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Date : _____27 March 2024_____

LAB 4: ANALZING NETWORK DATA LOG

You are provided with the data file, in .csv format, in the working directory. Write the program to extract the following informations.

EXERCISE 4A: TOP TALKERS AND LISTENERS

One of the most commonly used function in analyzing data log is finding out the IP address of the hosts that send out large amount of packet and hosts that receive large number of packets, usually know as TOP TALKERS and LISTENERS. Based on the IP address we can obtained the organization who owns the IP address.

List the TOP 5 TALKERS

Rank	IP address	# of packets	Organisation
1	193.62.192.8	3041	JANET Jisc Services Limited, GB
2	155.69.160.32	2975	NTU-AS-AP Nanyang Technological University, SG
3	130.14.250.11	2604	NLM-GW, US
4	14.139.196.58	2452	NKN-EDGE-NW NKN EDGE Network, IN
5	140.112.8.139	2056	NTU-TW National Taiwan University, TW

TOP 5 LISTENERS

Rank	IP address	# of packets	Organisation
1	103.37.198.100	3841	A-STAR-AS-AP A-STAR, SG
2	137.132.228.15	3715	NUS-AS-AP NUS Information Technology, SG
3	202.21.159.244	2446	REPUBLICPOLYTECHNIC-AS Republic Polytechnic. Multihoming AS Singapore, SG
4	192.101.107.153	2368	ESNET-AS, US
5	103.21.126.2	2056	IITB-IN Powai, IN

EXERCISE 4B: TRANSPORT PROTOCOL

Using the IP protocol type attribute, determine the percentage of TCP and UDP protocol

	Header value	Transport layer protocol	# of packets	% of packets
1	6	TCP	56064	82.368324%
2	17	UDP	9462	13.901418%
3	50	ESP	1698	2.494674%
4	47	GRE	657	0.965254%
5	41	IPv6	104	0.152795%

EXERCISE 4C: APPLICATIONS PROTOCOL

Using the Destination IP port number determine the most frequently used application protocol. (For finding the service given the port number https://www.adminsub.net/tcp-udp-port-finder/)

Rank	Destination IP port number	# of packets	Service
1	443	13423	HTTPS
2	80	2647	HTTP
3	52866	2068	Dynamic/Private Ports
4	45512	1356	Unassigned
5	56152	1341	Dynamic/Private Ports

EXERCISE 4D: TRAFFIC

The traffic intensity is an important parameter that a network engineer needs to monitor closely to determine if there is congestion. You would use the IP packet size to calculate the estimated total traffic over the monitored period of 15 seconds. (Assume the sampling rate is 1 in 2048)

Total Traffic(MB)	126519.18359375 MB

EXERCISE 4E: ADDITIONAL ANALYSIS

Please append ONE page to provide additional analysis of the data and the insight it provides. Examples include:
Top 5 communication pairs;
Visualization of communications between different IP hosts;
etc.

Please limit your results within one page (and any additional results that fall beyond one page limit will not be assessed).

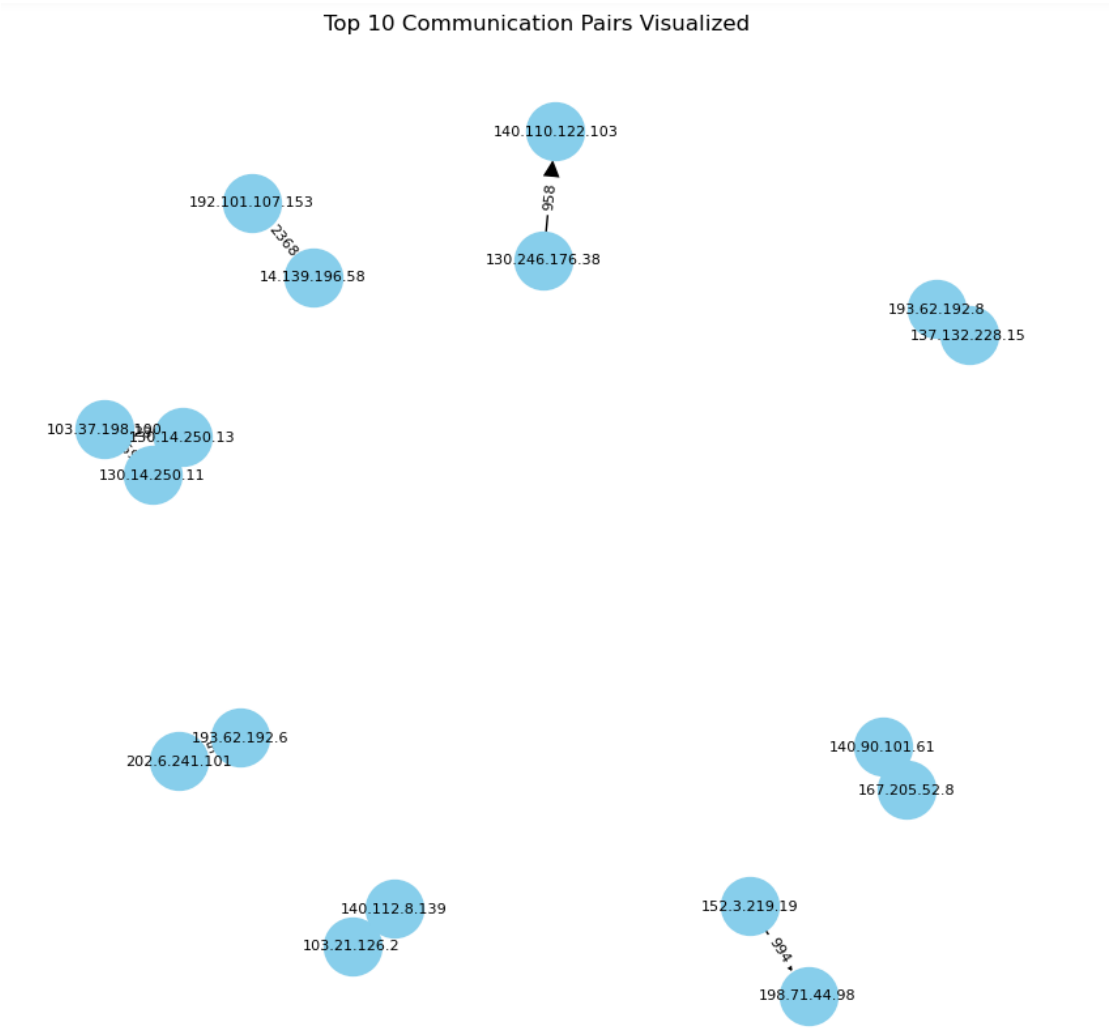
4e

```
In [24]: import networkx as nx
         import matplotlib.pyplot as plt
```

Top 5 communication pairs visualized

```
In [66]: communication_pairs = dfC.groupby(["src_IP", "dst_IP"]).size().sort_values(ascending=False)
         communication_pairs.head(5)
```

```
Out[66]: src_IP          dst_IP
         193.62.192.8    137.132.228.15     3041
         130.14.250.11   103.37.198.100     2599
         14.139.196.58   192.101.107.153    2368
         140.112.8.139   103.21.126.2       2056
         137.132.228.15  193.62.192.8       1910
         dtype: int64
```



EXERCISE 4F: SOFTWARE CODE

Please also submit your code to the NTULearn lab site.

In [1]:
```
!pip install ipwhois
```

```
Requirement already satisfied: ipwhois in c:\users\tdrdi\anaconda3\lib\site-packages (1.2.0)
Requirement already satisfied: dnspython<=2.0.0 in c:\users\tdrdi\anaconda3\lib\site-packages (from ipwhois) (2.0.0)
```

In [2]:
```
import numpy as np
import pandas as pd
import seaborn as sns
from ipwhois import IPWhois
```

In [3]:
```
df = pd.read_csv("Data_3.csv",names=range(21))
```

In [4]:
```
df.dtypes
```

Out[4]:
```
0      object
1      object
2       int64
3       int64
4      object
5      object
6      object
7       int64
8       int64
9      object
10     object
11      int64
12     object
13      int64
14      int64
15      int64
16     object
17      int64
18      int64
19      int64
20    float64
dtype: object
```

In [5]:
```
# drop the CNTR counter samples
# reset the indexes
# drop the last NaN column
dfC= df[df[0]=='FLOW']
dfC.reset_index(inplace=True,drop=True)
dfC.dropna(axis=1,inplace=True)
dfC
```

```
C:\Users\TdrDi\AppData\Local\Temp\ipykernel_10716\822251700.py:6: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  dfC.dropna(axis=1,inplace=True)
```

Out[5]:

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
0	FLOW	203.30.38.251	137	200	d404ff55fd4d	80711fc76001	0x0800	919	280	130.246.176.22	140.115.32.81	6	0x00	50	51216	23505	0x10	15
1	FLOW	203.30.38.251	129	193	609c9f851b00	0031466b23cf	0x0800	11	919	155.69.160.32	64.233.188.128	6	0x00	56	23159	80	0x10	
2	FLOW	203.30.38.251	137	200	d404ff55fd4d	80711fc76001	0x0800	919	280	130.246.176.53	140.115.32.83	6	0x00	50	50041	20739	0x10	15
3	FLOW	203.30.38.251	129	135	609c9f851b00	002688cd5fc7	0x0800	11	919	155.69.160.32	54.169.174.79	17	0x00	120	54241	26510	0x10	1
4	FLOW	203.30.38.251	130	199	00239cd087c1	544b8cf9a7df	0x0800	919	600	137.132.228.15	193.62.192.8	6	0x00	56	53923	34262	0x10	
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
68060	FLOW	203.30.38.251	258	199	204e71cf1b0f	ccef48570144	0x0800	537	601	207.241.228.157	210.48.222.9	6	0x00	56	443	57434	0x10	15
68061	FLOW	203.30.38.251	131	193	00a742233e9e	0031466b23cf	0x0800	43	919	192.122.131.36	216.58.203.234	6	0x00	121	4920	443	0x10	14
68062	FLOW	203.30.38.251	130	199	00239cd087c1	544b8cf9a7df	0x0800	919	600	137.132.228.15	193.62.192.8	6	0x00	56	34153	3123	0x10	
68063	FLOW	203.30.38.251	129	193	609c9f851b00	0031466b23cf	0x0800	11	919	155.69.196.9	74.125.56.6	17	0x00	58	56221	60786	0x10	12
68064	FLOW	203.30.38.251	137	200	d404ff55fd4d	80711fc76001	0x0800	919	280	14.139.196.58	192.101.107.153	6	0x00	57	34625	41211	0x10	

68065 rows × 20 columns

In [6]:
```
# append column names
column_names = ['type',
                'sflow_agent_addr',
                'inputPort',
                'outputPort',
                'src_MAC',
                'dst_MAC',
                'ethernet_type',
                'in_vlan',
                'out_vlan',
                'src_IP',
                'dst_IP',
                'IP_protocol',
                'ip_tos',
                'ip_ttl',
                'TRANSPORT_src_port',
                'TRANSPORT_dst_port',
                'tcp_flags',
                'packet_size',
                'IP_size',
                'sampling_rate']
dfC.columns = column_names
dfC
```

Out[6]:

	type	sflow_agent_addr	inputPort	outputPort	src_MAC	dst_MAC	ethernet_type	in_vlan	out_vlan	src_IP	dst_IP	IP_pr
0	FLOW	203.30.38.251	137	200	d404ff55fd4d	80711fc76001	0x0800	919	280	130.246.176.22	140.115.32.81	
1	FLOW	203.30.38.251	129	193	609c9f851b00	0031466b23cf	0x0800	11	919	155.69.160.32	64.233.188.128	
2	FLOW	203.30.38.251	137	200	d404ff55fd4d	80711fc76001	0x0800	919	280	130.246.176.53	140.115.32.83	
3	FLOW	203.30.38.251	129	135	609c9f851b00	002688cd5fc7	0x0800	11	919	155.69.160.32	54.169.174.79	
4	FLOW	203.30.38.251	130	199	00239cd087c1	544b8cf9a7df	0x0800	919	600	137.132.228.15	193.62.192.8	
...	...	...	...	...	...	...	...	...	...	...	...	
68060	FLOW	203.30.38.251	258	199	204e71cf1b0f	ccef48570144	0x0800	537	601	207.241.228.157	210.48.222.9	
68061	FLOW	203.30.38.251	131	193	00a742233e9e	0031466b23cf	0x0800	43	919	192.122.131.36	216.58.203.234	
68062	FLOW	203.30.38.251	130	199	00239cd087c1	544b8cf9a7df	0x0800	919	600	137.132.228.15	193.62.192.8	
68063	FLOW	203.30.38.251	129	193	609c9f851b00	0031466b23cf	0x0800	11	919	155.69.196.9	74.125.56.6	

In [8]:
```
# convert all the columns with object type into string
for col in dfC:
    if dfC[col].dtype == 'object':
        dfC[col] = dfC[col].astype("string")
dfC.dtypes
```

```
C:\Users\TdrDi\AppData\Local\Temp\ipykernel_10716\1519574019.py:4: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  dfC[col] = dfC[col].astype("string")
```

Out[8]:
```
type                  string
sflow_agent_addr      string
inputPort              int64
outputPort             int64
src_MAC               string
dst_MAC               string
ethernet_type         string
in_vlan                int64
out_vlan               int64
src_IP                string
dst_IP                string
IP_protocol            int64
ip_tos                string
ip_ttl                 int64
TRANSPORT_src_port     int64
TRANSPORT_dst_port     int64
tcp_flags             string
packet_size            int64
IP_size                int64
sampling_rate          int64
dtype: object
```

4a

In [9]:
```
def findOrg(ipAddr):
    """
    function that calls IPWhois to return the organization information as a dictionary
    """
    ipwhois = IPWhois(ipAddr)
    try:
        org = ipwhois.lookup_rdap()
    except:
        org = None
    return org
```

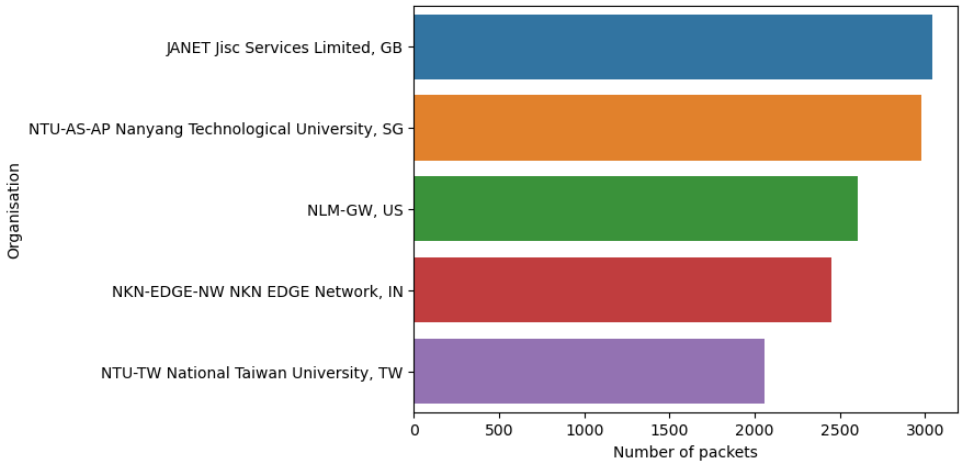
In [10]:
```
# get top 5 talkers
top_5_talkers = dfC['src_IP'].value_counts().head(5)


# find organisation names of top 5 talkers
org_list = [findOrg(index)['asn_description'] for index in top_5_talkers.index]

# append data together
top_5_talkers = pd.DataFrame(top_5_talkers).reset_index()
top_5_talkers.columns = ['src_IP','Number of packets']
top_5_talkers['Organisation'] = org_list
top_5_talkers
```

Out[10]:

	src_IP	Number of packets	Organisation
0	193.62.192.8	3041	JANET Jisc Services Limited, GB
1	155.69.160.32	2975	NTU-AS-AP Nanyang Technological University, SG
2	130.14.250.11	2604	NLM-GW, US
3	14.139.196.58	2452	NKN-EDGE-NW NKN EDGE Network, IN
4	140.112.8.139	2056	NTU-TW National Taiwan University, TW

In [11]:
```
sns.barplot(data=top_5_talkers,x='Number of packets',y='Organisation')
```

Out[11]:
```
<AxesSubplot:xlabel='Number of packets', ylabel='Organisation'>
```



4b

In [14]:
```
# get ranked list of most common transport protocol in IP header
transport_layer_protocol = dfC['IP_protocol'].value_counts(normalize = False)
transport_layer_protocol = pd.DataFrame(transport_layer_protocol).reset_index()
transport_layer_protocol.columns = ['IP_protocol','Number of packets']
transport_layer_protocol.head(5)
```

Out[14]:

	IP_protocol	Number of packets
0	6	56064
1	17	9462
2	50	1698
3	47	657
4	41	104

Finding out the mapping for the name of the transport layer protocol to the protocol number in the IP packet header
6: Transmission Control Protocol (TCP)
17: User Datagram Protocol (UDP)
50: Encapsulating Security Payload (ESP)
47: Generic Routing Encapsulation (GRE)
41: IPv6 Encapsulation (IPv6)

In [15]:
```
transport_layer_protocol['IP_protocol'] = transport_layer_protocol['IP_protocol'].replace({6:'TCP',
                                                                                           17:'UDP',
                                                                                           50:'ESP',
                                                                                           47:'GRE',
                                                                                           41:'IPv6'})
transport_layer_protocol.head(5)
```

Out[15]:

	IP_protocol	Number of packets
0	TCP	56064
1	UDP	9462
2	ESP	1698
3	GRE	657
4	IPv6	104

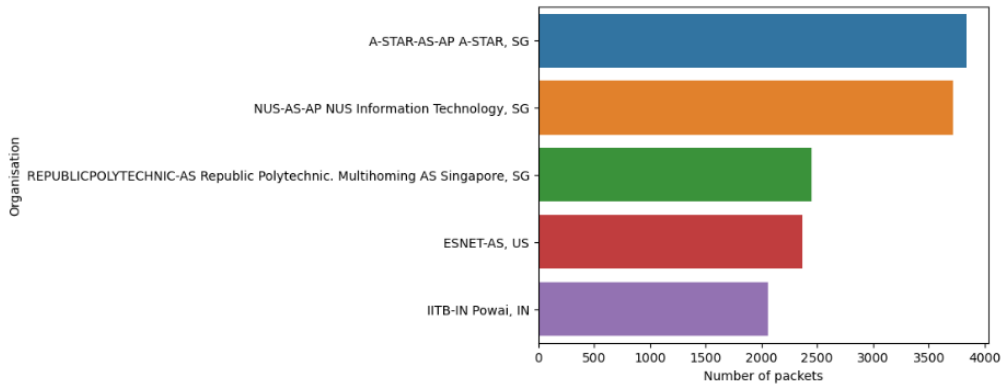
In [12]:
```
# get top 5 listeners
top_5_listeners = dfC['dst_IP'].value_counts().head(5)


# find organisation names of top 5 talkers
org_list = [findOrg(index)['asn_description'] for index in top_5_listeners.index]

# append data together
top_5_listeners = pd.DataFrame(top_5_listeners).reset_index()
top_5_listeners.columns = ['dst_IP','Number of packets']
top_5_listeners['Organisation'] = org_list
top_5_listeners
```

Out[12]:

	dst_IP	Number of packets	Organisation
0	103.37.198.100	3841	A-STAR-AS-AP A-STAR, SG
1	137.132.228.15	3715	NUS-AS-AP NUS Information Technology, SG
2	202.21.159.244	2446	REPUBLICPOLYTECHNIC-AS Republic Polytechnic. M...
3	192.101.107.153	2368	ESNET-AS, US
4	103.21.126.2	2056	IITB-IN Powai, IN

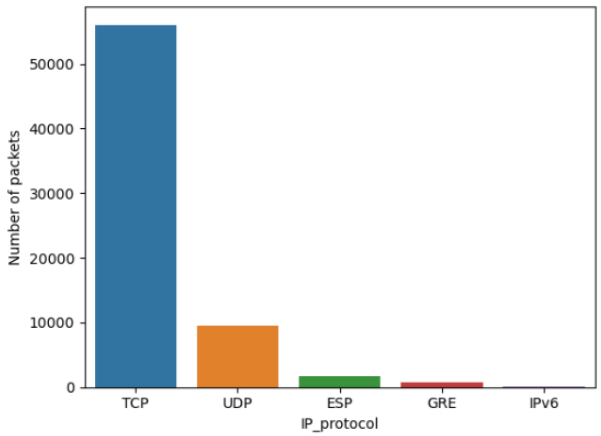
In [13]:
```
sns.barplot(data=top_5_listeners,x='Number of packets',y='Organisation')
```

Out[13]:
```
<AxesSubplot:xlabel='Number of packets', ylabel='Organisation'>
```



In [16]:
```
sns.barplot(data=transport_layer_protocol.head(5),x='IP_protocol',y='Number of packets')
```

Out[16]:
```
<AxesSubplot:xlabel='IP_protocol', ylabel='Number of packets'>
```



In [17]:
```
# get ranked list of most common transport protocol in IP header by percentage
transport_layer_protocol_norm = dfC['IP_protocol'].value_counts(normalize = True)
transport_layer_protocol_norm = pd.DataFrame(transport_layer_protocol_norm).reset_index()
transport_layer_protocol_norm.columns = ['IP_protocol','Percentage of packets']
transport_layer_protocol_norm['Percentage of packets'] =transport_layer_protocol_norm['Percentage of packets'].apply(lambda x: x*
transport_layer_protocol_norm.head(5)
```

Out[17]:

	IP_protocol	Percentage of packets
0	6	82.368324
1	17	13.901418
2	50	2.494674
3	47	0.965254
4	41	0.152795

Finding out the mapping for the name of the transport layer protocol to the protocol number in the IP packet header
6: Transmission Control Protocol (TCP)
17: User Datagram Protocol (UDP)
50: Encapsulating Security Payload (ESP)
47: Generic Routing Encapsulation (GRE)
41: IPv6 Encapsulation (IPv6)

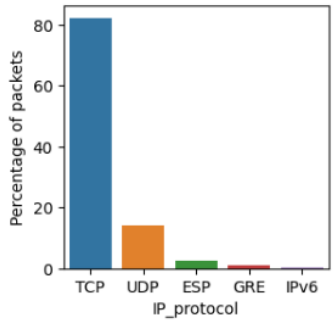
In [18]:
```
transport_layer_protocol_norm['IP_protocol'] = transport_layer_protocol_norm['IP_protocol'].replace({6:'TCP',
                                                                                                     17:'UDP',
                                                                                                     50:'ESP',
                                                                                                     47:'GRE',
                                                                                                     41:'IPv6'})
transport_layer_protocol_norm.head(5)
```

Out[18]:

	IP_protocol	Percentage of packets
0	TCP	82.368324
1	UDP	13.901418
2	ESP	2.494674
3	GRE	0.965254
4	IPv6	0.152795

In [74]:
```
plt.figure(figsize=(3, 3))
sns.barplot(data=transport_layer_protocol_norm.head(5),x='IP_protocol',y='Percentage of packets')
```

Out[74]:
```
<AxesSubplot:xlabel='IP_protocol', ylabel='Percentage of packets'>
```



4c

In [20]:
```
# get ranked list of most common application protocol in IP header
app_layer_protocol = dfC['TRANSPORT_dst_port'].value_counts(normalize = False)
app_layer_protocol = pd.DataFrame(app_layer_protocol).reset_index()
app_layer_protocol.columns = ['Application_protocol','Number of packets']
app_layer_protocol.head(5)
```

Out[20]:

	Application_protocol	Number of packets
0	443	13423
1	80	2647
2	52866	2068
3	45512	1356
4	56152	1341

Finding out the mapping for the name of the application layer protocol to the transport port number in the IP packet header from here
443: Hypertext Transfer Protocol over SSL/TLS (HTTPS)
80: Hypertext Transfer Protocol (HTTP)
52866: Dynamic and/or Private Ports
45512: Unassigned
56152: Dynamic and/or Private Ports

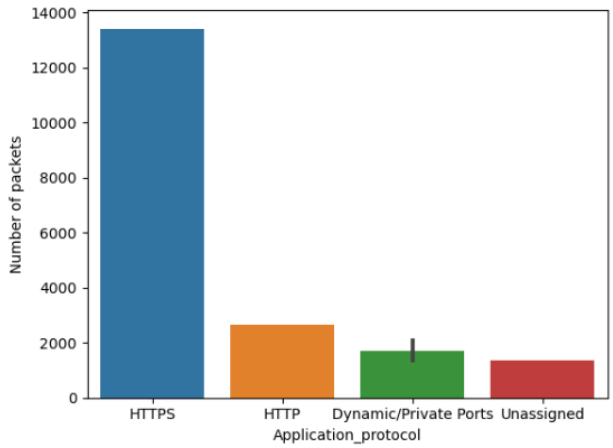
In [21]:
```
app_layer_protocol['Application_protocol'] = app_layer_protocol['Application_protocol'].replace({443:'HTTPS',
                                                                                                 80:'HTTP',
                                                                                                 52866:'Dynamic/Private Ports',
                                                                                                 45512:'Unassigned',
                                                                                                 56152:'Dynamic/Private Ports'})
app_layer_protocol.head(5)
```

Out[21]:

	Application_protocol	Number of packets
0	HTTPS	13423
1	HTTP	2647
2	Dynamic/Private Ports	2068
3	Unassigned	1356
4	Dynamic/Private Ports	1341

In [75]:
```
sns.barplot(data=app_layer_protocol.head(5),x='Application_protocol',y='Number of packets')
```

Out[75]:
```
<AxesSubplot:xlabel='Application_protocol', ylabel='Number of packets'>
```



4d

Since all packets in the entire dataset are over the span of 15 seconds, the sum of the size of all IP packets would only give us 1/2048 of the total traffic, on average, since sampling rate is 2048 meaning only one in every 2048 packets are sampled. The packet size given in IP header is in Bytes.

In [23]:
```
print("Estimated Total traffic size is")
print(dfC['IP_size'].sum() * 2048, " Bytes")
print((dfC['IP_size'].sum() * 2048)/2**20, " MB")
print()
print("Traffic intensity is")
print((dfC['IP_size'].sum() * 2048)/(15* (2**20)), " MB per second")
```

```
Estimated Total traffic size is
132664979456  Bytes
126519.18359375  MB

Traffic intensity is
8434.612239583334  MB per second
```

4e

In [24]:
```
import networkx as nx
import matplotlib.pyplot as plt
```

Top 5 communication pairs visualized

In [66]:
```
communication_pairs = dfC.groupby(["src_IP", "dst_IP"]).size().sort_values(ascending=False)
communication_pairs.head(5)
```

Out[66]:
```
src_IP          dst_IP
193.62.192.8    137.132.228.15     3041
130.14.250.11   103.37.198.100     2599
14.139.196.58   192.101.107.153    2368
140.112.8.139   103.21.126.2       2056
137.132.228.15  193.62.192.8       1910
dtype: int64
```

Visualization of communications between different IP hosts

In [67]:
```
communication_pairs = dfC.groupby(["src_IP", "dst_IP"]).size().reset_index(name='count')
top_10_pairs = communication_pairs.sort_values('count', ascending=False).head(10)

# Create a directed graph from the filtered dataframe
G_filtered = nx.from_pandas_edgelist(top_10_pairs, "src_IP", "dst_IP", create_using=nx.DiGraph())

# Draw the filtered graph with node labels
pos_filtered = nx.spring_layout(G_filtered, seed=42)
plt.figure(figsize=(8, 8))
nx.draw(G_filtered, pos_filtered, with_labels=True, node_size=1000, node_color="skyblue", arrowsize=20, font_size=8)

# Add edge labels with packet count
edge_labels_filtered = {(src_IP, dst_IP): top_10_pairs[(top_10_pairs["src_IP"] == src_IP) & (top_10_pairs["dst_IP"] == dst_IP)].
#edge_labels_filtered = {(src_IP, dst_IP): top_10_pairs[(top_10_pairs["src_IP"] == src_IP) & (top_10_pairs["dst_IP"] == dst_IP)].
nx.draw_networkx_edge_labels(G_filtered, pos_filtered, edge_labels=edge_labels_filtered, font_size=8)

plt.title("Top 10 Communication Pairs Visualized")
plt.show()
```