subflow_fwd_pkts    1623295 non-null  float64
 64  subflow_fwd_byts    1623295 non-null  float64
 65  subflow_bwd_pkts    1623295 non-null  float64
 66  subflow_bwd_byts    1623295 non-null  float64
 67  init_fwd_win_byts   1623295 non-null  float64
 68  init_bwd_win_byts   1623295 non-null  float64
 69  fwd_act_data_pkts   1623295 non-null  float64
 70  fwd_seg_size_min    1623295 non-null  float64
 71  active_mean         1623295 non-null  float64
 72  active_std          1623295 non-null  float64
 73  active_max          1623295 non-null  float64
 74  active_min          1623295 non-null  float64
 75  idle_mean           1623295 non-null  float64
 76  idle_std            1623295 non-null  float64
 77  idle_max            1623295 non-null  float64
 78  idle_min            1623295 non-null  float64
 79  label               1623303 non-null  category
 80  flow_id             0 non-null        float64
 81  src_ip              0 non-null        float64
 82  src_port            794875 non-null   float64
 83  dst_ip              0 non-null        float64
 84  is_attack           1623303 non-null  int64
dtypes: category(1), float64(83), int64(1)
```

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

[17]:
```
attack_counts = combined_df['label'].value_counts()
table_data = pd.DataFrame({'Type of Attack': attack_counts.index, 'Number of␣
 ↪Attacks': attack_counts.values})
table_data
```

[17]:

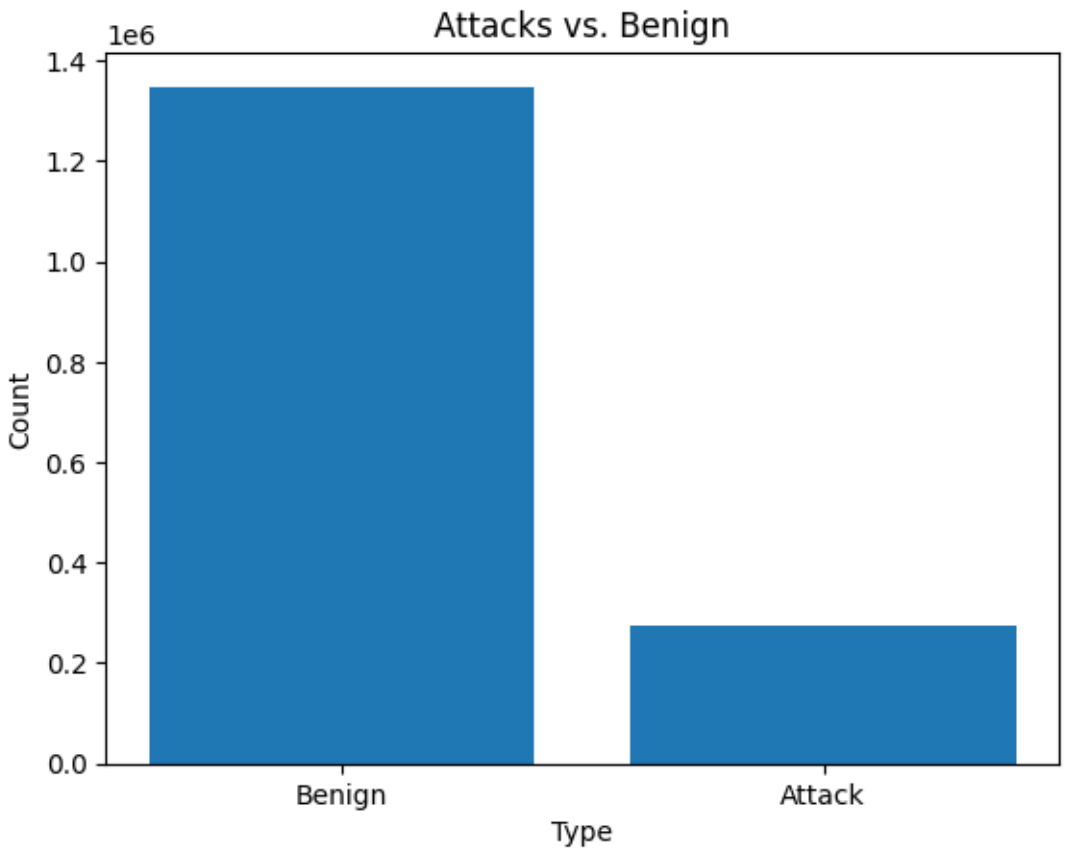
	Type of Attack	Number of Attacks
0	Benign	1347929
1	DDOS attack-HOIC	68817
2	DDoS attacks-LOIC-HTTP	57678
3	DoS attacks-Hulk	46307
4	Bot	28759
5	FTP-BruteForce	19400
6	SSH-Bruteforce	18759
7	Infilteration	16093
8	DoS attacks-SlowHTTPTest	14029
9	DoS attacks-GoldenEye	4215
10	DoS attacks-Slowloris	1055
11	DDOS attack-LOIC-UDP	168
12	Brute Force -Web	53
13	Brute Force -XSS	27
14	Label	8
15	SQL Injection	6

[18]:
```
# Remove rows where the 'label' column has the value 'label'
combined_df = combined_df[combined_df['label'] != 'label']
# Verify the rows were removed
print(combined_df['label'].unique())
```

```
['Bot' 'Benign' 'DoS attacks-SlowHTTPTest' 'DoS attacks-Hulk'
 'Brute Force -XSS' 'Brute Force -Web' 'SQL Injection'
 'DDoS attacks-LOIC-HTTP' 'Label' 'Infilteration' 'DoS attacks-Slowloris'
 'DoS attacks-GoldenEye' 'FTP-BruteForce' 'SSH-Bruteforce'
 'DDOS attack-HOIC' 'DDOS attack-LOIC-UDP']
```

1.1 Benign Network Flows vs Attacks

[6]:
```
attack_counts = combined_df['is_attack'].value_counts()
plt.bar(attack_counts.index, attack_counts.values)
plt.xlabel('Type')
plt.ylabel('Count')
plt.title('Attacks vs. Benign')
plt.xticks(ticks=[0, 1], labels=['Benign', 'Attack']) # Add custom x-axis labels
plt.show()
```



[8]:
```
attack_percentages = (attack_counts / attack_counts.sum()) * 100
# Create a new DataFrame for the table
table_data = pd.DataFrame({'Type': attack_counts.index, 'Number of Attacks':␣
 ↪attack_counts.values, 'Percentage': attack_percentages.values})
# Display the table
table_data
```

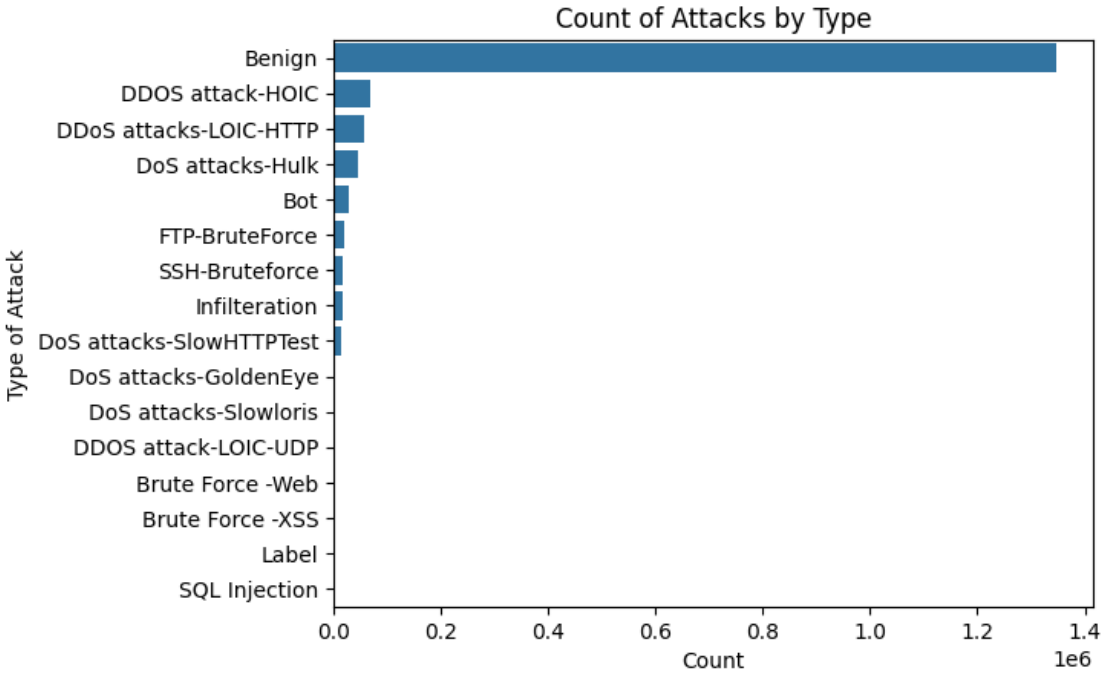
[8]:

	Type	Number of Attacks	Percentage
0	0	1347929	83.036192
1	1	275374	16.963808

1.2 Plot by the Type of Network Traffic

[15]:
```
# Get the counts of each label
label_counts = combined_df['label'].value_counts()
# Plot the count plot ordered by the number of occurrences
sns.countplot(y='label', data=combined_df, order=label_counts.index)
plt.xlabel('Count')
plt.ylabel('Type of Attack')
plt.title('Count of Attacks by Type')
```

```
plt.show()
```

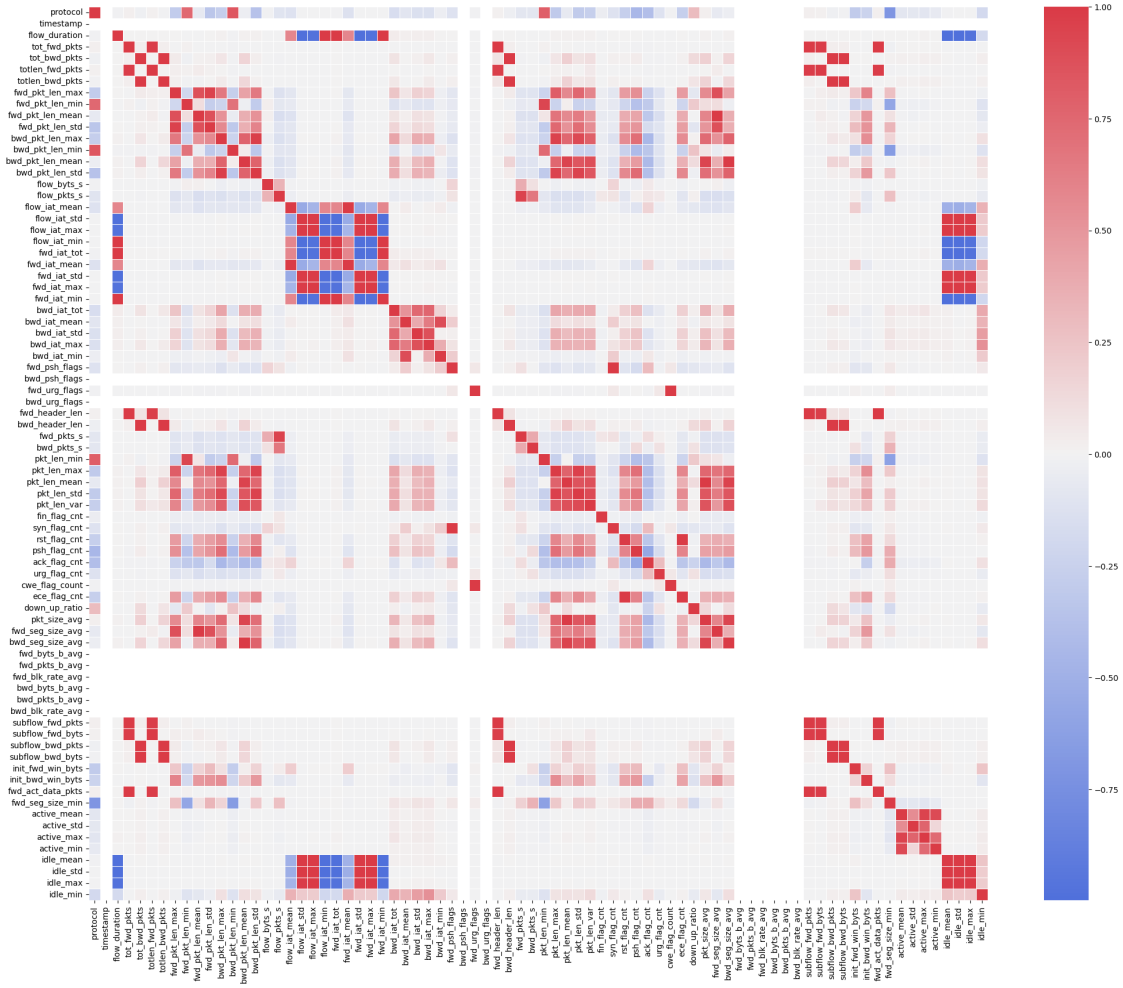


1.3 Correlation between Features

A heatmap for the correlation matrix of all relevant features is used to visualize groups of highly correlated features.

[25]:
```
new_df = combined_df.iloc[:, 1:79]
corr = new_df.corr()
plt.figure(figsize=(25, 20))
sns.heatmap(corr, xticklabels=corr.columns, yticklabels=corr.columns,␣
 ↪linewidths=.5, cmap=sns.diverging_palette(620, 10, as_cmap=True))
```

[25]: <Axes: >



1.4 Conclusion

[ ]:
```
Similarly to the ids2017 dataset, the IDS2018
```