AnalysingDDoS

November 27, 2022

1 Analysing DDoS Attack Data and Comparison Traffic

This notebook contains the calculations described in Chapter 4 Results. The metrics described in Chapter 3 are being calculated for die files from the CIC-DDoS2019 Dataset from 2019 and the Comparison Traffic (One coming from the Stratosphere Laboratory Dataset, the others are recorded Skype traffic).

[6]:
```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
from datetime import datetime, timedelta
from nfstream import NFStreamer, NFPlugin

#global
attacks_only = ['snmp', 'mssql', 'tftp','netBIOS']
comp_only = ['comparison', 'skypecomparison', 'skype2comparison']
data = attacks_only + comp_only
```

First, we define classes that calculate different values on packet-level and then add it to the dataframes below.

The class TimeDiff counts the number of packets whose delta-time falls below 1 ms.

The class PayloadSize calculates the payload-size for packets based on their direction, which is needed to calculate the amplification attack factor.

The class Delta_time returns a list of all data-time for each packet in the flow.

[7]:
```
class TimeDiff(NFPlugin):
    def on_init(self, pkt, flow): # flow creation with the first packet
            if pkt.delta_time < 1:
                flow.udps.low_time_packets = 1
            else:
                flow.udps.low_time_packets = 0

    def on_update(self, pkt, flow): # flow update with each packet belonging to␣
 ↪the flow
        if pkt.delta_time < 1:
            flow.udps.low_time_packets += 1
```

```
class PayloadSize(NFPlugin):
    def on_init(self, pkt, flow): # flow creation with the first packet
            if pkt.direction == 0:
                flow.udps.src2dst_size = pkt.payload_size
                flow.udps.dst2src_size = 0
            elif pkt.direction == 1:
                flow.udps.src2dst_size = 0
                flow.udps.dst2src_size = pkt.payload_size

    def on_update(self, pkt, flow): # flow update with each packet belonging to␣
 ↪the flow
            if pkt.direction == 0:
                flow.udps.src2dst_size += pkt.payload_size
            elif pkt.direction == 1:
                flow.udps.dst2src_size += pkt.payload_size


class DeltaTime(NFPlugin):
    def on_init(self, pkt, flow):
        flow.udps.delta_time = [pkt.delta_time]

    def on_update(self, pkt, flow):
        pkt_dt_list = [pkt.delta_time]
        flow.udps.delta_time = flow.udps.delta_time + pkt_dt_list
```

[3]:
```
# load data
#NetBIOS (SAT-01-12-2018_0475 - SAT-01-12-2018_0485)
for i in range(10):
    a = i + 75
    dat = NFStreamer(source="/home/student/BA/PCAP-01-12/PCAP-01-12_0250-0499/
 ↪SAT-01-12-2018_04"+str(a)+".pcap",
                                decode_tunnels=True,
                                bpf_filter=None,
                                promiscuous_mode=True,
                                snapshot_length=1536,
                                idle_timeout=120,
                                active_timeout=1800,
                                accounting_mode=0,
                                udps=[TimeDiff(), PayloadSize(), DeltaTime()],
                                n_dissections=20,
                                statistical_analysis=True,
                                splt_analysis=0,
                                n_meters=0,
                                performance_report=0,
```

```
                                system_visibility_mode=0,
                                system_visibility_poll_ms=100,
                                system_visibility_extension_port=28314).to_pandas()

    if i == 0:
        netBIOS = dat

    else:
        netBIOS = pd.concat([netBIOS, dat], ignore_index = True)


#SNMP
for i in range(10):

    if i < 10:
        dat = NFStreamer(source="/home/student/BA/PCAP-01-12/
 ↪PCAP-01-12_0500-0749/SAT-01-12-2018_050"+str(i)+".pcap",
                                    decode_tunnels=True,
                                    bpf_filter=None,
                                    promiscuous_mode=True,
                                    snapshot_length=1536,
                                    idle_timeout=120,
                                    active_timeout=1800,
                                    accounting_mode=0,
                                    udps=[TimeDiff(), PayloadSize(), DeltaTime()],
                                    n_dissections=20,
                                    statistical_analysis=True,
                                    splt_analysis=0,
                                    n_meters=0,
                                    performance_report=0,
                                    system_visibility_mode=0,
                                    system_visibility_poll_ms=100,
                                    system_visibility_extension_port=28314).
 ↪to_pandas()
    else:
        dat = NFStreamer(source="/home/student/BA/PCAP-01-12/
 ↪PCAP-01-12_0500-0749/SAT-01-12-2018_05"+str(i)+".pcap",
                                    decode_tunnels=True,
                                    bpf_filter=None,
                                    promiscuous_mode=True,
                                    snapshot_length=1536,
                                    idle_timeout=120,
                                    active_timeout=1800,
                                    accounting_mode=0,
                                    udps=[TimeDiff(), PayloadSize(), DeltaTime()],
                                    n_dissections=20,
                                    statistical_analysis=True,
```

```
                                    splt_analysis=0,
                                    n_meters=0,
                                    performance_report=0,
                                    system_visibility_mode=0,
                                    system_visibility_poll_ms=100,
                                    system_visibility_extension_port=28314).
 ↪to_pandas()

    if i == 0:
        snmp = dat

    else:
        snmp = pd.concat([snmp, dat], ignore_index = True)


#TFTP (SAT-01-12-2018_0750 - SAT-01-12-2018_075?)
for i in range(10):
    dat = NFStreamer(source="/home/student/BA/PCAP-01-12/PCAP-01-12_0750-0818/
 ↪SAT-01-12-2018_075"+str(i)+".pcap",
                                decode_tunnels=True,
                                bpf_filter=None,
                                promiscuous_mode=True,
                                snapshot_length=1536,
                                idle_timeout=120,
                                active_timeout=1800,
                                accounting_mode=0,
                                udps=[TimeDiff(), PayloadSize(), DeltaTime()],
                                n_dissections=20,
                                statistical_analysis=True,
                                splt_analysis=0,
                                n_meters=0,
                                performance_report=0,
                                system_visibility_mode=0,
                                system_visibility_poll_ms=100,
                                system_visibility_extension_port=28314).to_pandas()

    if i == 0:
        tftp = dat

    else:
        tftp = pd.concat([tftp, dat], ignore_index = True)



# MSSQL (SAT-01-12-2018_0444)
mssql = NFStreamer(source="/home/student/BA/PCAP-01-12/PCAP-01-12_0250-0499/
 ↪SAT-01-12-2018_0444.pcap",
```

```
                          decode_tunnels=True,
                          bpf_filter=None,
                          promiscuous_mode=True,
                          snapshot_length=1536,
                          idle_timeout=120,
                          active_timeout=1800,
                          accounting_mode=0,
                          udps=[TimeDiff(), PayloadSize(), DeltaTime()],
                          n_dissections=20,
                          statistical_analysis=True,
                          splt_analysis=0,
                          n_meters=0,
                          performance_report=0,
                          system_visibility_mode=0,
                          system_visibility_poll_ms=100,
                          system_visibility_extension_port=28314).to_pandas()



#2013-12-17_capture1
comparison = NFStreamer(source="/home/student/BA/Comparison-Traffic/
 ↪2013-12-17_capture1.pcap",
                          decode_tunnels=True,
                          bpf_filter=None,
                          promiscuous_mode=True,
                          snapshot_length=1536,
                          idle_timeout=120,
                          active_timeout=1800,
                          accounting_mode=0,
                          udps=[TimeDiff(), PayloadSize(), DeltaTime()],
                          n_dissections=20,
                          statistical_analysis=True,
                          splt_analysis=0,
                          n_meters=0,
                          performance_report=0,
                          system_visibility_mode=0,
                          system_visibility_poll_ms=100,
                          system_visibility_extension_port=28314).to_pandas()


skypecomparison = NFStreamer(source="/home/student/BA/Comparison-Traffic/test2.
 ↪pcap",
                          decode_tunnels=True,
                          bpf_filter=None,
                          promiscuous_mode=True,
                          snapshot_length=1536,
                          idle_timeout=120,
```

```
                          active_timeout=1800,
                          accounting_mode=0,
                          udps=[TimeDiff(), PayloadSize(),DeltaTime()],
                          n_dissections=20,
                          statistical_analysis=True,
                          splt_analysis=0,
                          n_meters=0,
                          performance_report=0,
                          system_visibility_mode=0,
                          system_visibility_poll_ms=100,
                          system_visibility_extension_port=28314).to_pandas()


skype2comparison = NFStreamer(source="/home/student/BA/Comparison-Traffic/
 ↪skype2.pcap",
                          decode_tunnels=True,
                          bpf_filter=None,
                          promiscuous_mode=True,
                          snapshot_length=1536,
                          idle_timeout=120,
                          active_timeout=1800,
                          accounting_mode=0,
                          udps=[TimeDiff(), PayloadSize(), DeltaTime()],
                          n_dissections=20,
                          statistical_analysis=True,
                          splt_analysis=0,
                          n_meters=0,
                          performance_report=0,
                          system_visibility_mode=0,
                          system_visibility_poll_ms=100,
                          system_visibility_extension_port=28314).to_pandas()
```

```
/home/student/.local/lib/python3.10/site-packages/nfstream/streamer.py:495:
DtypeWarning: Columns (81,82,83,84,85) have mixed types. Specify dtype option on
import or set low_memory=False.
  df = pd.read_csv(temp_file_path)
/home/student/.local/lib/python3.10/site-packages/nfstream/streamer.py:495:
DtypeWarning: Columns (81,82,83,85) have mixed types. Specify dtype option on
import or set low_memory=False.
  df = pd.read_csv(temp_file_path)
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```

```
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import or set low_memory=False.
  df = pd.read_csv(temp_file_path)
/home/student/.local/lib/python3.10/site-packages/nfstream/streamer.py:495:
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/home/student/.local/lib/python3.10/site-packages/nfstream/streamer.py:495:
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import or set low_memory=False.
  df = pd.read_csv(temp_file_path)
/home/student/.local/lib/python3.10/site-packages/nfstream/streamer.py:495:
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import or set low_memory=False.
  df = pd.read_csv(temp_file_path)
/home/student/.local/lib/python3.10/site-packages/nfstream/streamer.py:495:
DtypeWarning: Columns (81,82,83) have mixed types. Specify dtype option on
import or set low_memory=False.
  df = pd.read_csv(temp_file_path)
/home/student/.local/lib/python3.10/site-packages/nfstream/streamer.py:495:
DtypeWarning: Columns (81,82,83,84,85) have mixed types. Specify dtype option on
import or set low_memory=False.
  df = pd.read_csv(temp_file_path)
/home/student/.local/lib/python3.10/site-packages/nfstream/streamer.py:495:
DtypeWarning: Columns (81,82,83,84,85) have mixed types. Specify dtype option on
import or set low_memory=False.
  df = pd.read_csv(temp_file_path)
/home/student/.local/lib/python3.10/site-packages/nfstream/streamer.py:495:
DtypeWarning: Columns (81,82,83,84,85) have mixed types. Specify dtype option on
import or set low_memory=False.
  df = pd.read_csv(temp_file_path)
/home/student/.local/lib/python3.10/site-packages/nfstream/streamer.py:495:
DtypeWarning: Columns (81) have mixed types. Specify dtype option on import or
set low_memory=False.
  df = pd.read_csv(temp_file_path)
/home/student/.local/lib/python3.10/site-packages/nfstream/streamer.py:495:
DtypeWarning: Columns (81,82,83,84,85) have mixed types. Specify dtype option on
import or set low_memory=False.
  df = pd.read_csv(temp_file_path)
/home/student/.local/lib/python3.10/site-packages/nfstream/streamer.py:495:
DtypeWarning: Columns (81,82) have mixed types. Specify dtype option on import
or set low_memory=False.
```

```
  df = pd.read_csv(temp_file_path)
/home/student/.local/lib/python3.10/site-packages/nfstream/streamer.py:495:
DtypeWarning: Columns (81,82) have mixed types. Specify dtype option on import
or set low_memory=False.
  df = pd.read_csv(temp_file_path)
/home/student/.local/lib/python3.10/site-packages/nfstream/streamer.py:495:
DtypeWarning: Columns (81,82) have mixed types. Specify dtype option on import
or set low_memory=False.
  df = pd.read_csv(temp_file_path)
/home/student/.local/lib/python3.10/site-packages/nfstream/streamer.py:495:
DtypeWarning: Columns (81,82,83) have mixed types. Specify dtype option on
import or set low_memory=False.
  df = pd.read_csv(temp_file_path)
/home/student/.local/lib/python3.10/site-packages/nfstream/streamer.py:495:
DtypeWarning: Columns (81,82,83,84,85) have mixed types. Specify dtype option on
import or set low_memory=False.
  df = pd.read_csv(temp_file_path)
/home/student/.local/lib/python3.10/site-packages/nfstream/streamer.py:495:
DtypeWarning: Columns (81,83) have mixed types. Specify dtype option on import
or set low_memory=False.
  df = pd.read_csv(temp_file_path)
/home/student/.local/lib/python3.10/site-packages/nfstream/streamer.py:495:
DtypeWarning: Columns (81,83) have mixed types. Specify dtype option on import
or set low_memory=False.
  df = pd.read_csv(temp_file_path)
/home/student/.local/lib/python3.10/site-packages/nfstream/streamer.py:495:
DtypeWarning: Columns (81,82,83,84,85) have mixed types. Specify dtype option on
import or set low_memory=False.
  df = pd.read_csv(temp_file_path)
/home/student/.local/lib/python3.10/site-packages/nfstream/streamer.py:495:
DtypeWarning: Columns (81,82) have mixed types. Specify dtype option on import
or set low_memory=False.
  df = pd.read_csv(temp_file_path)
/home/student/.local/lib/python3.10/site-packages/nfstream/streamer.py:495:
DtypeWarning: Columns (81,82,83,84,85) have mixed types. Specify dtype option on
import or set low_memory=False.
  df = pd.read_csv(temp_file_path)
/home/student/.local/lib/python3.10/site-packages/nfstream/streamer.py:495:
DtypeWarning: Columns (81,82,83,84,85) have mixed types. Specify dtype option on
import or set low_memory=False.
  df = pd.read_csv(temp_file_path)
/home/student/.local/lib/python3.10/site-packages/nfstream/streamer.py:495:
DtypeWarning: Columns (81,84,85) have mixed types. Specify dtype option on
import or set low_memory=False.
  df = pd.read_csv(temp_file_path)
/home/student/.local/lib/python3.10/site-packages/nfstream/streamer.py:495:
DtypeWarning: Columns (81,82) have mixed types. Specify dtype option on import
or set low_memory=False.
```

```
  df = pd.read_csv(temp_file_path)
/home/student/.local/lib/python3.10/site-packages/nfstream/streamer.py:495:
DtypeWarning: Columns (81,82,84,85) have mixed types. Specify dtype option on
import or set low_memory=False.
  df = pd.read_csv(temp_file_path)
/home/student/.local/lib/python3.10/site-packages/nfstream/streamer.py:495:
DtypeWarning: Columns (81,82,84,85) have mixed types. Specify dtype option on
import or set low_memory=False.
  df = pd.read_csv(temp_file_path)
/home/student/.local/lib/python3.10/site-packages/nfstream/streamer.py:495:
DtypeWarning: Columns (81,82) have mixed types. Specify dtype option on import
or set low_memory=False.
  df = pd.read_csv(temp_file_path)
/home/student/.local/lib/python3.10/site-packages/nfstream/streamer.py:495:
DtypeWarning: Columns (81,82,83) have mixed types. Specify dtype option on
import or set low_memory=False.
  df = pd.read_csv(temp_file_path)
```

[8]:
```
# organising data

for a in data:
    #add new columns with shorter name/in datetime/in seconds
    df = vars()[a]
    df['fs_ms'] = df['src2dst_first_seen_ms']
    df['fs_dt'] = pd.to_datetime(df['fs_ms'], unit = 'ms') - timedelta(hours=4,␣
 ↪minutes=0)
    df['fs_dt_s'] = df['fs_dt'].astype('datetime64[s]')

    #sort by first_seen
    df.sort_values(by=['fs_ms'], inplace=True)

    #name tables the correct name
    df.columns.name = a

    #add timestamp that gives time from first row (normed timestamp for␣
 ↪comparison in same plot)
    df['time_norm'] = df.loc[:,'fs_dt'] - df.loc[0]['fs_dt']

    vars()[a] = df


# New Dataframes to store results for different metrics
metrics = ['time_diff_pkt',
           'time_diff_flow',
           'freq_pp',
           'freq_pf',
           'freq_pdf',
```

```
            'packet_count_pf',
            'low_delta_time',
            'aaf']
columns = data
for n in metrics:
    vars()['results_'+n]  = pd.DataFrame(columns = [n] + columns)
    df = vars()['results_'+n]

    df[n] = ['min',
             'max',
             'mean',
             'std_dev']
    df = df.set_index(n)
    vars()['results_'+n] = df
```

2 Calculating Metrics

2.1 1. Time difference

2.1.1 a. Time difference per flow

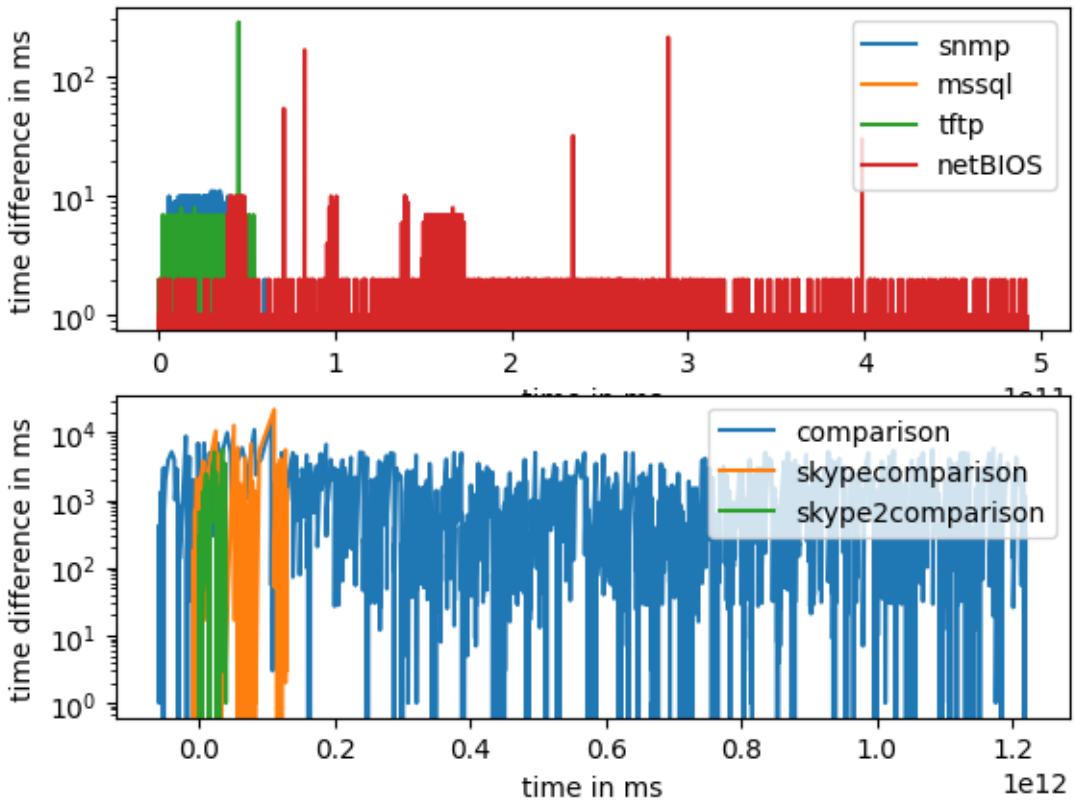
[9]:
```
for i in data:
    df = vars()[i]
    #calculate difference
    df['timediff'] = df['fs_ms'].diff()
    vars()[i] = df
    results_time_diff_flow.loc['min'][i] = df['timediff'].min()
    results_time_diff_flow.loc['mean'][i] = df['timediff'].mean()
    results_time_diff_flow.loc['max'][i] = df['timediff'].max()
    results_time_diff_flow.loc['std_dev'][i] = df['timediff'].std()

results_time_diff_flow
```

[9]:

time_diff_flow	snmp	mssql	tftp	netBIOS	comparison	skypecomparison	skype2comparison
min	0.0	0.0	0.0	0.0	0.0	0.0	0.0
max	11.0	2.0	285.0	213.0	14722.0	22061.0	5556.0
mean	0.122806	0.123833	0.050004	0.141525	480.902329	808.388235	456.678161
std_dev	0.340995	0.329474	0.352016	0.381061	1034.445185	2366.161029	1000.716424

[45]:
```
fig, (ax1, ax2) = plt.subplots(2,1)
for i in attacks_only:
    df = vars()[i]
    ax1.plot(df['time_norm'], df['timediff'], label = i)
    ax1.set_yscale('log')
ax1.legend()
ax1.set_xlabel("time in ms")
ax1.set_ylabel("time difference in ms")
for i in comp_only:
    df = vars()[i]
    ax2.plot(df['time_norm'], df['timediff'], label = i)
ax2.set_yscale('log')
ax2.set_xlabel("time in ms")
ax2.set_ylabel("time difference in ms")
plt.legend()
plt.show()
```

```
/home/student/.local/lib/python3.10/site-
packages/IPython/core/pylabtools.py:151: UserWarning: Creating legend with
loc="best" can be slow with large amounts of data.
  fig.canvas.print_figure(bytes_io, **kw)
```



2.1.2 1b. Time difference per packet

[11]:
```
for i in data:
    df = vars()[i]
    vars()[i] = df
    #add lists of delta_time

    alist = df['udps.delta_time'].tolist()
    flat_list = [item for sublist in alist for item in sublist]

    flat_list = [int(x) for x in flat_list if x.lstrip('-').isdigit()]
    df2 = pd.DataFrame(flat_list, columns=['dt'])
    vars()['pkt_dt_'+i] = df2

    df = vars()[i]
    results_time_diff_pkt.loc['min'][i] = df2['dt'].min()
    results_time_diff_pkt.loc['mean'][i] = df2['dt'].mean()
    results_time_diff_pkt.loc['max'][i] = df2['dt'].max()
    results_time_diff_pkt.loc['std_dev'][i] = df2['dt'].std()

results_time_diff_pkt
```

[11]:

	snmp	mssql	tftp	netBIOS	comparison	\
time_diff_pkt						
min	0	0	0	0	0	
max	9	9	9	9	9	
mean	0.00871	0.0129	1.18458	0.016764	1.755786	
std_dev	0.201748	0.260333	2.490309	0.280083	2.565096	

	skypecomparison	skype2comparison
time_diff_pkt		
min	0	0
max	9	9
mean	2.640506	2.489322
std_dev	2.598634	2.753836

[ ]:
```

```

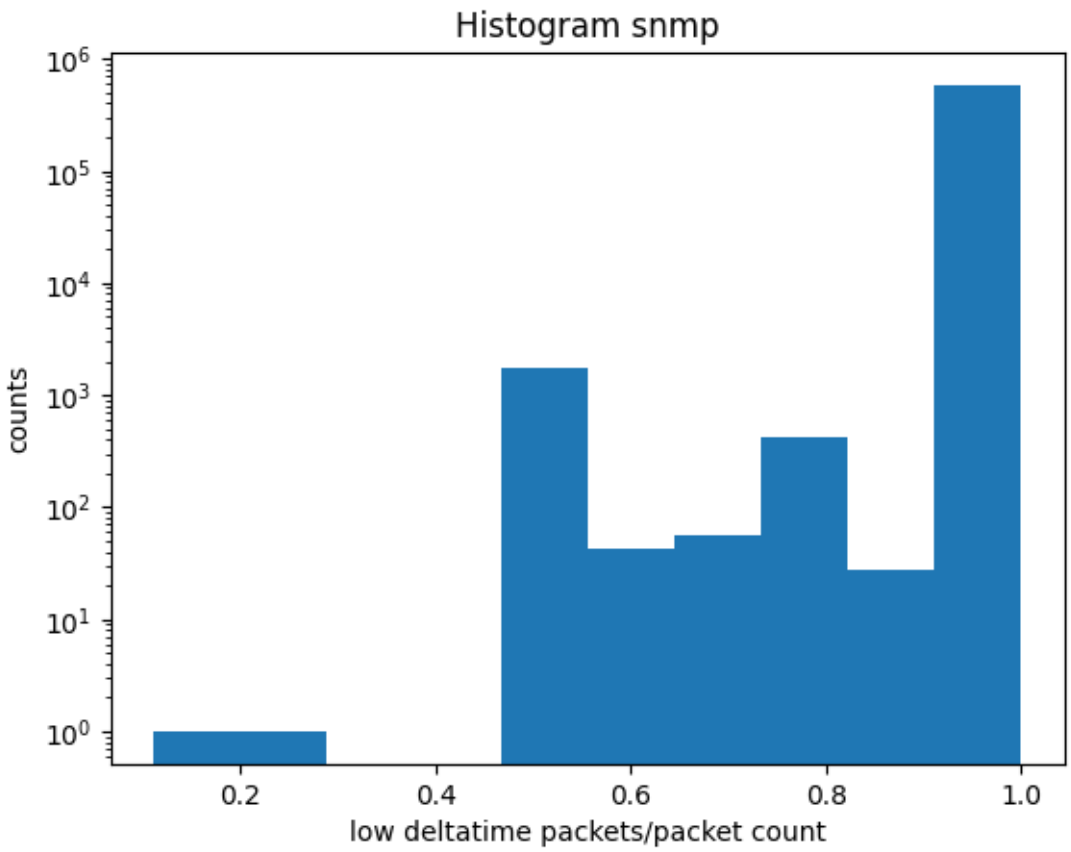
2.1.3 1c. packets with delta_time < 1 ms

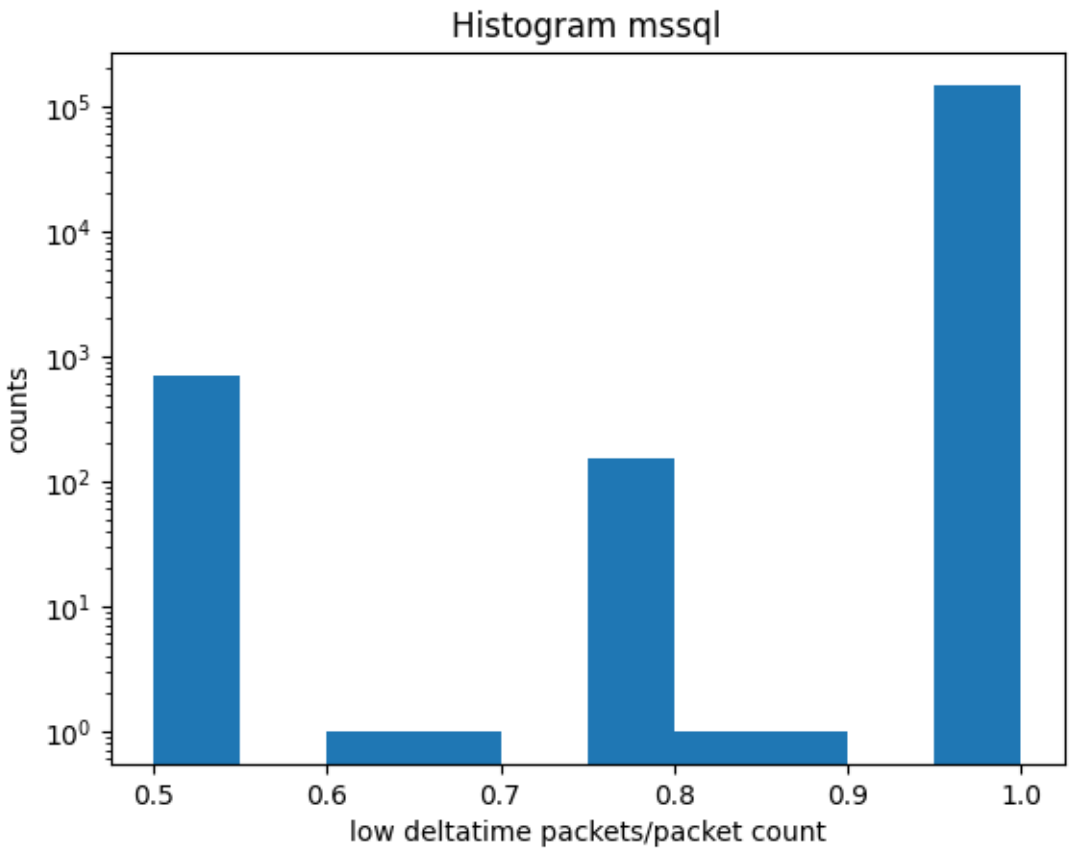
[47]:
```
for i in data:
    df = vars()[i]

    df['lowtimediffcount/packetcount'] = df['udps.low_time_packets']/
 ↪df['bidirectional_packets']
    results_low_delta_time[i]['min'] = df['lowtimediffcount/packetcount'].min()
```

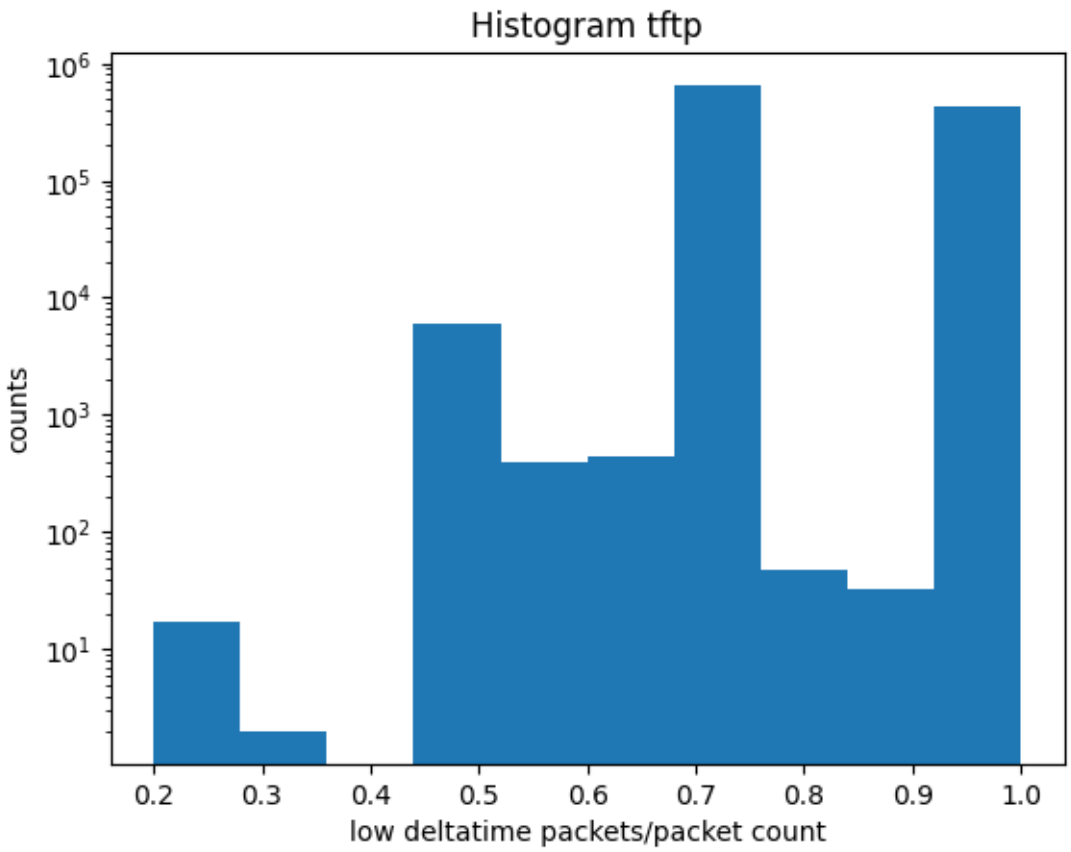
```
    results_low_delta_time[i]['mean'] = df['lowtimediffcount/packetcount'].
↪mean()
    results_low_delta_time[i]['max'] = df['lowtimediffcount/packetcount'].max()
    results_low_delta_time[i]['std_dev'] = df['lowtimediffcount/packetcount'].
↪std()

    #hist
    fig, ax = plt.subplots()
    plt.hist(df['lowtimediffcount/packetcount'])
    ax.set_yscale('log')
    ax.set_title('Histogram '+i)
    #ax.set_yscale('log')
    ax.set_xlabel("low deltatime packets/packet count")
    ax.set_ylabel("counts")
    plt.show



    vars()[i] = df
results_low_delta_time
```

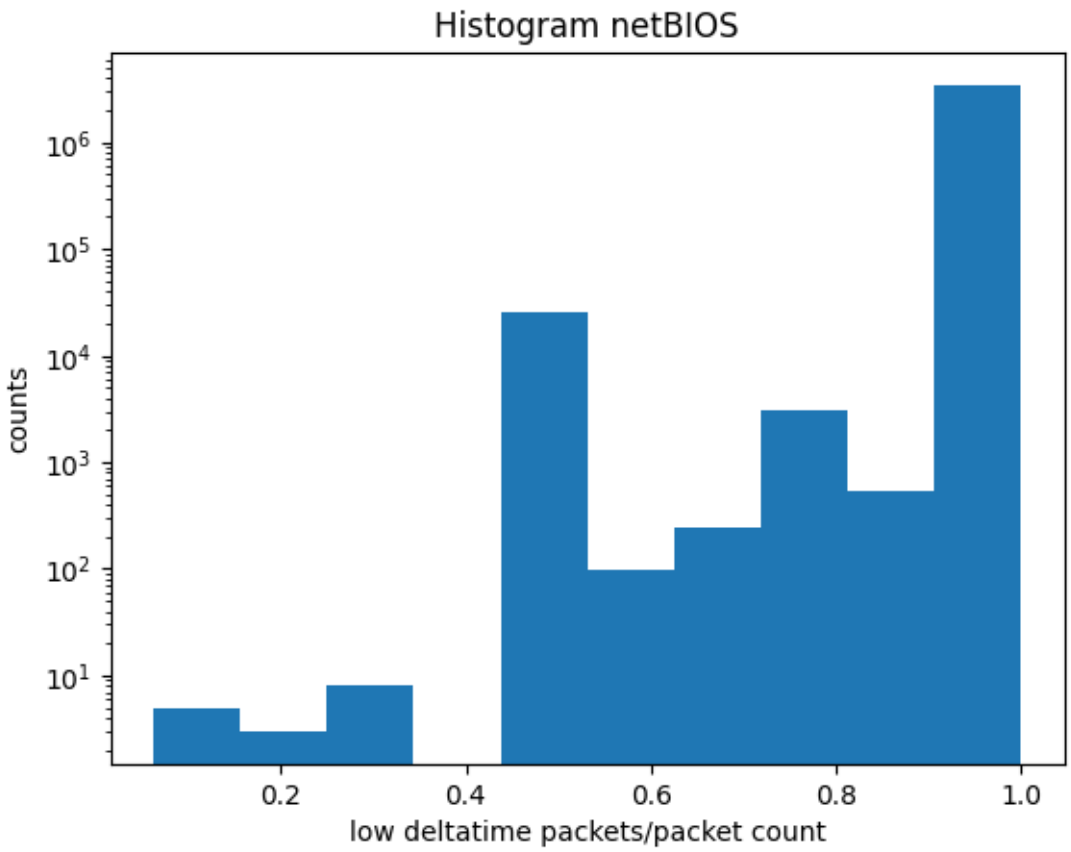
[47]:

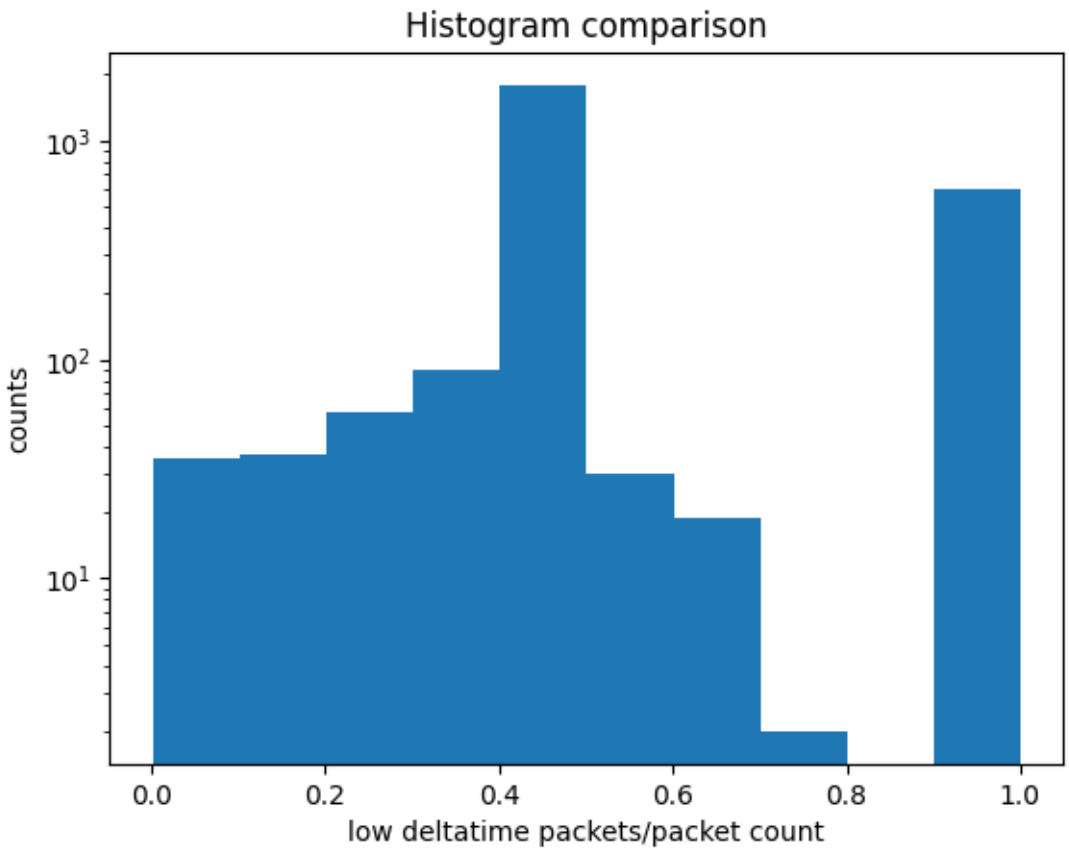
low_delta_time	snmp	mssql	tftp	netBIOS	comparison	skypecomparison	skype2comparison
min	0.111111	0.5	0.2	0.0625	0.002075	0.00627	0.044118
max	1.0	1.0	1.0	1.0	1.0	1.0	1.0
mean	0.998273	0.997379	0.84645	0.996103	0.59256	0.470765	0.515328
std_dev	0.028379	0.035175	0.124718	0.04321	0.234294	0.228087	0.187205

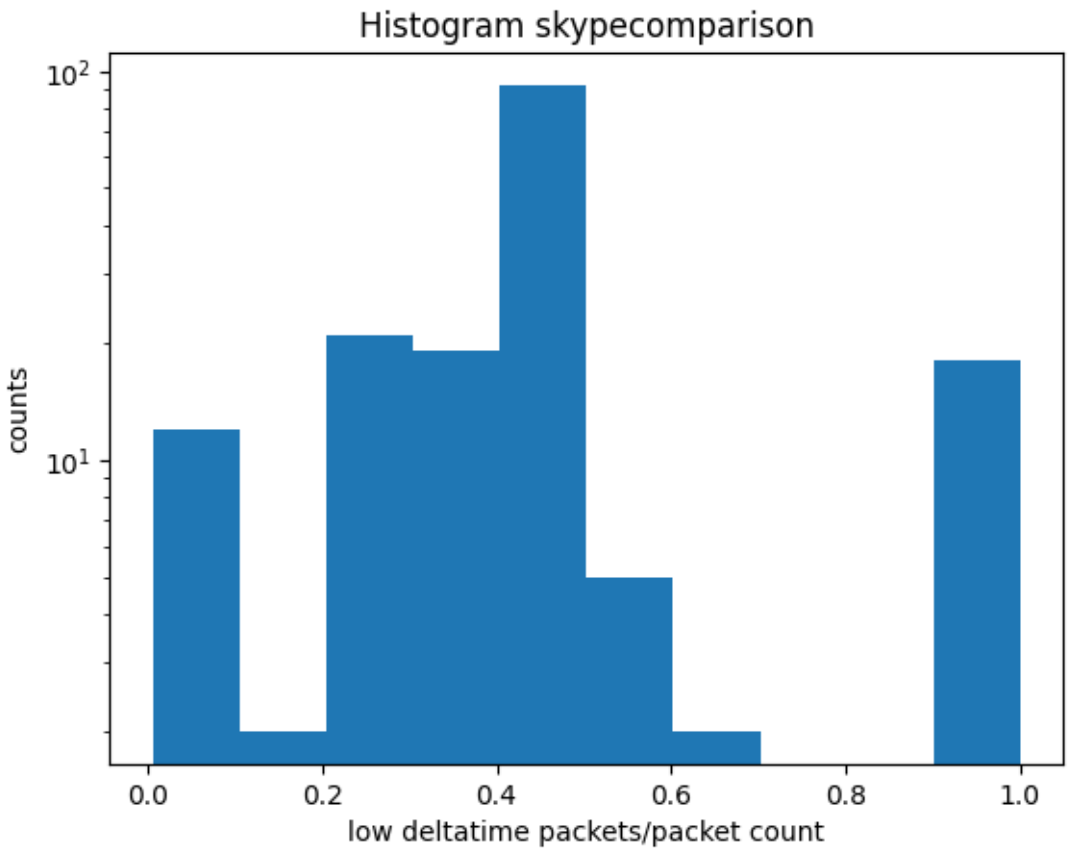

Histogram snmp
counts
10^6
10^5
10^4
10^3
10^2
10^1
10^0
0.2
0.4
0.6
0.8
1.0
low deltatime packets/packet count

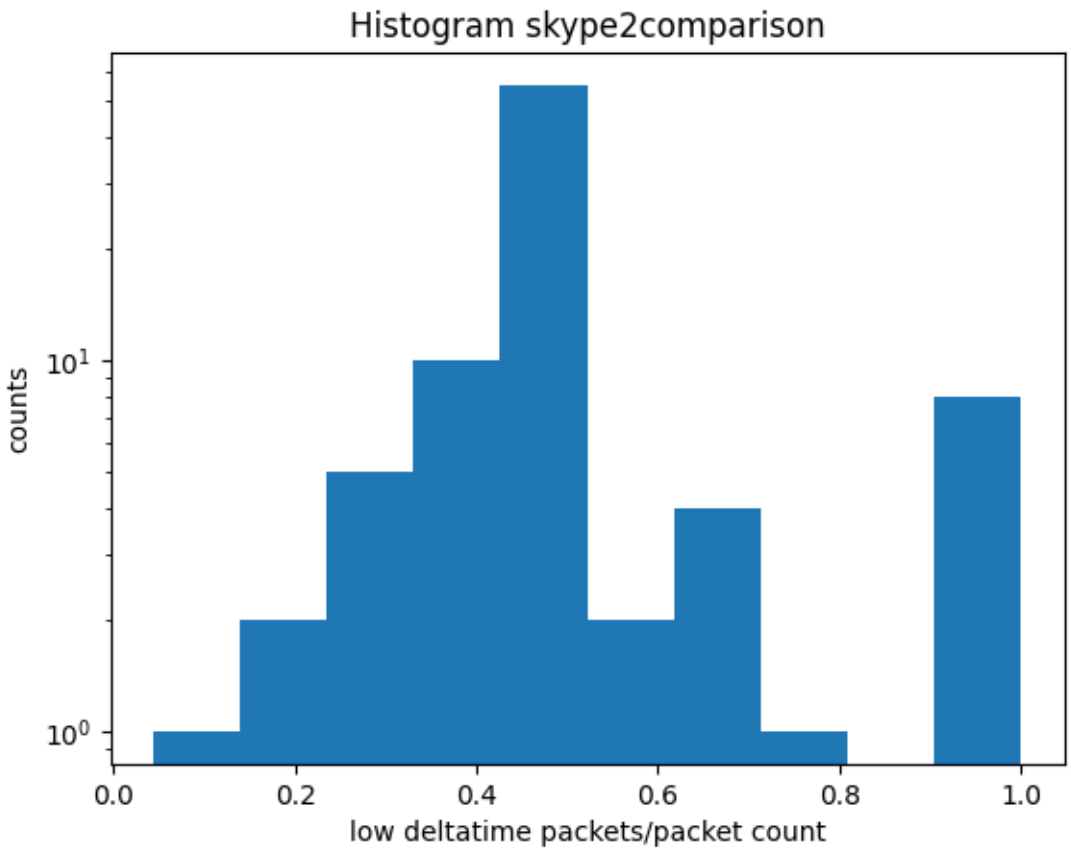

Histogram mssql
counts
10^5
10^4
10^3
10^2
10^1
10^0
0.5
0.6
0.7
0.8
0.9
1.0
low deltatime packets/packet count


Histogram tftp
counts
10^6
10^5
10^4
10^3
10^2
10^1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
low deltatime packets/packet count

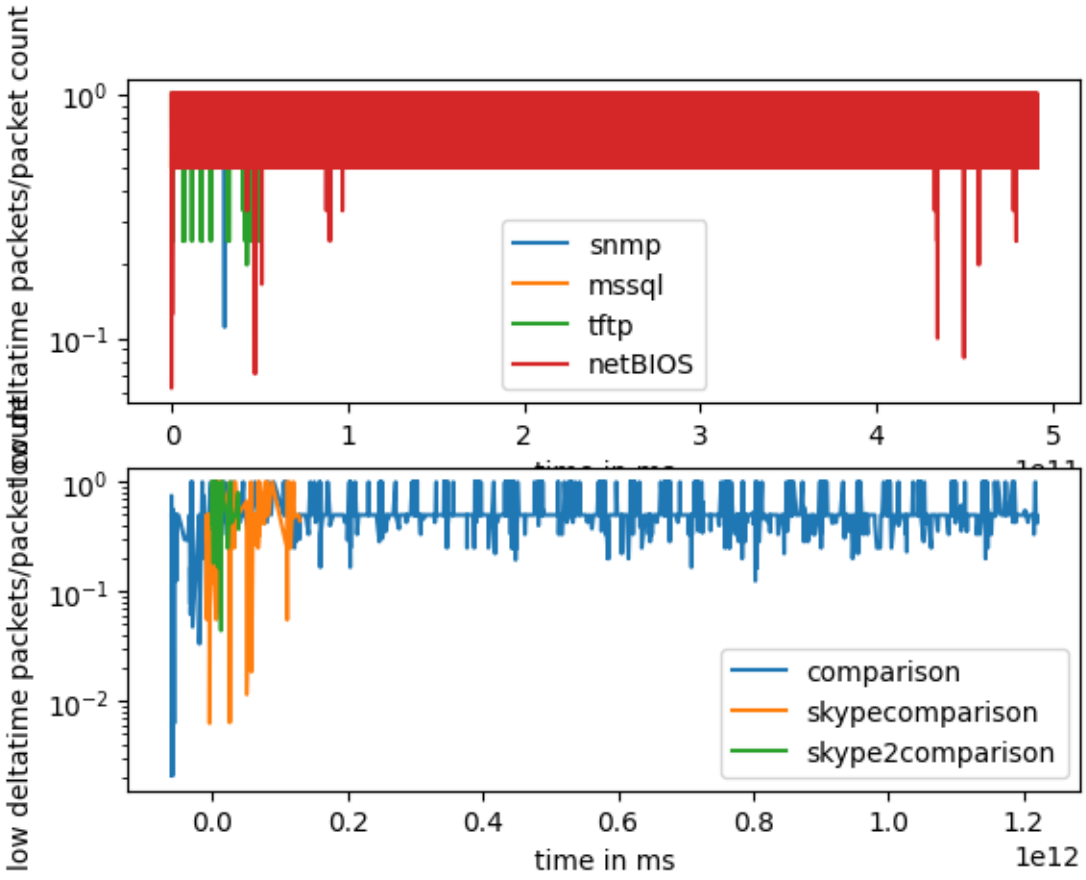

Histogram netBIOS
counts
10^6
10^5
10^4
10^3
10^2
10^1
0.2
0.4
0.6
0.8
1.0
low deltatime packets/packet count


Histogram comparison
counts
10^3
10^2
10^1
0.0
0.2
0.4
0.6
0.8
1.0
low deltatime packets/packet count


Histogram skypecomparison
counts
10^2
10^1
0.0
0.2
0.4
0.6
0.8
1.0
low deltatime packets/packet count



[48]:
```
fig, (ax1, ax2) = plt.subplots(2,1)
for i in attacks_only:
    df = vars()[i]
    ax1.plot(df['time_norm'], df['lowtimediffcount/packetcount'], label = i)
    ax1.set_yscale('log')
ax1.legend()
ax1.set_xlabel("time in ms")
ax1.set_ylabel("low deltatime packets/packet count")
for i in comp_only:
    df = vars()[i]
    ax2.plot(df['time_norm'], df['lowtimediffcount/packetcount'], label = i)
    ax2.set_yscale('log')
    ax2.set_xlabel("time in ms")
    ax2.set_ylabel("low deltatime packets/packet count")

plt.legend()
plt.show()
```



2.2 2. Frequency

2.2.1 2a. Frequency per packet

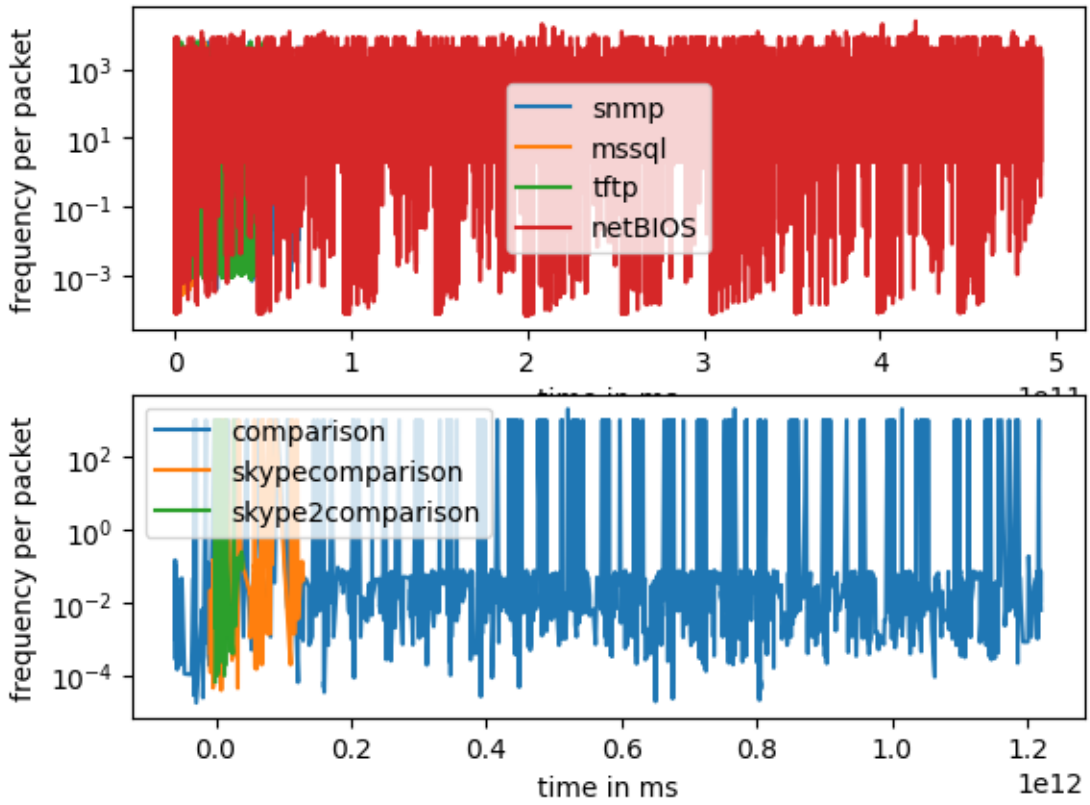
[15]:
```
for i in data:
    df = vars()[i]
    df['timediff_nn'] = df['timediff']
    #df.loc[(df.timediff == 0),'timediff_nn'] = 0.00001
    df['bidir_dur'] = df['bidirectional_duration_ms']
    df.loc[(df.bidirectional_duration_ms == 0), 'bidir_dur'] = 0.001

    df['frequency_nn'] = df['bidirectional_packets']/df['bidir_dur']
    df['frequency'] = df['bidirectional_packets']/
 ↪df['bidirectional_duration_ms']
    results_freq_pp.loc['min'][i] = df['frequency_nn'].min()
    results_freq_pp.loc['mean'][i] = df['frequency_nn'].mean()
    results_freq_pp.loc['max'][i] = df['frequency_nn'].max()
    results_freq_pp.loc['std_dev'][i] = df['frequency_nn'].std()
```

```
    vars()[i] = df

display(results_freq_pp)
```

```
               snmp        mssql        tftp      netBIOS  comparison  \
freq_pp
min        0.000422     0.000244     0.00075     0.000074    0.000017
max          6000.0       6000.0      6000.0      24000.0      2000.0
mean     1992.43252  1988.680047  783.805995  1985.746537   227.95735
std_dev  127.091629   153.319547  976.784733   214.724791  422.248642

        skypecomparison skype2comparison
freq_pp
min            0.000039         0.000067
max              1000.0           1000.0
mean         105.308529        90.955433
std_dev      307.777902       289.112516
```

[49]:
```
fig, (ax1, ax2) = plt.subplots(2,1)
for i in attacks_only:
    df = vars()[i]
    ax1.plot(df['time_norm'], df['frequency_nn'], label = i)
    ax1.set_yscale('log')
    ax1.set_xlabel("time in ms")
    ax1.set_ylabel("frequency per packet")
ax1.legend()
for i in comp_only:
    df = vars()[i]
    ax2.plot(df['time_norm'], df['frequency_nn'], label = i)
    ax2.set_yscale('log')
    ax2.set_xlabel("time in ms")
    ax2.set_ylabel("frequency per packet")
plt.legend()
plt.show()
```

```
/home/student/.local/lib/python3.10/site-
packages/IPython/core/pylabtools.py:151: UserWarning: Creating legend with
loc="best" can be slow with large amounts of data.
  fig.canvas.print_figure(bytes_io, **kw)
```



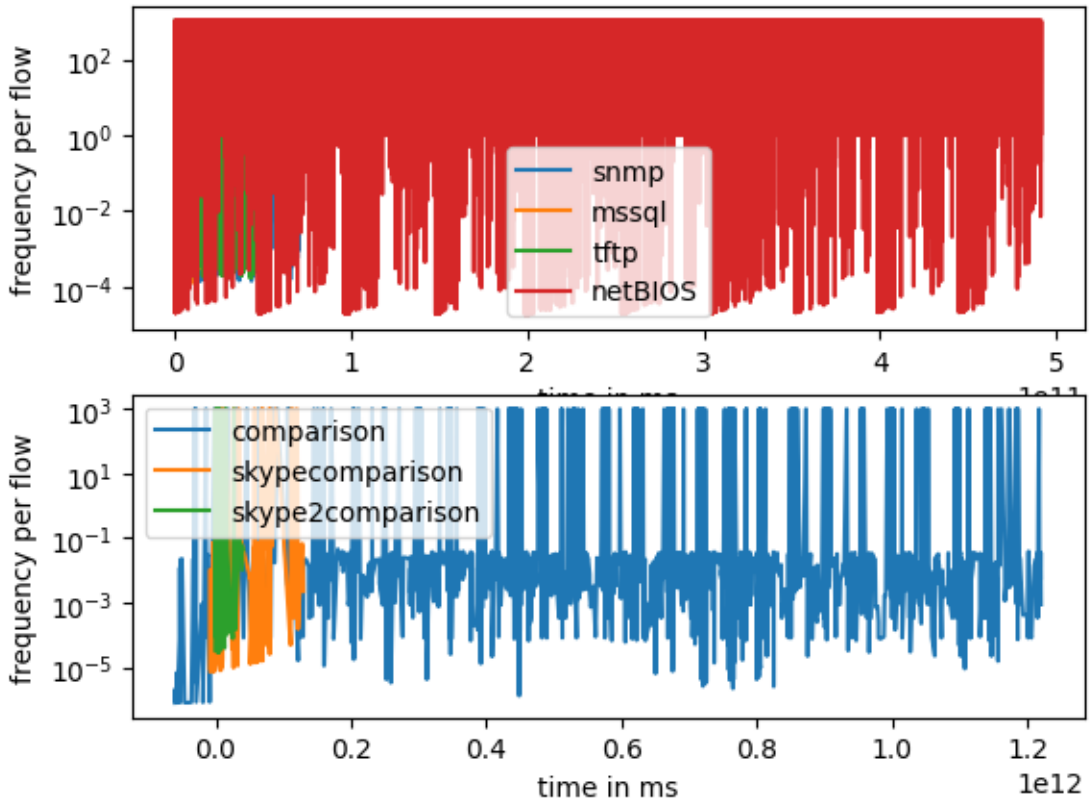
2.2.2 2b. Frequency per flow

[18]:
```
for i in data:
    df = vars()[i]
    df['bidir_dur'] = df['bidirectional_duration_ms']
    df.loc[(df.bidirectional_duration_ms == 0), 'bidir_dur'] = 0.001

    df['freq_pf'] = 1/df['bidir_dur']

    results_freq_pf.loc['min'][i] = df['freq_pf'].min()
    results_freq_pf.loc['mean'][i] = df['freq_pf'].mean()
    results_freq_pf.loc['max'][i] = df['freq_pf'].max()
    results_freq_pf.loc['std_dev'][i] = df['freq_pf'].std()


    vars()[i] = df

display(results_freq_pf)
```

```
                snmp       mssql        tftp     netBIOS  comparison  \
freq_pf
```

```
min        0.000143    0.000056    0.000175    0.000018    0.000001
max          1000.0      1000.0      1000.0      1000.0      1000.0
mean     996.101417  994.229158  391.806666  991.627808  226.821109
std_dev   62.292027   75.715607  488.152241   91.075167  418.843561

         skypecomparison skype2comparison
freq_pf
min             0.000007         0.000028
max               1000.0           1000.0
mean          105.284259        90.926309
std_dev       307.786248       289.121775
```

[50]:
```
fig, (ax1, ax2) = plt.subplots(2,1)
for i in attacks_only:
    df = vars()[i]
    ax1.plot(df['time_norm'], df['freq_pf'], label = i)
    ax1.set_yscale('log')
    ax1.set_xlabel("time in ms")
    ax1.set_ylabel("frequency per flow")
ax1.legend()
for i in comp_only:
    df = vars()[i]
    ax2.plot(df['time_norm'], df['freq_pf'], label = i)
    ax2.set_yscale('log')
    ax2.set_xlabel("time in ms")
    ax2.set_ylabel("frequency per flow")
plt.legend()
plt.show()
```



2.2.3 2c. Mean Packet Frequency

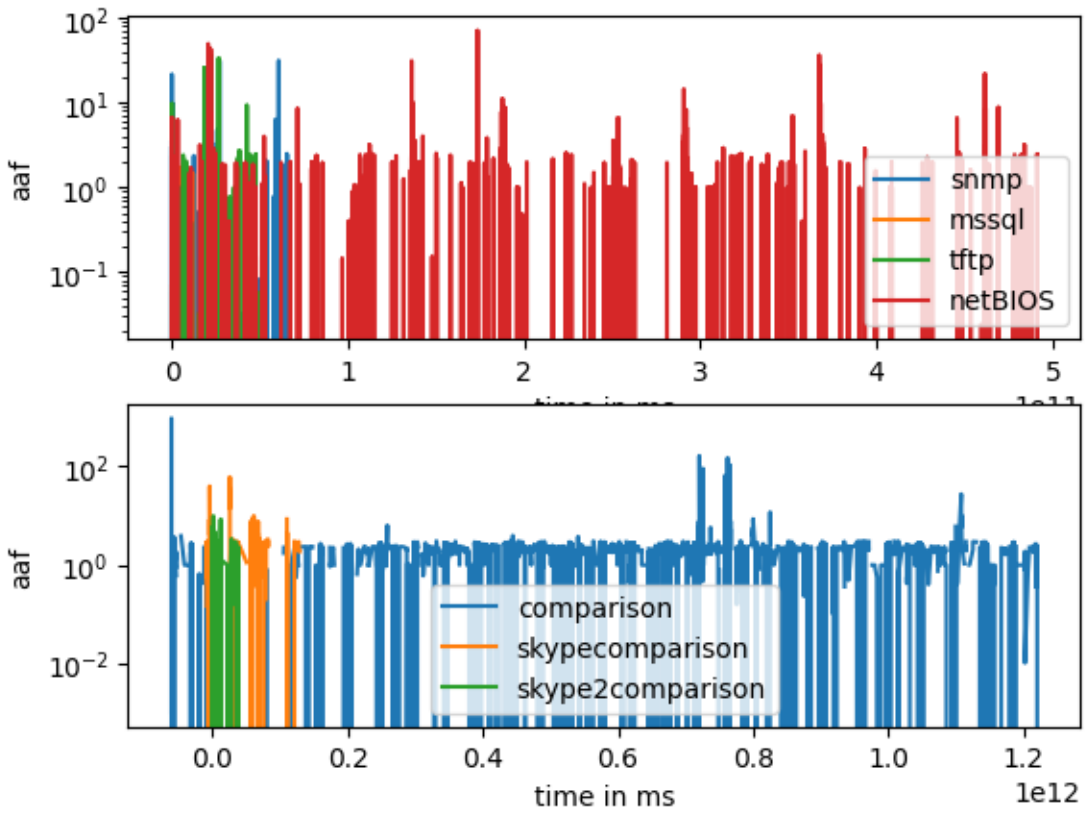
[31]:
```
results_freq_pdf = pd.DataFrame(columns=data, index = ['mean'])
results_freq_pdf.index.name = 'Mean pkt freq'


for i in data:
    df = vars()[i]
    df['freq_pdf'] = df['bidirectional_packets'].sum()/
 ↪(df['bidirectional_last_seen_ms'].max()-df['bidirectional_first_seen_ms'].
 ↪min())


    results_freq_pdf.loc['mean'][i] = df['freq_pdf'].mean()


    vars()[i] = df
display(results_freq_pdf)
```

```
                 snmp      mssql       tftp    netBIOS comparison  \
Mean pkt freq
```

```
mean           16.333533  16.179457  64.401301  14.199128   0.367612

              skypecomparison skype2comparison
Mean pkt freq
mean                 0.095193          0.139792
```

2.3 Amplification Attack Factor

[51]:
```
for i in data:
    df = vars()[i]
    df['aaf'] = df['udps.dst2src_size']/df['udps.src2dst_size']

    results_aaf.loc['min'][i] = df['aaf'].min()
    results_aaf.loc['mean'][i] = df['aaf'].mean()
    results_aaf.loc['max'][i] = df['aaf'].max()
    results_aaf.loc['std_dev'][i] = df['aaf'].std()

    vars()[i] = df


    #plot
fig, (ax1, ax2) = plt.subplots(2,1)
for i in attacks_only:
    df = vars()[i]
    ax1.plot(df['time_norm'], df['aaf'], label = i)
    ax1.set_yscale('log')
    ax1.set_xlabel("time in ms")
    ax1.set_ylabel("aaf")
ax1.legend()
for i in comp_only:
    df = vars()[i]
    ax2.plot(df['time_norm'], df['aaf'], label = i)
    ax2.set_yscale('log')
    ax2.set_xlabel("time in ms")
    ax2.set_ylabel("aaf")
plt.legend()
plt.show()



results_aaf
```



[51]:

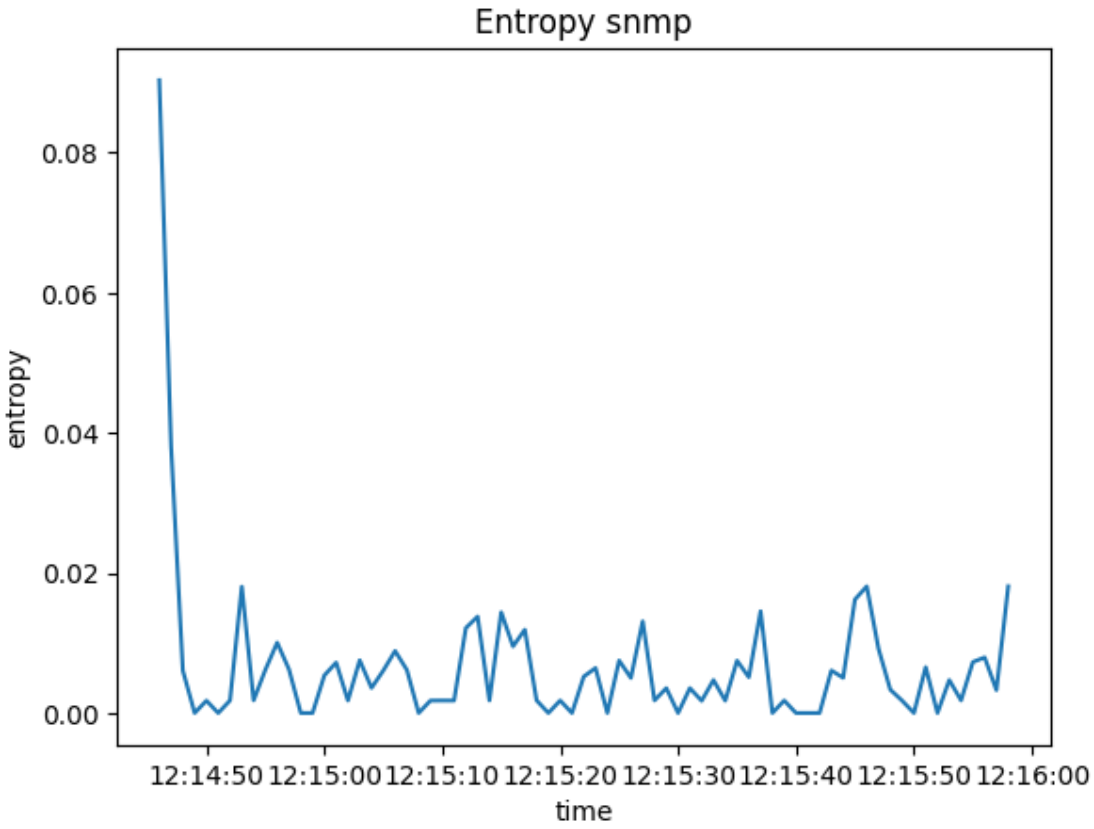
	snmp	mssql	tftp	netBIOS	comparison	skypecomparison	skype2comparison
aaf							
min	0.0	0.0	0.0	0.0	0.0	0.0	0.0
max	31.0	1.740364	36.113322	inf	952.664285	inf	9.936937
mean	0.000613	0.000022	0.000335	inf	2.380391	inf	2.252601
std_dev	0.076589	0.005908	0.0672	NaN	20.128849	NaN	2.018147

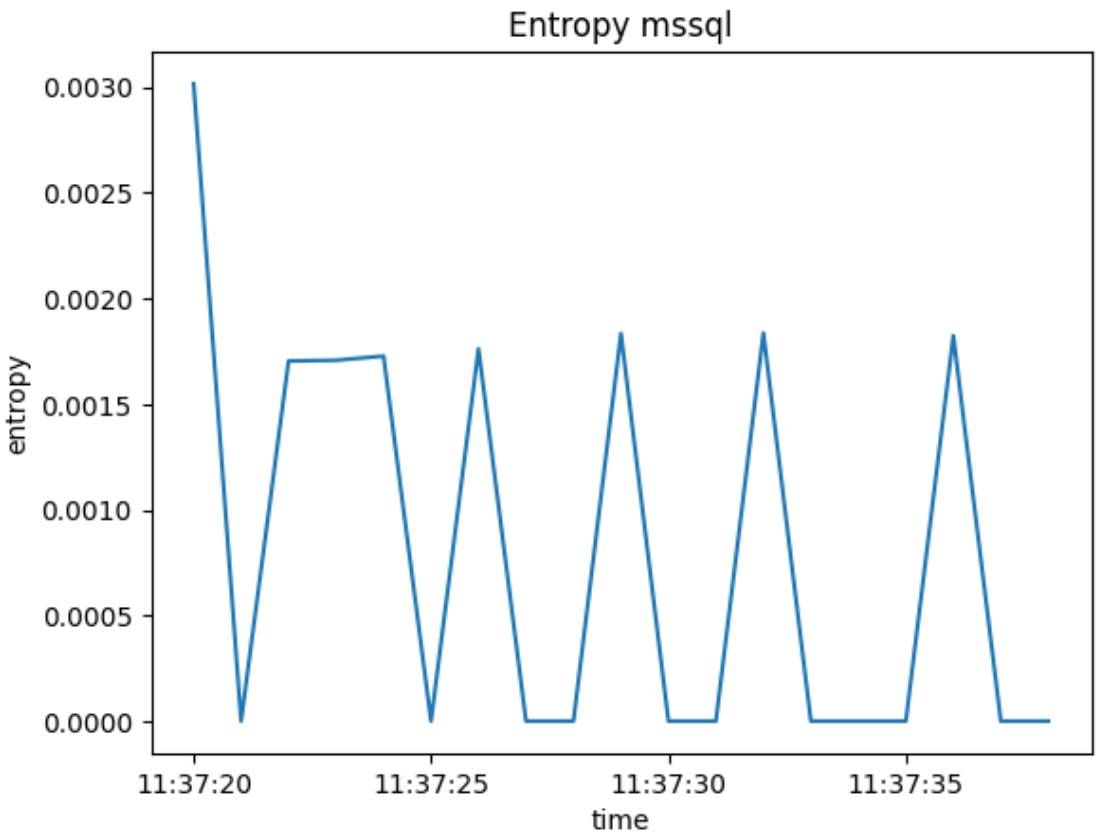
[ ]:

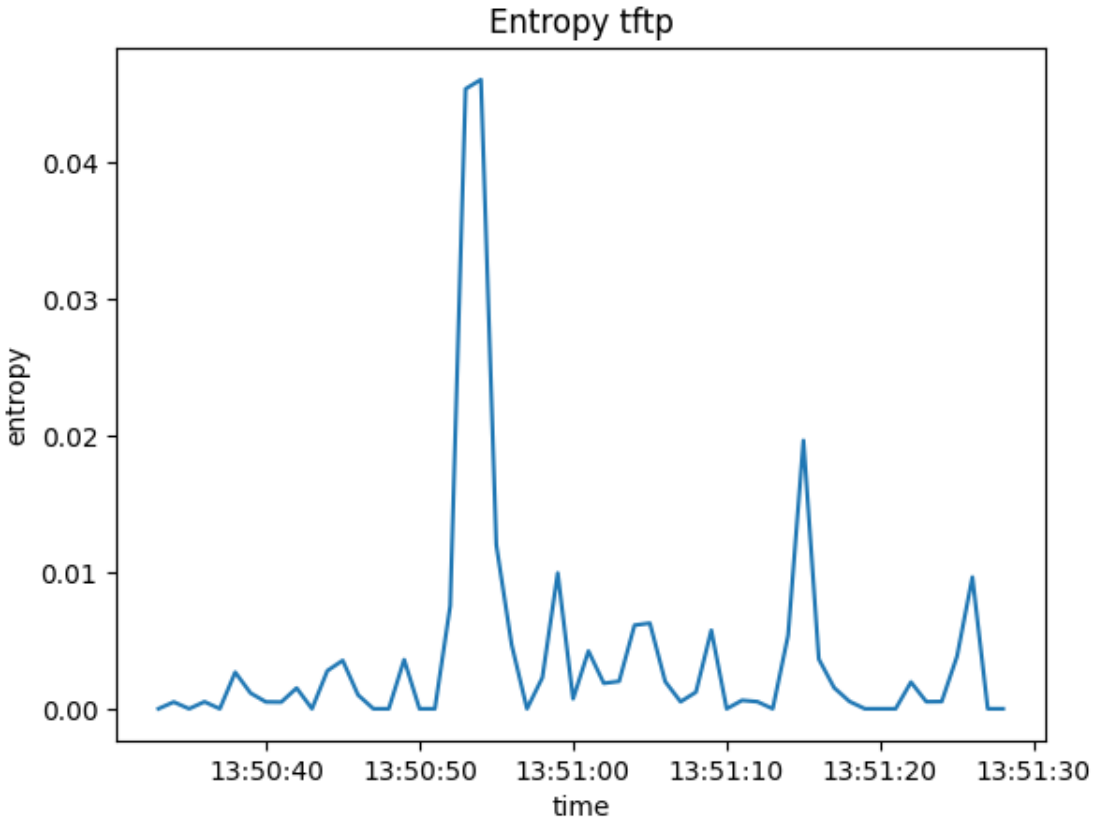
[ ]:

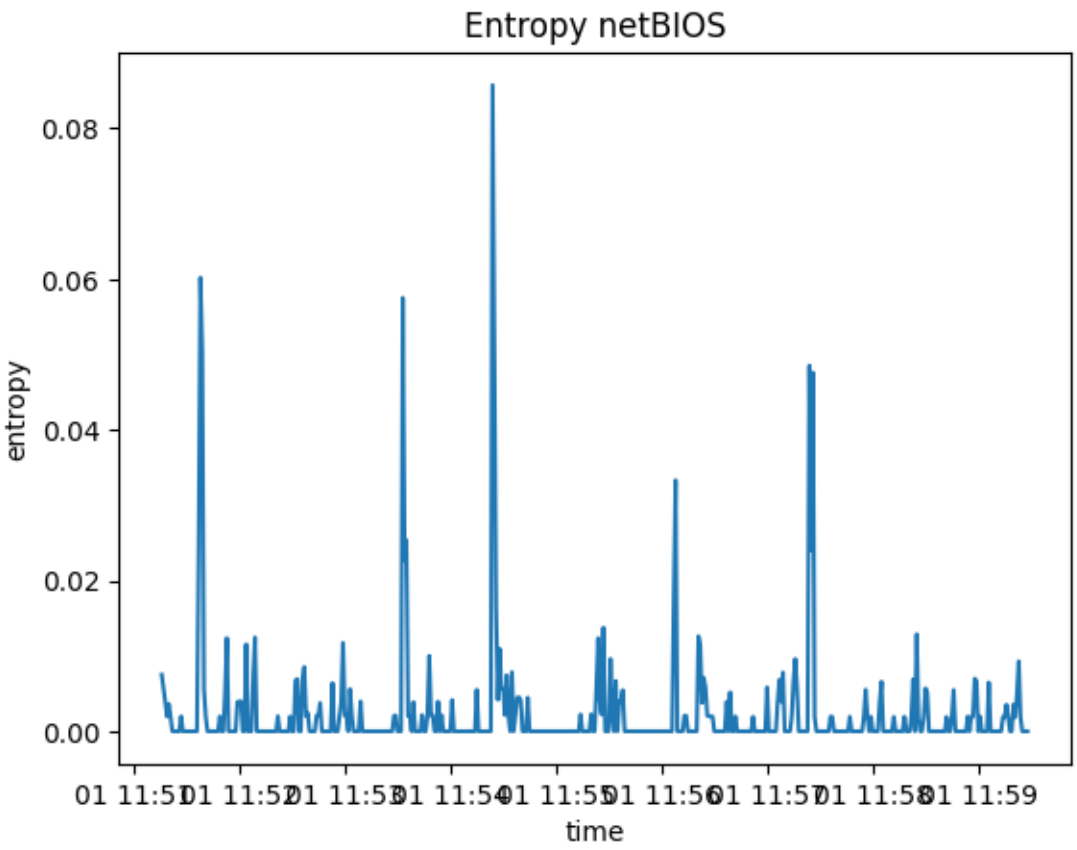
2.4 4. Entropy per second

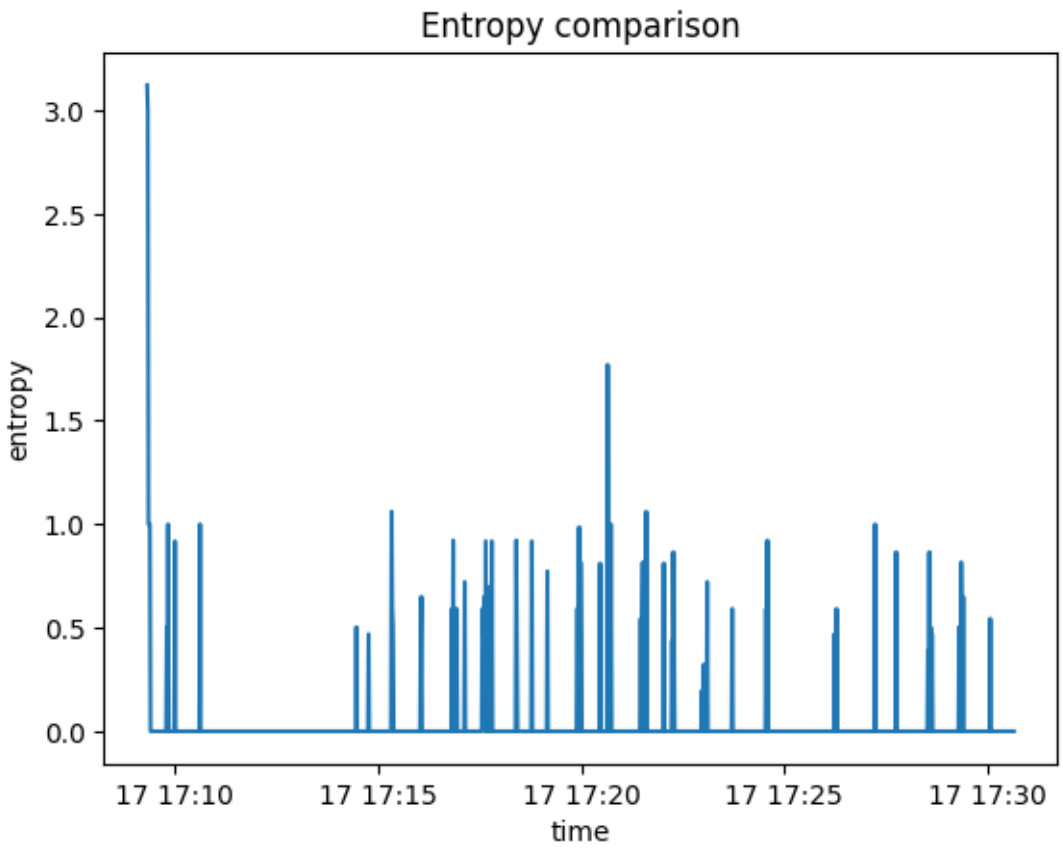
[52]:
```
for i in data:
    df = vars()[i]

    ms_split = {n: g for n, g in df.groupby(pd.Grouper(key='fs_dt_s',␣
 ↪freq='1s'))}
    ms_split = {k.to_pydatetime():v for k,v in ms_split.items()}

    entropy_time = {}
    for k,v in ms_split.items():
        #group by src_ip and get count
        value, counts = np.unique(v['src_ip'], return_counts = True)
        df1 = pd.DataFrame({'src_ip': value, 'ip_counts': counts})
        #display(df1)

        #calculate entropy
        df1['p_i'] = df1['ip_counts']/df1['ip_counts'].sum()
        entropy = - (df1['p_i'] * np.log2(df1['p_i'])).sum()
        #print(entropy)

        entropy_time[k] = entropy
        #entropy_time['entropy'] = entropy
    #display(entropy_time)
    entropy_time = pd.DataFrame.from_dict(entropy_time, orient='index',␣
 ↪columns=['entropy'])
    entropy_time.columns.name = i
    vars()["entropy_time_"+i] = entropy_time

     #plot
    fig, ax = plt.subplots()
    ax.plot(vars()["entropy_time_"+i])
    ax.set_title("Entropy "+i)
    ax.set_xlabel("time")
    ax.set_ylabel("entropy")
    #plt.hist(stat)
    plt.show

    vars()[i] = df
```

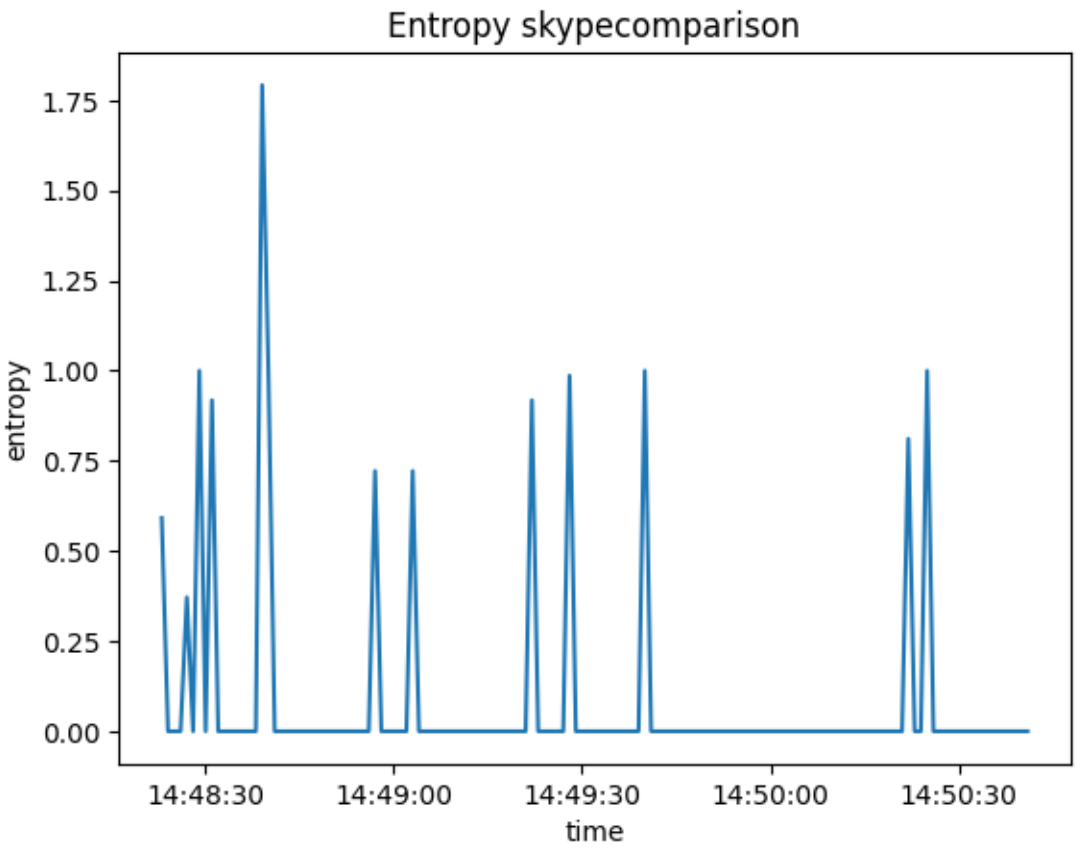

Entropy snmp
0.08
0.06
0.04
0.02
0.00
entropy
12:14:50
12:15:00
12:15:10
12:15:20
12:15:30
12:15:40
12:15:50
12:16:00
time

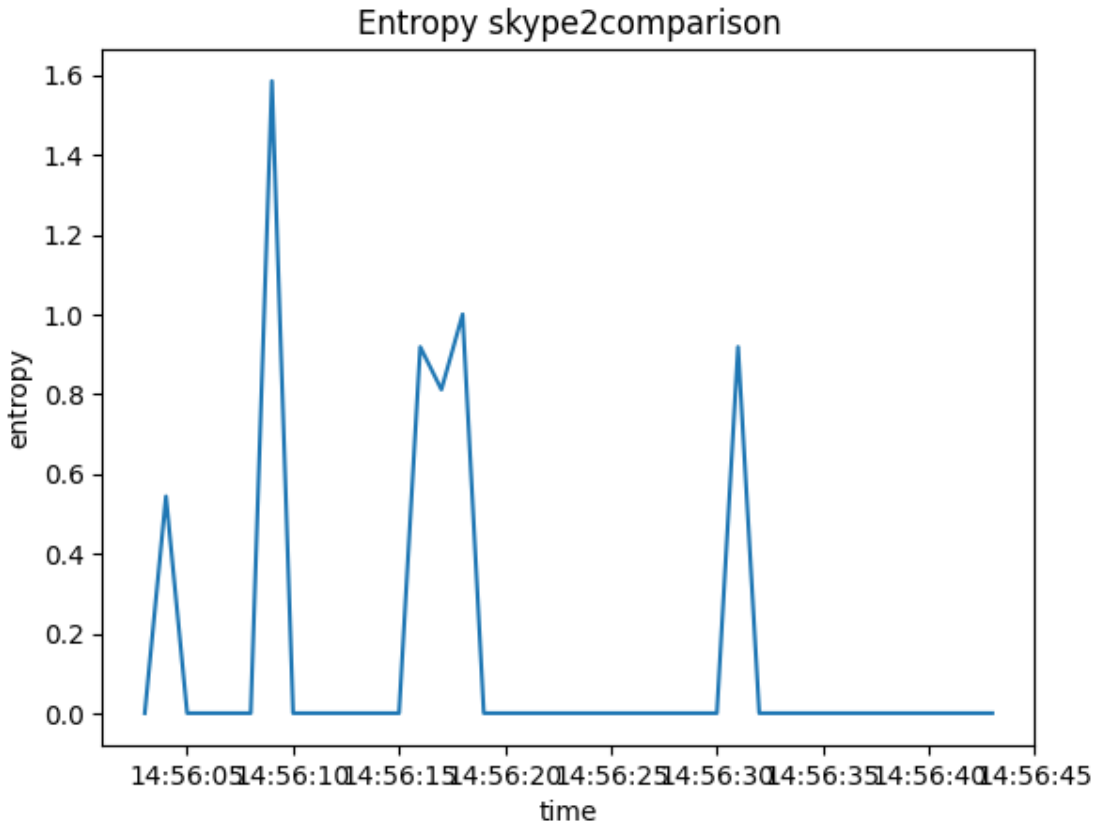

Entropy mssql
0.0030
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
entropy
11:37:20
11:37:25
11:37:30
11:37:35
time


Entropy tftp
entropy
0.04
0.03
0.02
0.01
0.00
13:50:40
13:50:50
13:51:00
13:51:10
13:51:20
13:51:30
time


Entropy netBIOS
0.08
0.06
0.04
0.02
0.00
entropy
01 11:51
01 11:52
01 11:53
01 11:54
01 11:55
01 11:56
01 11:57
01 11:58
01 11:59
time


Entropy comparison
entropy
3.0
2.5
2.0
1.5
1.0
0.5
0.0
17 17:10
17 17:15
17 17:20
17 17:25
17 17:30
time


Entropy skypecomparison
entropy
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
14:48:30
14:49:00
14:49:30
14:50:00
14:50:30
time



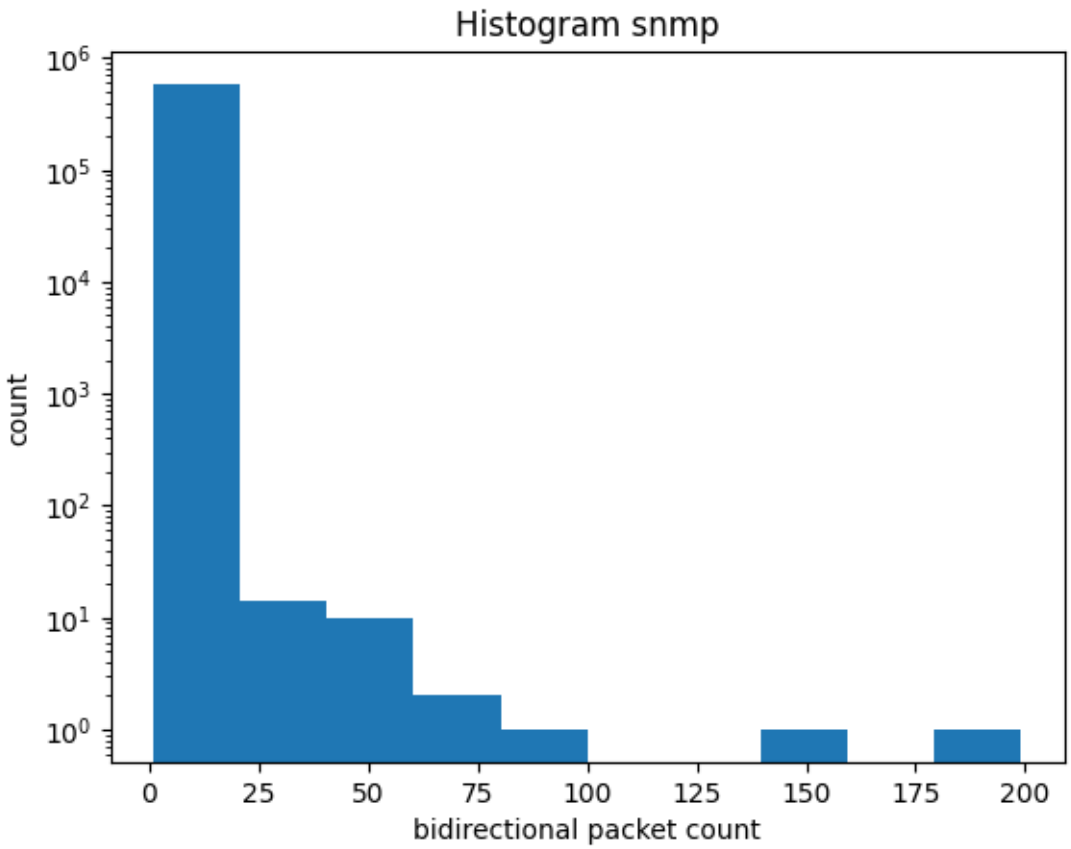
2.5 5. packet count

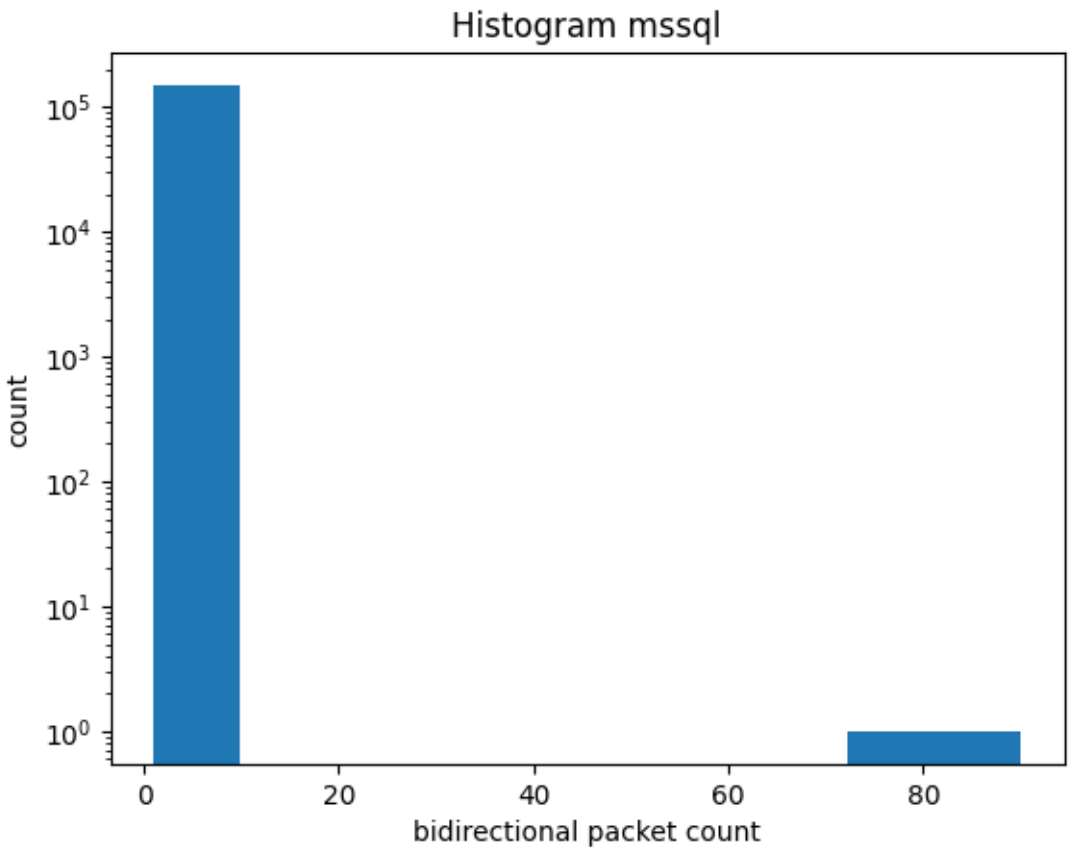
[53]:
```
for i in data:
    df = vars()[i]
    results_packet_count_pf.loc['min'][i] = df['bidirectional_packets'].min()
    results_packet_count_pf.loc['mean'][i] = df['bidirectional_packets'].mean()
    results_packet_count_pf.loc['max'][i] = df['bidirectional_packets'].max()
    results_packet_count_pf.loc['std_dev'][i] = df['bidirectional_packets'].
 ↪std()

     #hist
    fig, ax = plt.subplots()
    plt.hist(df['bidirectional_packets'])
    ax.set_title('Histogram '+i)
    ax.set_yscale('log')
    ax.set_xlabel("bidirectional packet count")
    ax.set_ylabel("count")
    plt.show
```

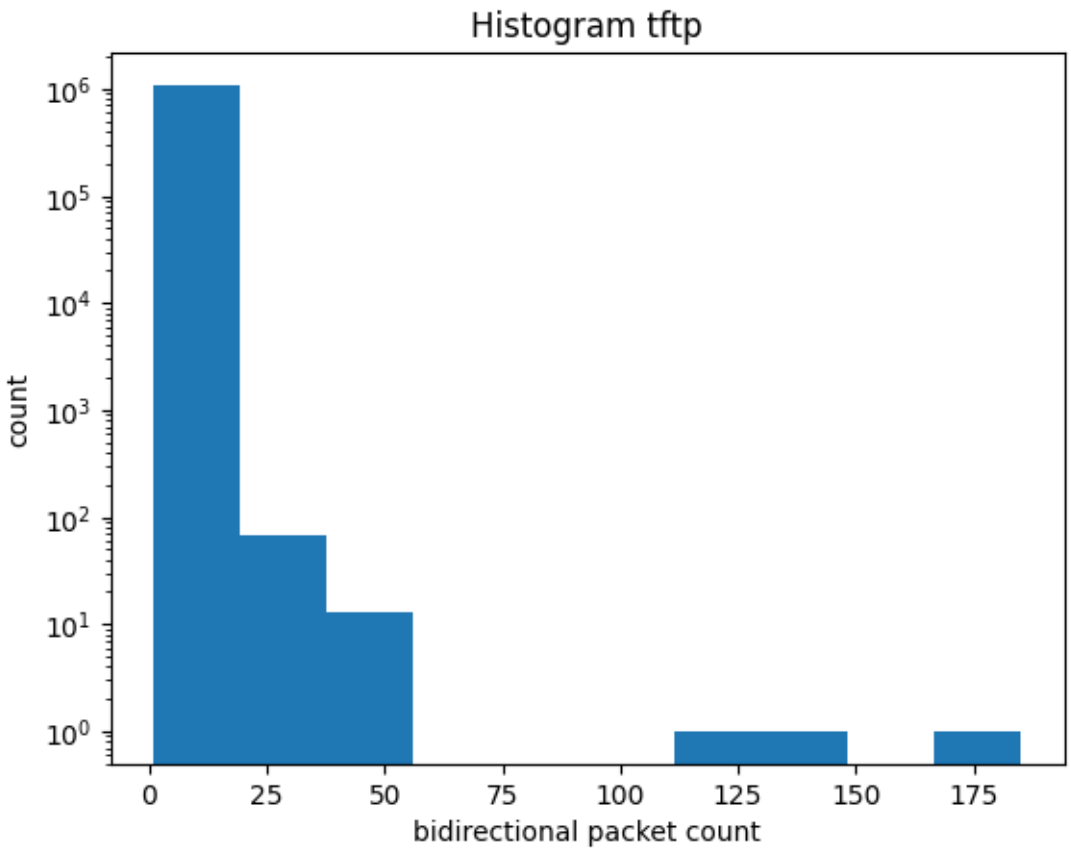
```
    vars()[i] = df
results_packet_count_pf
```

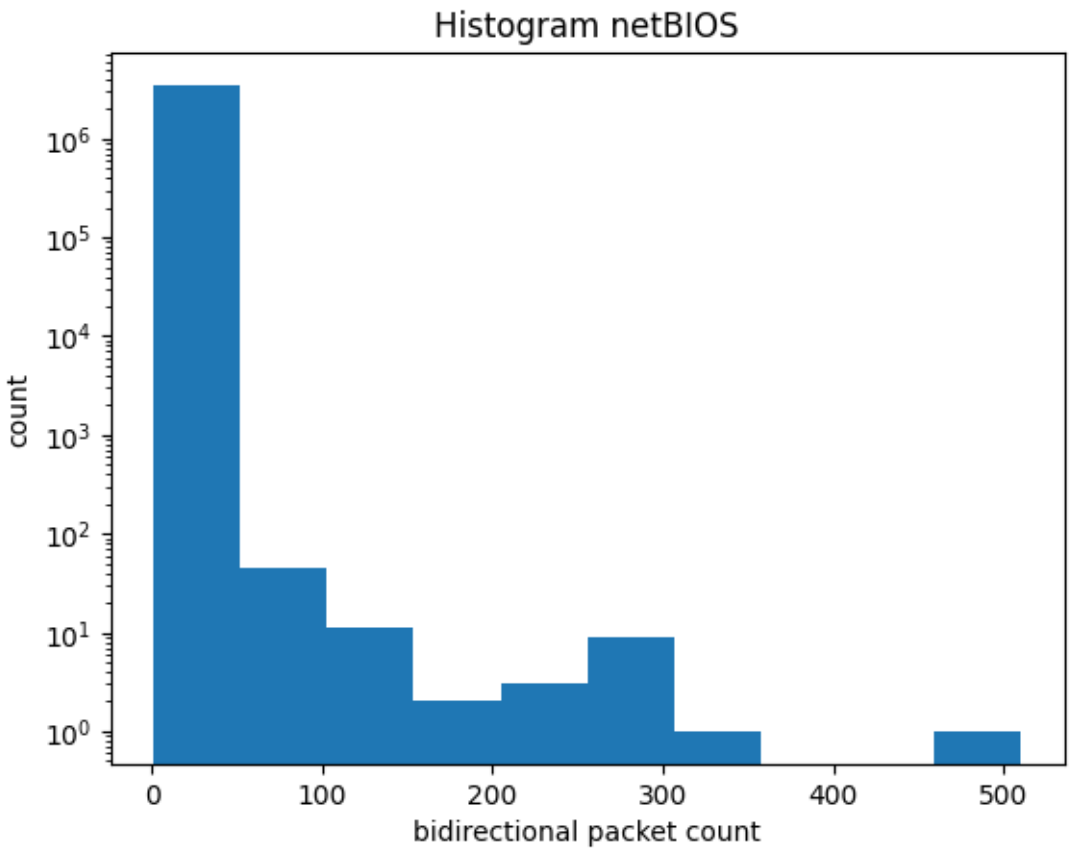
[53]:

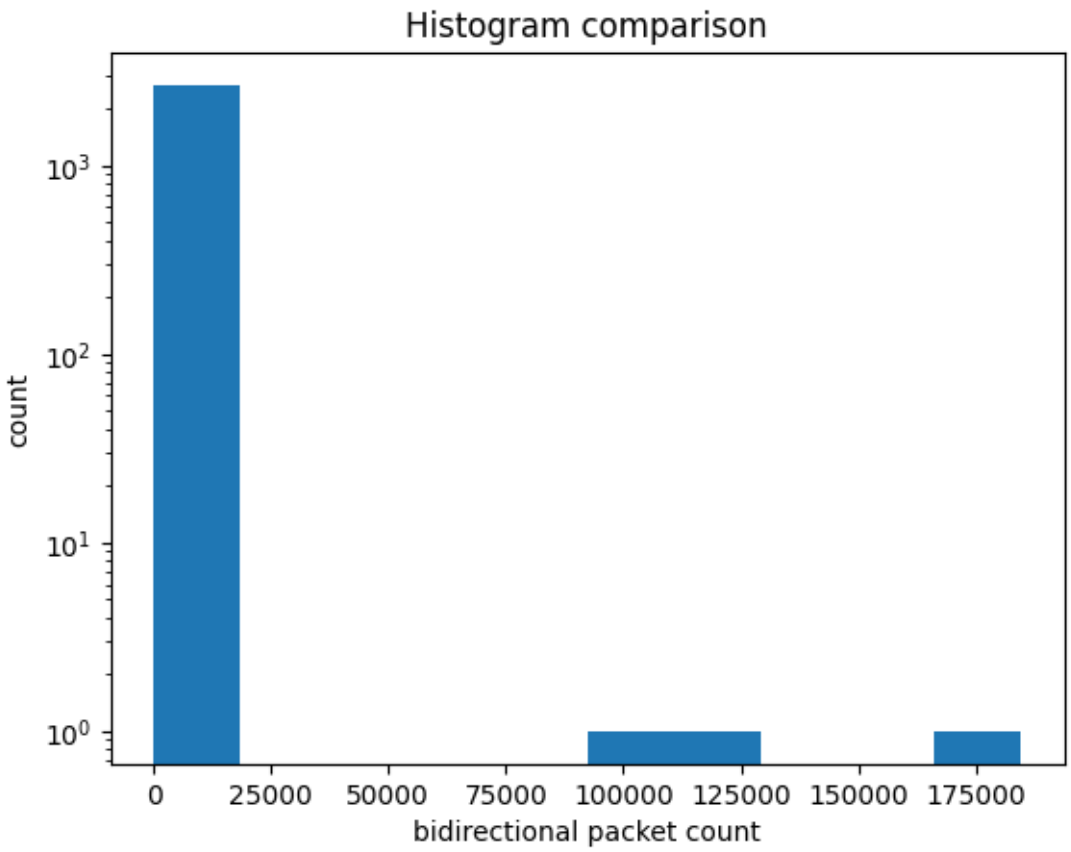
packet_count_pf	snmp	mssql	tftp	netBIOS	comparison	skypecomparison	skype2comparison
min	1	1	1	1	1	1	1
max	199	90	185	510	184518	6265	4775
mean	2.00586	2.003539	3.220306	2.009533	176.957191	78.035088	63.295455
std_dev	0.454566	0.313122	1.054226	0.723176	4831.180902	574.254318	508.48832

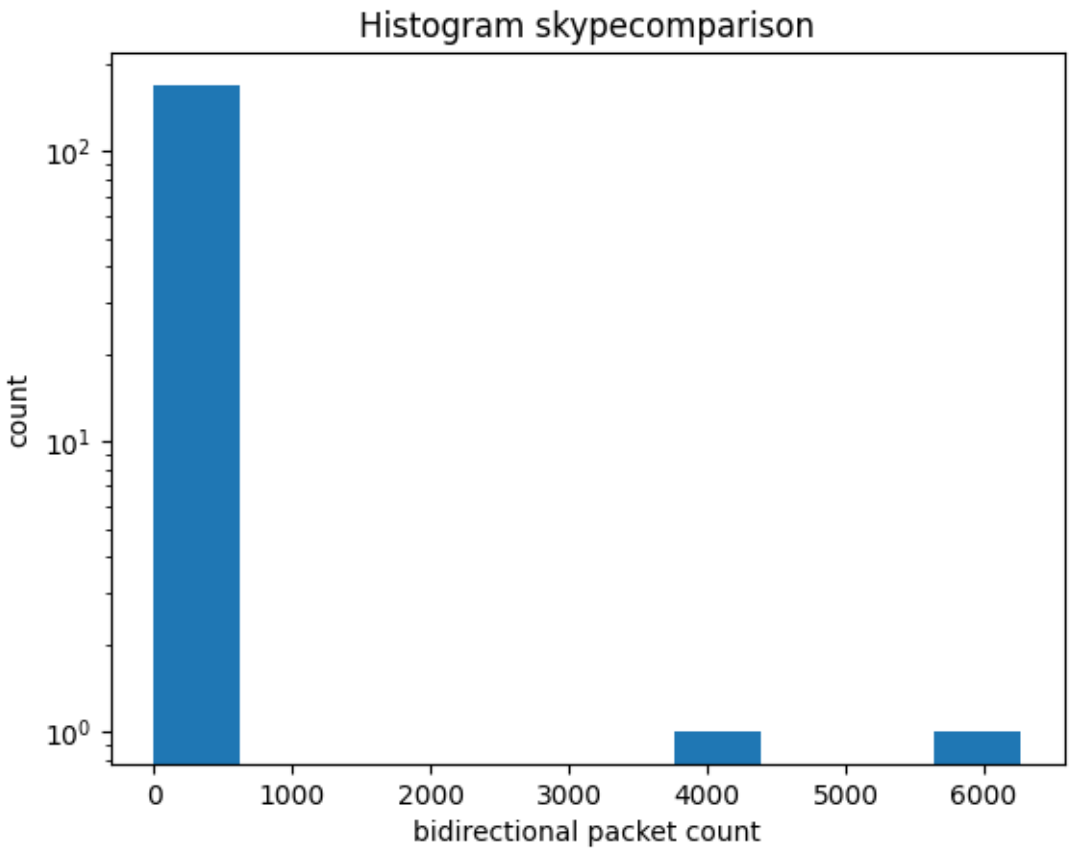


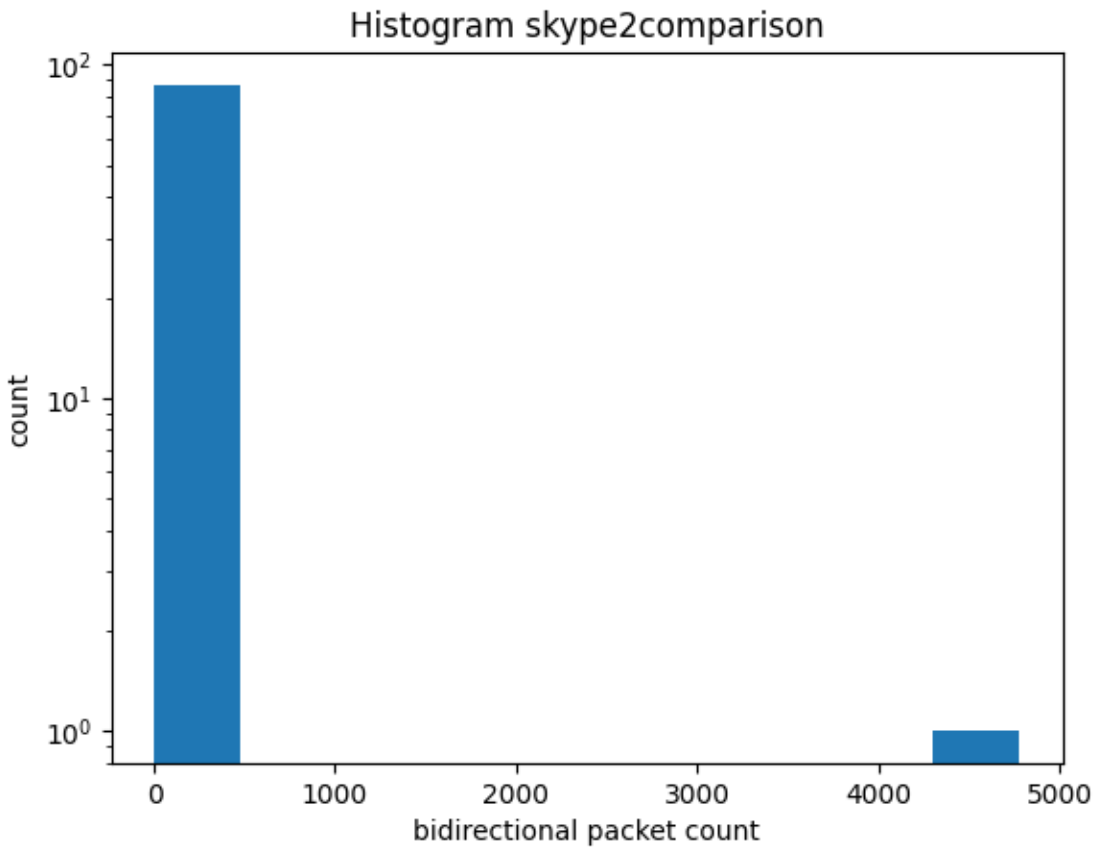

Histogram mssql
count
10^5
10^4
10^3
10^2
10^1
10^0
0
20
40
60
80
bidirectional packet count


Histogram tftp
count
10^6
10^5
10^4
10^3
10^2
10^1
10^0
0
25
50
75
100
125
150
175
bidirectional packet count


Histogram netBIOS
count
10^6
10^5
10^4
10^3
10^2
10^1
10^0
0
100
200
300
400
500
bidirectional packet count


Histogram comparison
count
10^3
10^2
10^1
10^0
0
25000
50000
75000
100000
125000
150000
175000
bidirectional packet count

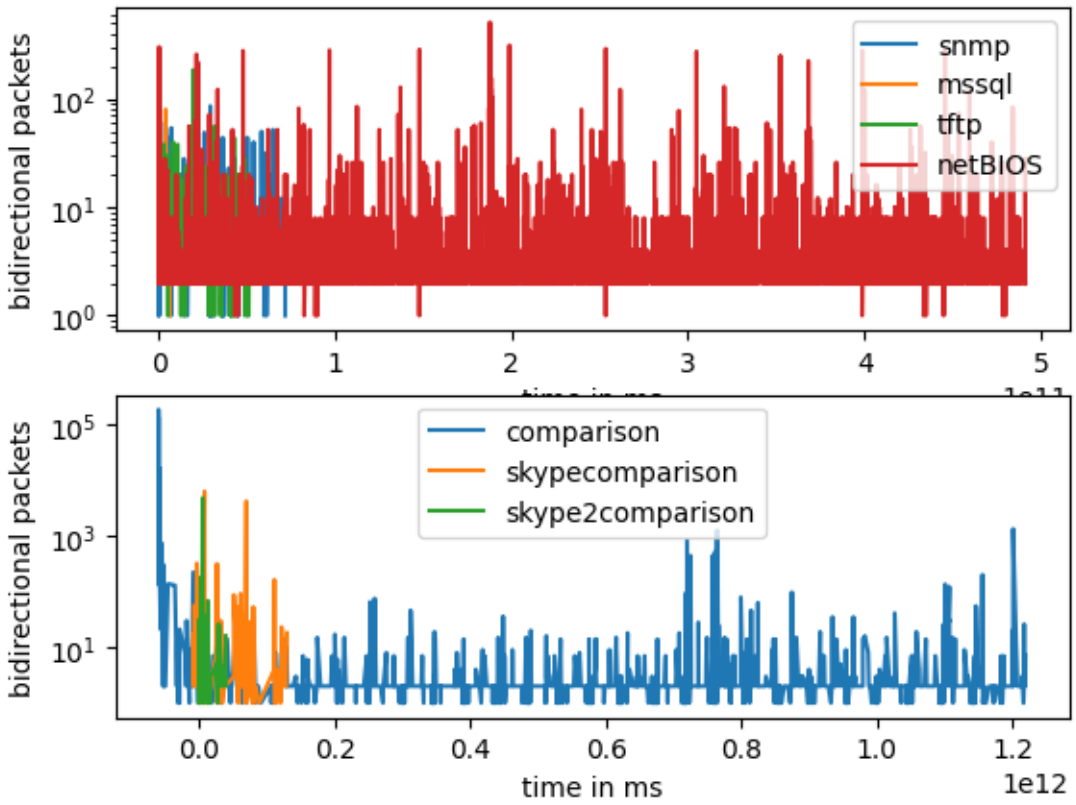

Histogram skypecomparison
count
10^2
10^1
10^0
0
1000
2000
3000
4000
5000
6000
bidirectional packet count



[54]:
```
fig, (ax1, ax2) = plt.subplots(2,1)
for i in attacks_only:
    df = vars()[i]
    ax1.plot(df['time_norm'], df['bidirectional_packets'], label = i)
    ax1.set_yscale('log')
    ax1.set_xlabel("time in ms")
    ax1.set_ylabel("bidirectional packets")
ax1.legend()
for i in comp_only:
    df = vars()[i]
    ax2.plot(df['time_norm'], df['bidirectional_packets'], label = i)
    ax2.set_yscale('log')
    ax2.set_xlabel("time in ms")
    ax2.set_ylabel("bidirectional packets")
plt.legend()
plt.show()
```

```
/home/student/.local/lib/python3.10/site-
```

```
packages/IPython/core/pylabtools.py:151: UserWarning: Creating legend with
loc="best" can be slow with large amounts of data.
  fig.canvas.print_figure(bytes_io, **kw)
```



[ ]: