DATA-WARE HOUSING and MINING PROJECT

Problem statement : The aim of the present project is to predict the next attacks in specific domain in the areas of social-engineering using Python

In [4]:
```
# 1) Most targeted Destination IP Address
# 2) Most Logical Ports attacked
# 3) Most Frequently/common type of Attack
# 4) Different time of the day , (odd , hours, day or night)
# 5) Find the Pattern
```

In [5]:
```
import pandas as pd
import seaborn as sns
import matplotlib.pyplot as plt
import ipaddress
import numpy as np
from scipy import stats
from scipy.stats import chi2_contingency
from datetime import datetime, timedelta
import math
plt.style.use('ggplot')
import warnings
```

In [6]:
```
warnings.filterwarnings('ignore')
```

In [7]:
```
df = pd.read_csv('Cybersecurity_attacks.csv')
df.shape
```

Out[7]:
```
(178031, 10)
```

In [8]:
```
df.columns
```

Out[8]:
```
Index(['Attack_category', 'Attack_subcategory', 'Protocol', 'Source IP',
       'Source Port', 'Destination IP', 'Destination Port', 'AttackName',
       'Attack Reference', 'Time'],
      dtype='object')
```

In [9]:
```
df.head(4)
```

Out[9]:

	Attack_category	Attack_subcategory	Protocol	Source IP	Source Port	Destination IP	Destinati Po
0	Reconnaissance	HTTP	tcp	175.45.176.0	13284	149.171.126.16	
1	Exploits	Unix 'r' Service	udp	175.45.176.3	21223	149.171.126.18	327
2	Exploits	Browser	tcp	175.45.176.2	23357	149.171.126.16	
3	Exploits	Miscellaneous Batch	tcp	175.45.176.2	13792	149.171.126.16	55

In [10]:
```
df[['Start time','Last time']] = df['Time'].str.split('-',expand=True)
df.head()
```

Out[10]:

	Attack_category	Attack_subcategory	Protocol	Source IP	Source Port	Destination IP	Destinati Po
0	Reconnaissance	HTTP	tcp	175.45.176.0	13284	149.171.126.16	
1	Exploits	Unix 'r' Service	udp	175.45.176.3	21223	149.171.126.18	327
2	Exploits	Browser	tcp	175.45.176.2	23357	149.171.126.16	
3	Exploits	Miscellaneous Batch	tcp	175.45.176.2	13792	149.171.126.16	55
4	Exploits	Cisco IOS	tcp	175.45.176.2	26939	149.171.126.10	

In [11]:
```
df.columns
```

Out[11]:
```
Index(['Attack_category', 'Attack_subcategory', 'Protocol', 'Source IP',
       'Source Port', 'Destination IP', 'Destination Port', 'AttackName',
       'Attack Reference', 'Time', 'Start time', 'Last time'],
      dtype='object')
```

In [12]:
```
df.shape
```

Out[12]:
```
(178031, 12)
```

In [13]:
```
df.isnull().sum()
```

Out[13]:
```
Attack_category           0
Attack_subcategory     4192
Protocol                  0
Source IP                 0
Source Port               0
Destination IP            0
Destination Port          0
AttackName                0
Attack Reference      51745
Time                      0
Start time                0
Last time                 0
dtype: int64
```

In [14]:
```
df["Attack_subcategory"] = df["Attack_subcategory"].fillna("Not Registered")
```

In [15]:
```
df.isnull().sum()
```

Out[15]:
```
Attack_category           0
Attack_subcategory        0
Protocol                  0
Source IP                 0
Source Port               0
Destination IP            0
Destination Port          0
AttackName                0
Attack Reference      51745
Time                      0
Start time                0
Last time                 0
dtype: int64
```

In [16]:
```
df[pd.isnull(df).any(axis=1)].shape
```

Out[16]:
```
(51745, 12)
```

In [17]:
```
df[df.duplicated()].shape
```

Out[17]:
```
(6, 12)
```

In [18]:
```
print('Dimensions before dropping duplicated rows: ' + str(df.shape))
df = df.drop(df[df.duplicated()].index)
print('Dimensions after dropping duplicated rows: ' + str(df.shape))
```

```
Dimensions before dropping duplicated rows: (178031, 12)
Dimensions after dropping duplicated rows: (178025, 12)
```

In [19]:
```
pqr = df[df.duplicated()]
pqr
```

Out[19]:

Attack_category	Attack_subcategory	Protocol	Source IP	Source Port	Destination IP	Destination Port	Attac

In [20]:
```
#port range 0 to 65535
```

In [21]:
```
invalid_SP = (df['Source Port'] < 0) | (df['Source Port'] > 65535)
invalid_DP = (df['Destination Port'] < 0) | (df['Destination Port'] > 65535)
df[invalid_SP | invalid_DP]
```

Out[21]:

	Attack_category	Attack_subcategory	Protocol	Source IP	Source Port	Destination IP	Des
174347	Generic	IXIA	udp	175.45.176.1	67520	149.171.126.18	
174348	Exploits	Browser	tcp	175.45.176.3	78573	149.171.126.18	
174349	Reconnaissance	HTTP	tcp	175.45.176.1	71804	149.171.126.10	
174350	DoS	Ethernet	pnni	175.45.176.3	0	149.171.126.19	
174351	Fuzzers	OSPF	trunk-1	175.45.176.0	73338	149.171.126.13	
...	...	...	...	...	...	...	
178026	Generic	IXIA	udp	175.45.176.0	72349	149.171.126.12	
178027	Exploits	Browser	sep	175.45.176.3	67647	149.171.126.18	
178028	Exploits	Office Document	tcp	175.45.176.0	78359	149.171.126.13	
178029	Exploits	Browser	tcp	175.45.176.2	68488	149.171.126.19	
178030	Reconnaissance	ICMP	unas	175.45.176.3	77929	149.171.126.19	

3684 rows × 12 columns

In [22]:
```
df = df[~(invalid_SP | invalid_DP)].reset_index(drop=True)
df
```

Out[22]:

	Attack_category	Attack_subcategory	Protocol	Source IP	Source Port	Destination IP	Des
0	Reconnaissance	HTTP	tcp	175.45.176.0	13284	149.171.126.16	
1	Exploits	Unix 'r' Service	udp	175.45.176.3	21223	149.171.126.18	
2	Exploits	Browser	tcp	175.45.176.2	23357	149.171.126.16	
3	Exploits	Miscellaneous Batch	tcp	175.45.176.2	13792	149.171.126.16	
4	Exploits	Cisco IOS	tcp	175.45.176.2	26939	149.171.126.10	
...	...	...	...	...	...	...	
174336	DoS	IGMP	tcp	175.45.176.0	33654	149.171.126.12	
174337	Fuzzers	SMB	tcp	175.45.176.3	36468	149.171.126.15	
174338	Reconnaissance	SunRPC Portmapper (TCP) UDP Service	tcp	175.45.176.2	64395	149.171.126.18	
174339	Generic	IXIA	udp	175.45.176.0	47439	149.171.126.10	
174340	Exploits	Office Document	tcp	175.45.176.0	17293	149.171.126.17	

174341 rows × 12 columns

In [23]:
```
df.shape
```

Out[23]:
```
(174341, 12)
```

In [24]:
```
print('Total number of different protocols:', len(df['Protocol'].unique()))
print('Total number of different Attack categories:', len(df['Attack_category'
].unique()))
df['Protocol'].unique()[:15]
```

```
Total number of different protocols: 131
Total number of different Attack categories: 14
```

Out[24]:
```
array(['tcp', 'udp', 'Tcp', 'UDP', 'ospf', 'sctp', 'sep', 'mobile',
       'sun-nd', 'swipe', 'pim', 'ggp', 'ip', 'ipnip', 'st2'],
      dtype=object)
```

In [25]:
```
df['Attack_category'].unique()
```

Out[25]:
```
array(['Reconnaissance', 'Exploits', 'DoS', 'Generic', 'Shellcode',
       ' Fuzzers', 'Worms', 'Backdoors', 'Analysis', ' Fuzzers ',
       ' Reconnaissance ', 'Backdoor', ' Shellcode ', 'Reconnaissance '],
      dtype=object)
```

In [26]:
```
df['Protocol'] = df['Protocol'].str.upper().str.strip()
df['Attack_category'] = df['Attack_category'].str.upper().str.strip()
df['Attack_category'] = df['Attack_category'].str.strip().replace('BACKDOORS',
'BACKDOOR')

df
```

Out[26]:

	Attack_category	Attack_subcategory	Protocol	Source IP	Source Port	Destination IP
0	RECONNAISSANCE	HTTP	TCP	175.45.176.0	13284	149.171.126.16
1	EXPLOITS	Unix 'r' Service	UDP	175.45.176.3	21223	149.171.126.18
2	EXPLOITS	Browser	TCP	175.45.176.2	23357	149.171.126.16
3	EXPLOITS	Miscellaneous Batch	TCP	175.45.176.2	13792	149.171.126.16
4	EXPLOITS	Cisco IOS	TCP	175.45.176.2	26939	149.171.126.10
...	...	...	...	...	...	...
174336	DOS	IGMP	TCP	175.45.176.0	33654	149.171.126.12
174337	FUZZERS	SMB	TCP	175.45.176.3	36468	149.171.126.15
174338	RECONNAISSANCE	SunRPC Portmapper (TCP) UDP Service	TCP	175.45.176.2	64395	149.171.126.18
174339	GENERIC	IXIA	UDP	175.45.176.0	47439	149.171.126.10
174340	EXPLOITS	Office Document	TCP	175.45.176.0	17293	149.171.126.17

174341 rows × 12 columns

In [27]:
```
print('Total number of different protocols:', len(df['Protocol'].unique()))
print('Total number of different Attack categories:', len(df['Attack_category'
].unique()))
```

```
Total number of different protocols: 129
Total number of different Attack categories: 9
```

In [28]:
```
df[pd.isnull(df['Attack Reference'])].shape
```

Out[28]:
```
(50638, 12)
```

In [29]:
```
print(df[pd.isnull(df['Attack Reference'])]['Attack_category'].value_counts())
```

```
FUZZERS           29649
RECONNAISSANCE    18149
ANALYSIS           1617
SHELLCODE           747
GENERIC             341
BACKDOOR             66
DOS                  53
WORMS                11
EXPLOITS              5
Name: Attack_category, dtype: int64
```

In [30]:
```
print(df['Attack_category'].value_counts())
```

```
EXPLOITS          68211
FUZZERS           33638
DOS               24582
RECONNAISSANCE    20136
GENERIC           19860
BACKDOOR           4353
ANALYSIS           1881
SHELLCODE          1511
WORMS               169
Name: Attack_category, dtype: int64
```

In [31]:
```
# Percentage of missing values in 'Attack Reference' per Attack Category
((df[pd.isnull(df['Attack Reference'])]['Attack_category'].value_counts()/df[
'Attack_category'].value_counts())*100).dropna().sort_values(ascending=False)
```

Out[31]:
```
RECONNAISSANCE    90.132102
FUZZERS           88.141388
ANALYSIS          85.964912
SHELLCODE         49.437459
WORMS              6.508876
GENERIC            1.717019
BACKDOOR           1.516196
DOS                0.215605
EXPLOITS           0.007330
Name: Attack_category, dtype: float64
```

In [32]:
```
tcp_ports = pd.read_csv('TCP-ports.csv')
tcp_ports['Service'] = tcp_ports['Service'].str.upper()
tcp_ports.head()
```

Out[32]:

	Port	Service	Description
0	0	NaN	Reserved
1	1	TCPMUX	TCP Port Service Multiplexer
2	2	COMPRESSNET	Management Utility
3	3	COMPRESSNET	Compression Process
4	5	RJE	Remote Job Entry

In [33]:
```
print('Dimensions before merging dataframes: ' ,(df.shape))

newdf = pd.merge(df, tcp_ports[['Port','Service']], left_on='Destination Port'
, right_on='Port', how='left')
newdf = newdf.rename(columns={'Service':'Destination Port Service'})

print('Dimensions after merging dataframes: ' + str(newdf.shape))
```

```
Dimensions before merging dataframes:  (174341, 12)
Dimensions after merging dataframes: (174341, 14)
```

In [34]:
```
newdf = newdf.drop(columns=['Port'])
newdf.head()
```

Out[34]:

	Attack_category	Attack_subcategory	Protocol	Source IP	Source Port	Destination IP	Destir
0	RECONNAISSANCE	HTTP	TCP	175.45.176.0	13284	149.171.126.16	
1	EXPLOITS	Unix 'r' Service	UDP	175.45.176.3	21223	149.171.126.18	
2	EXPLOITS	Browser	TCP	175.45.176.2	23357	149.171.126.16	
3	EXPLOITS	Miscellaneous Batch	TCP	175.45.176.2	13792	149.171.126.16	
4	EXPLOITS	Cisco IOS	TCP	175.45.176.2	26939	149.171.126.10	

In [35]:
```
newdf['Attack_category'].unique()
```

Out[35]:
```
array(['RECONNAISSANCE', 'EXPLOITS', 'DOS', 'GENERIC', 'SHELLCODE',
       'FUZZERS', 'WORMS', 'BACKDOOR', 'ANALYSIS'], dtype=object)
```

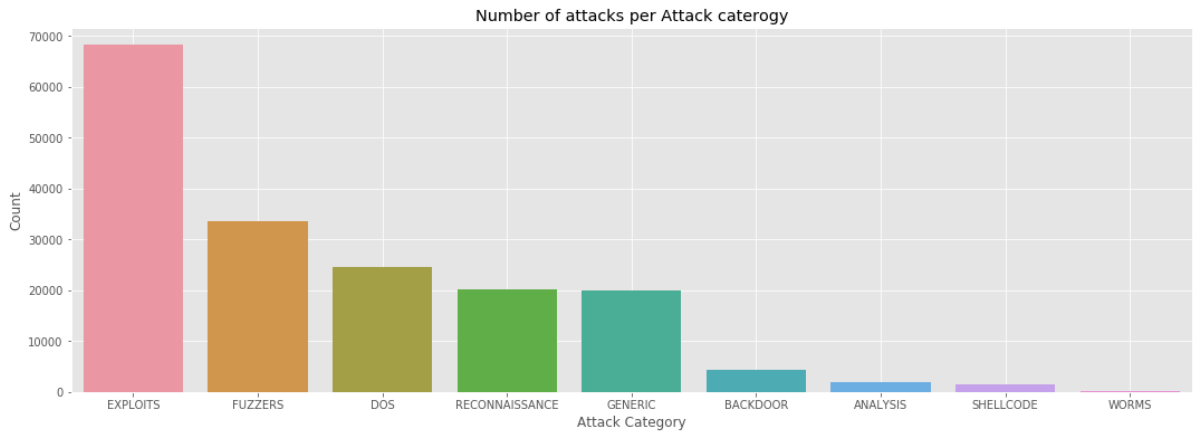
In [36]:
```
newdf['Attack_category'].value_counts()
```

Out[36]:
```
EXPLOITS          68211
FUZZERS           33638
DOS               24582
RECONNAISSANCE    20136
GENERIC           19860
BACKDOOR           4353
ANALYSIS           1881
SHELLCODE          1511
WORMS               169
Name: Attack_category, dtype: int64
```

In [37]:
```
newdf['Attack_category'].value_counts()*100/newdf['Attack_category'].value_cou
nts().sum()
```

Out[37]:
```
EXPLOITS          39.125048
FUZZERS           19.294371
DOS               14.099954
RECONNAISSANCE    11.549779
GENERIC           11.391468
BACKDOOR           2.496831
ANALYSIS           1.078920
SHELLCODE          0.866692
WORMS              0.096936
Name: Attack_category, dtype: float64
```

In [38]:
```
plt.figure(figsize=(18,6))
sns.barplot(x=newdf['Attack_category'].value_counts().index,y=newdf['Attack_ca
tegory'].value_counts())
plt.xlabel('Attack Category')
plt.ylabel('Count')
plt.title('Number of attacks per Attack caterogy')
plt.grid(True)
```



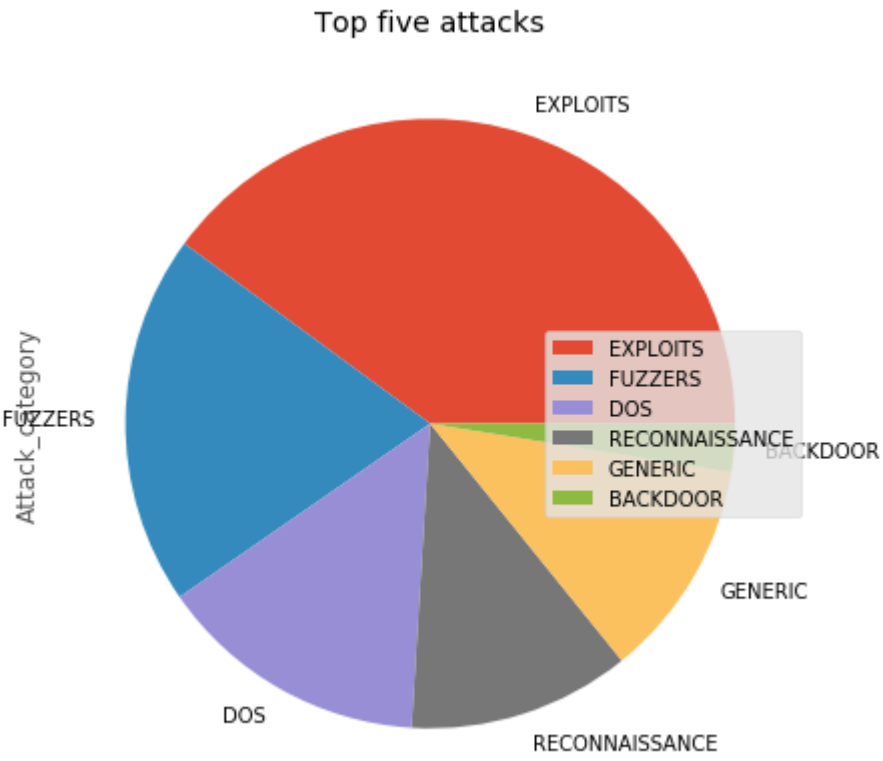
In [39]:
```
pd.DataFrame(newdf['Attack_category'].value_counts())[:]
```

Out[39]:

	Attack_category
EXPLOITS	68211
FUZZERS	33638
DOS	24582
RECONNAISSANCE	20136
GENERIC	19860
BACKDOOR	4353
ANALYSIS	1881
SHELLCODE	1511
WORMS	169

In [40]:
```
a=pd.DataFrame(newdf['Attack_category'].value_counts())[:6]
```

In [41]:
```
a.plot(kind='pie', subplots=True, figsize=(7, 7))
plt.title('Top five attacks')
plt.legend(loc='right')
plt.show()
```



NOW TO ANALYSE Attacks WITH DATE AND TIME

In [42]:
```
newdf['Start time']
```

Out[42]:
```
0         1421927414
1         1421927415
2         1421927416
3         1421927417
4         1421927418
             ...
174336    1424262066
174337    1424262067
174338    1424262067
174339    1424262068
174340    1424262068
Name: Start time, Length: 174341, dtype: object
```

In [43]:
```
newdf['Start time'] = pd.to_datetime(newdf['Start time'], unit='s')
newdf['Last time'] = pd.to_datetime(newdf['Last time'], unit='s')
newdf['Duration'] = ((newdf['Last time'] - newdf['Start time']).dt.seconds).as
type(int)
```

In [44]:
```
newdf[:5]
```

Out[44]:

	Attack_category	Attack_subcategory	Protocol	Source IP	Source Port	Destination IP	Destir
0	RECONNAISSANCE	HTTP	TCP	175.45.176.0	13284	149.171.126.16	
1	EXPLOITS	Unix 'r' Service	UDP	175.45.176.3	21223	149.171.126.18	3
2	EXPLOITS	Browser	TCP	175.45.176.2	23357	149.171.126.16	
3	EXPLOITS	Miscellaneous Batch	TCP	175.45.176.2	13792	149.171.126.16	
4	EXPLOITS	Cisco IOS	TCP	175.45.176.2	26939	149.171.126.10	

In [45]:
```
newdf['Start time'].astype(str).str.split(' ').str[0].unique()
```

Out[45]:
```
array(['2015-01-22', '2015-02-18'], dtype=object)
```

CASE: we can take as => we are going to execute from now on is based on information related to two days, Thursday - January 22nd/2015, and on Wednesday - February 18th/2015.

In [46]:
```
newdf.describe()
```

Out[46]:

	Source Port	Destination Port	Duration
count	174341.000000	174341.000000	174341.000000
mean	15391.130382	1304.599423	2.341572
std	21707.824000	7466.035607	9.309381
min	0.000000	0.000000	0.000000
25%	0.000000	0.000000	0.000000
50%	0.000000	0.000000	0.000000
75%	31862.000000	80.000000	1.000000
max	65535.000000	65535.000000	60.000000

Mean and 75% percentile is very different for SOurcePOrt and Destination Port is very different. However minimum and maximum is same. Here comes the Hypothesis testing.

In [47]:
```
statistic, pvalue = stats.ttest_ind( newdf['Source Port'], newdf['Destination
 Port'], equal_var=False)
print('Finally p-value in T-test is: ' + str(pvalue))
```

```
Finally p-value in T-test is: 0.0
```

In [48]:
```
newdf.corr(method='pearson')
```

Out[48]:

	Source Port	Destination Port	Duration
Source Port	1.000000	0.137155	-0.078024
Destination Port	0.137155	1.000000	-0.026770
Duration	-0.078024	-0.026770	1.000000

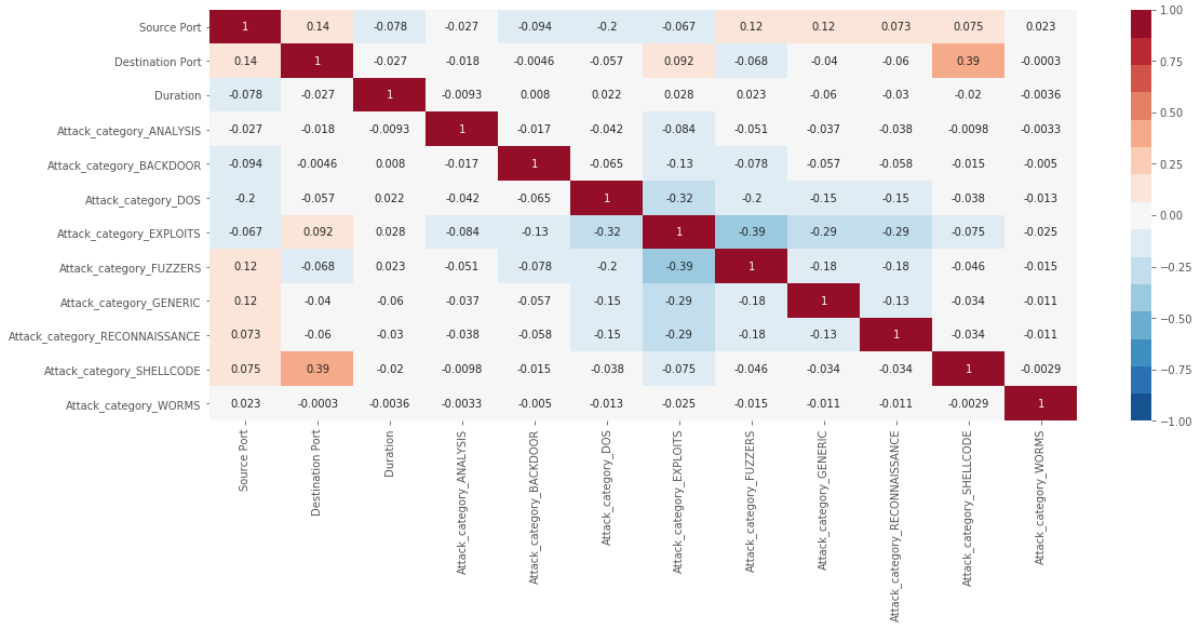
In [49]:
```
newdf.corr(method='spearman')
```

Out[49]:

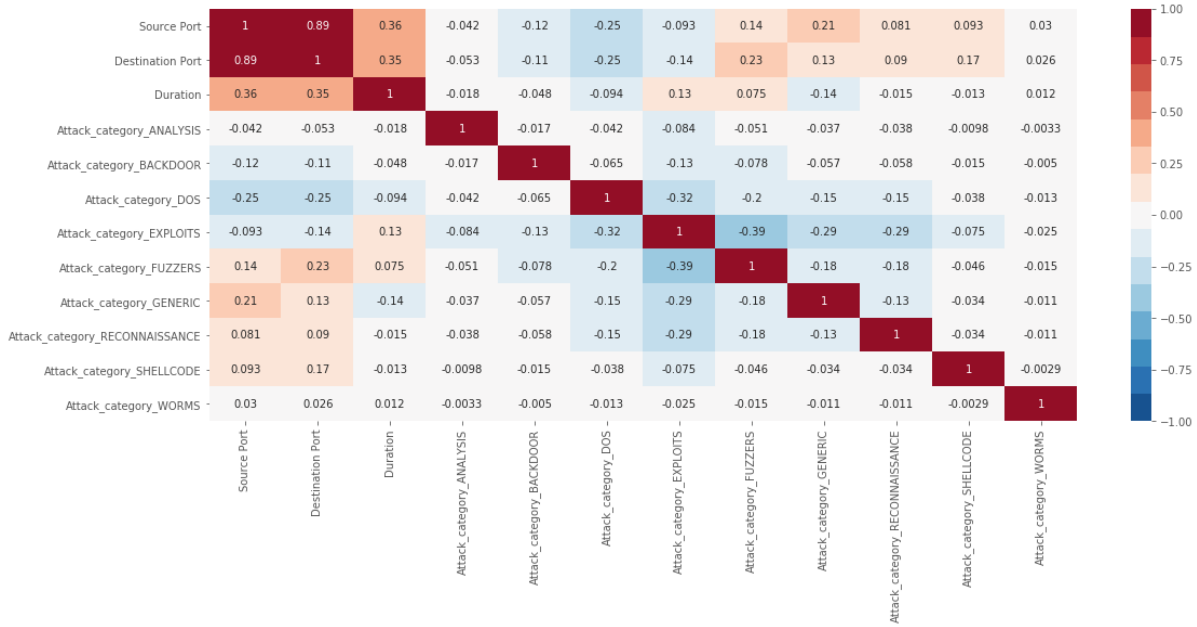
	Source Port	Destination Port	Duration
Source Port	1.000000	0.885328	0.361013
Destination Port	0.885328	1.000000	0.346909
Duration	0.361013	0.346909	1.000000

In [50]:
```
df_dummies = pd.get_dummies(newdf, columns=['Attack_category'])
```

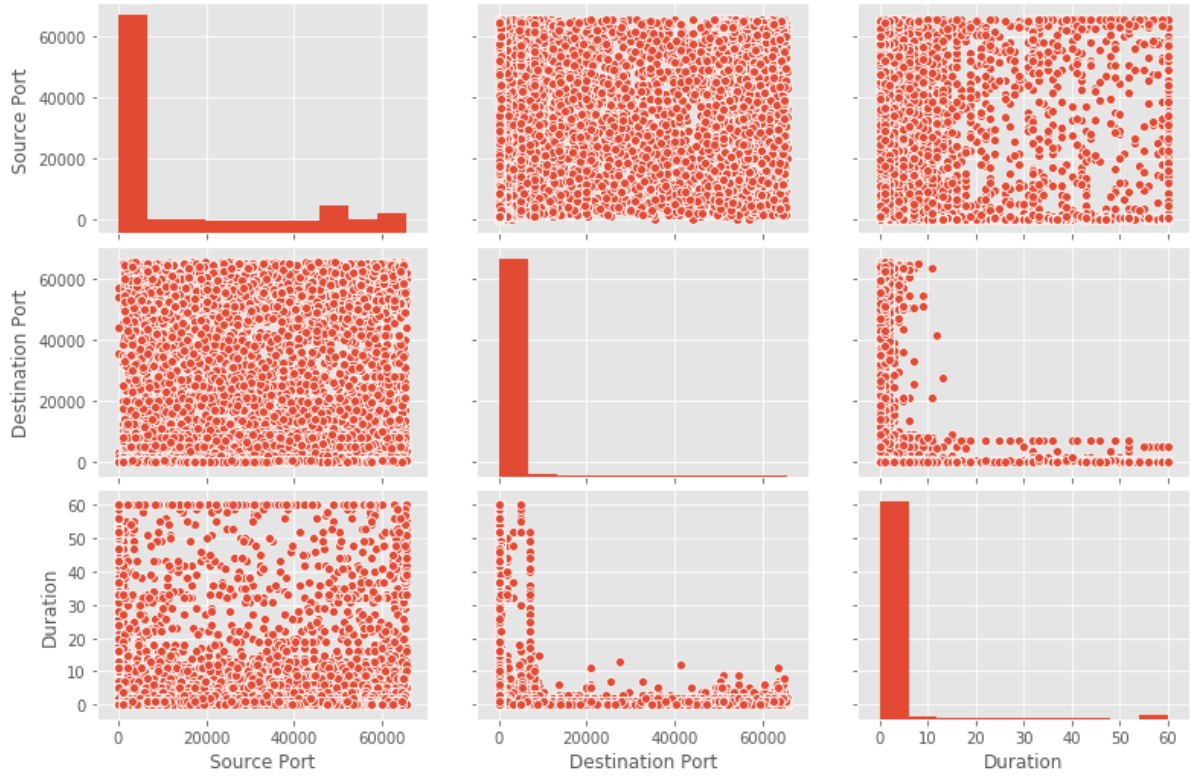
In [51]:
```
plt.figure(figsize=(18,7))
sns.heatmap(df_dummies.corr(method='pearson'),
            annot=True, vmin=-1.0, vmax=1.0, cmap=sns.color_palette("RdBu_r",
15))
plt.show()
```



In [52]:
```
plt.figure(figsize=(18,7))
sns.heatmap(df_dummies.corr(method='spearman'),
            annot=True, vmin=-1.0, vmax=1.0, cmap=sns.color_palette("RdBu_r",
15))
plt.show()
```



In [53]:
```
g = sns.pairplot(newdf)
g.fig.set_size_inches(11,7)
plt.show()
```

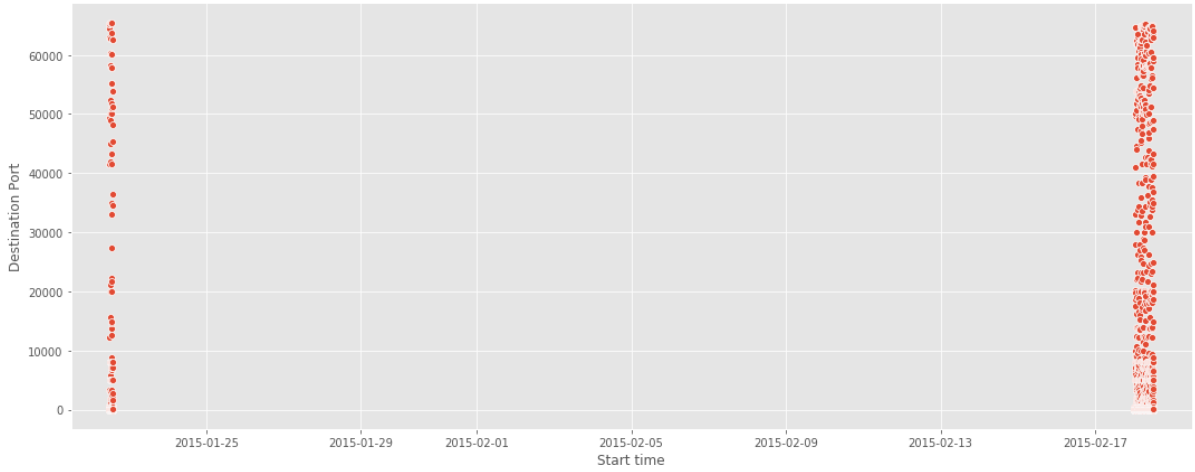


In [ ]:
```
```

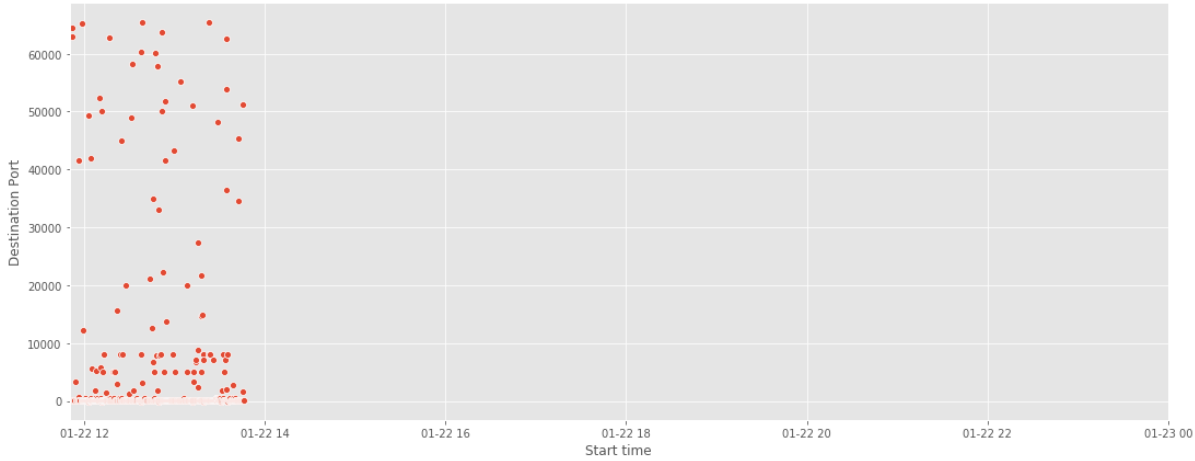
In [54]:
```
newdf['Destination IP'].value_counts()[:5]
```

Out[54]:
```
149.171.126.17    43199
149.171.126.10    24002
149.171.126.19    21619
149.171.126.13    20464
149.171.126.18    13301
Name: Destination IP, dtype: int64
```

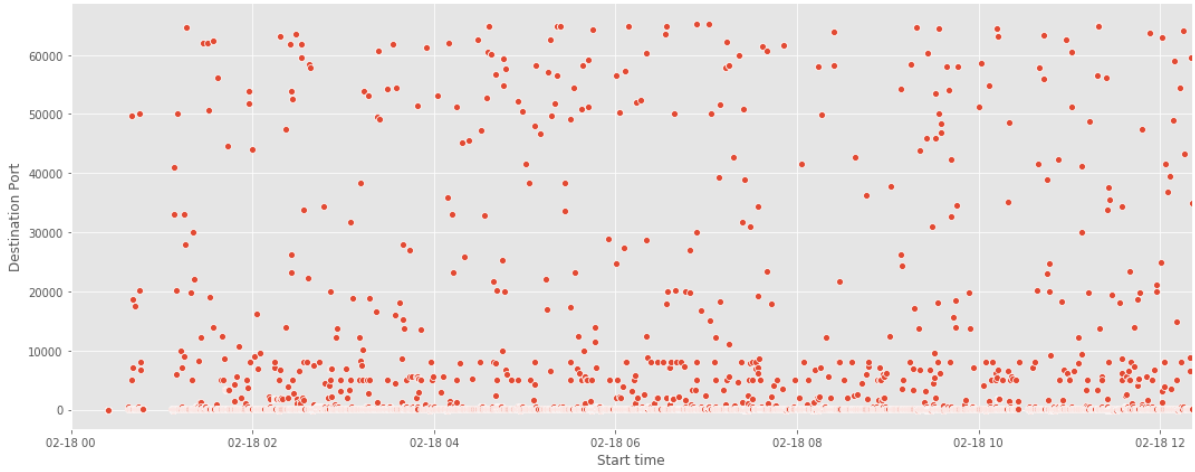
In [55]:
```
plt.figure(figsize=(18,7))
sns.scatterplot(x=newdf[newdf['Destination IP']=='149.171.126.17']['Start tim
e'], y=newdf[newdf['Destination IP']=='149.171.126.17']['Destination Port'])
plt.xlim(left=newdf['Start time'].min()-timedelta(days=1),right=newdf['Start t
ime'].max()+timedelta(days=1))
plt.grid(True)
plt.show()
```



In [56]:
```
plt.figure(figsize=(18,7))
sns.scatterplot(x=newdf[newdf['Destination IP']=='149.171.126.17']['Start tim
e'], y=newdf[newdf['Destination IP']=='149.171.126.17']['Destination Port'])
plt.xlim(left=newdf['Start time'].min(),right=datetime.strptime('15-01-23', '%
y-%m-%d'))
plt.grid(True)
plt.show()
```



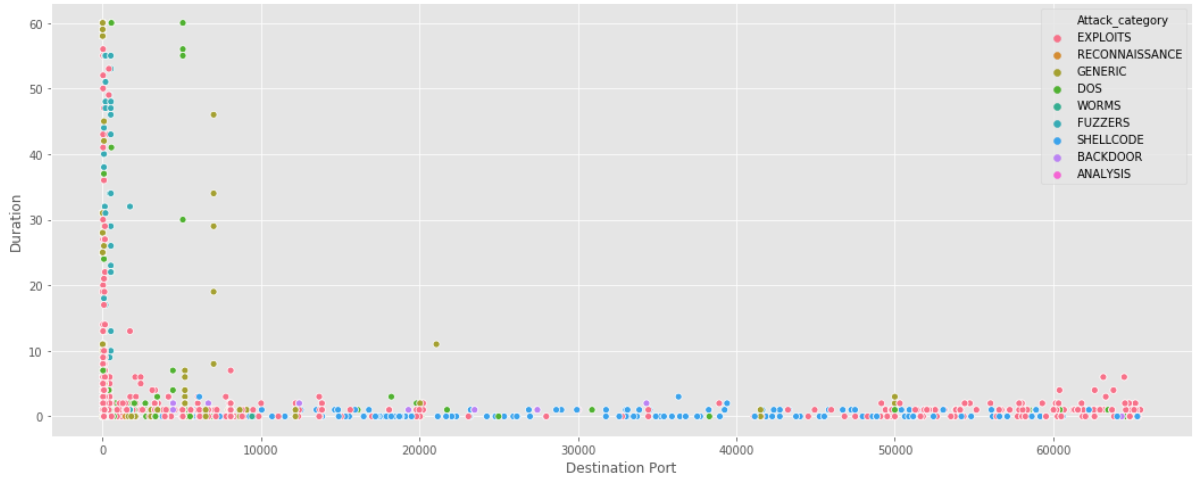
In [57]:
```
plt.figure(figsize=(18,7))
sns.scatterplot(x=newdf[newdf['Destination IP']=='149.171.126.17']['Start tim
e'], y=newdf[newdf['Destination IP']=='149.171.126.17']['Destination Port'])
plt.xlim(left=datetime.strptime('15-02-18', '%y-%m-%d'),right=newdf['Start tim
e'].max())
plt.grid(True)
plt.show()
```



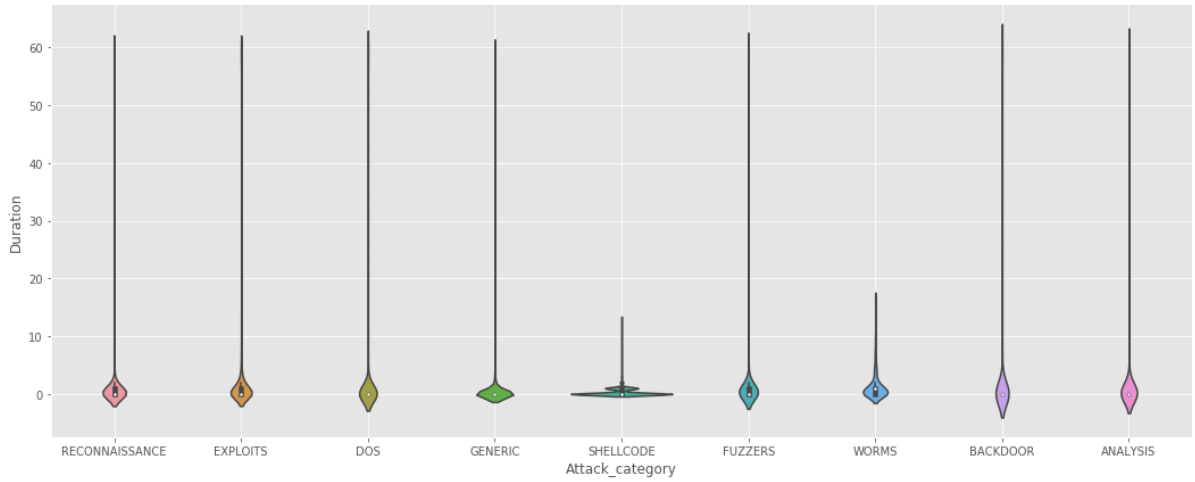
In [58]:
```
plt.figure(figsize=(18,7))
sns.scatterplot(x='Start time', y='Destination Port', hue='Attack_category',
                data=newdf[(newdf['Destination IP']=='149.171.126.17')&(newdf[
'Destination Port']<=150)],
                s=65)
plt.xlim(left=datetime.strptime('15-02-18 00:00:00', '%y-%m-%d %H:%M:%S'),
         right=datetime.strptime('15-02-18 13:00:00', '%y-%m-%d %H:%M:%S'))
plt.grid(True)
plt.show()
```

Duration vs Destination Ports

In [61]:
```
plt.figure(figsize=(18,7))
sns.scatterplot(x='Destination Port', y='Duration', hue='Attack_category', dat
a=newdf[newdf['Destination IP']=='149.171.126.17'])
plt.grid(True)
plt.show()
```



In [62]:
```
plt.figure(figsize=(18,7))
sns.violinplot(x='Attack_category', y='Duration', data=newdf)
plt.grid(True)
plt.show()
```



In [63]:
```
def heatmap_graph(df, xlabel, ylabel, title):
    plt.figure(figsize=(18,8))
    ax = sns.heatmap(df)
    plt.xlabel(xlabel)
    plt.ylabel(ylabel)
    plt.title(title)
    plt.xticks(rotation=90)
    plt.yticks(rotation=0)
    plt.show()
```

In [64]:
```
newdf["Start time"][1].hour
```

Out[64]: 11

In [65]:
```
df_pivot = newdf.copy()
df_pivot['hour'] = df_pivot.apply(lambda row: '0'*(2-len(str(row['Start time'].hour)))+str(row['Start time'].hour)+':00:00', axis=1)
```

In [66]:
```
df_pivot[:5]
```

Out[66]:

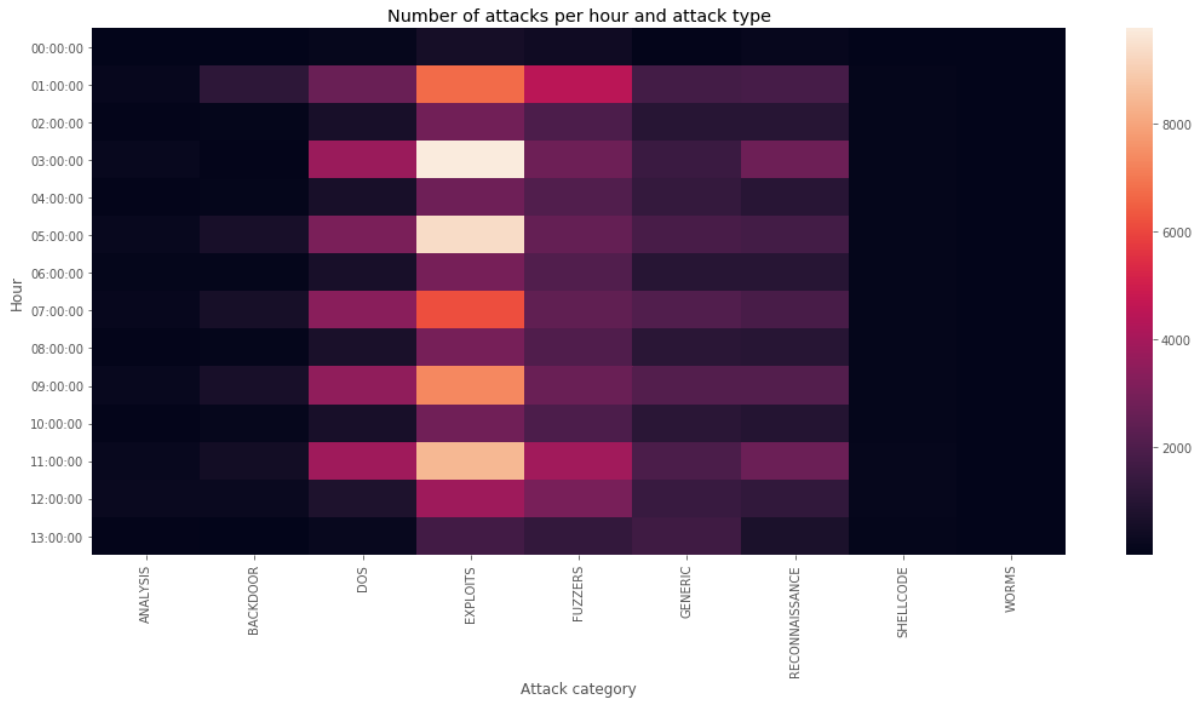
	Attack_category	Attack_subcategory	Protocol	Source IP	Source Port	Destination IP	Destir
0	RECONNAISSANCE	HTTP	TCP	175.45.176.0	13284	149.171.126.16	
1	EXPLOITS	Unix 'r' Service	UDP	175.45.176.3	21223	149.171.126.18	
2	EXPLOITS	Browser	TCP	175.45.176.2	23357	149.171.126.16	
3	EXPLOITS	Miscellaneous Batch	TCP	175.45.176.2	13792	149.171.126.16	
4	EXPLOITS	Cisco IOS	TCP	175.45.176.2	26939	149.171.126.10	

In [67]:
```
df_p1 = pd.pivot_table(df_pivot,values='AttackName', index=['hour'], columns=[
'Attack_category'], aggfunc='count')
df_p1
```

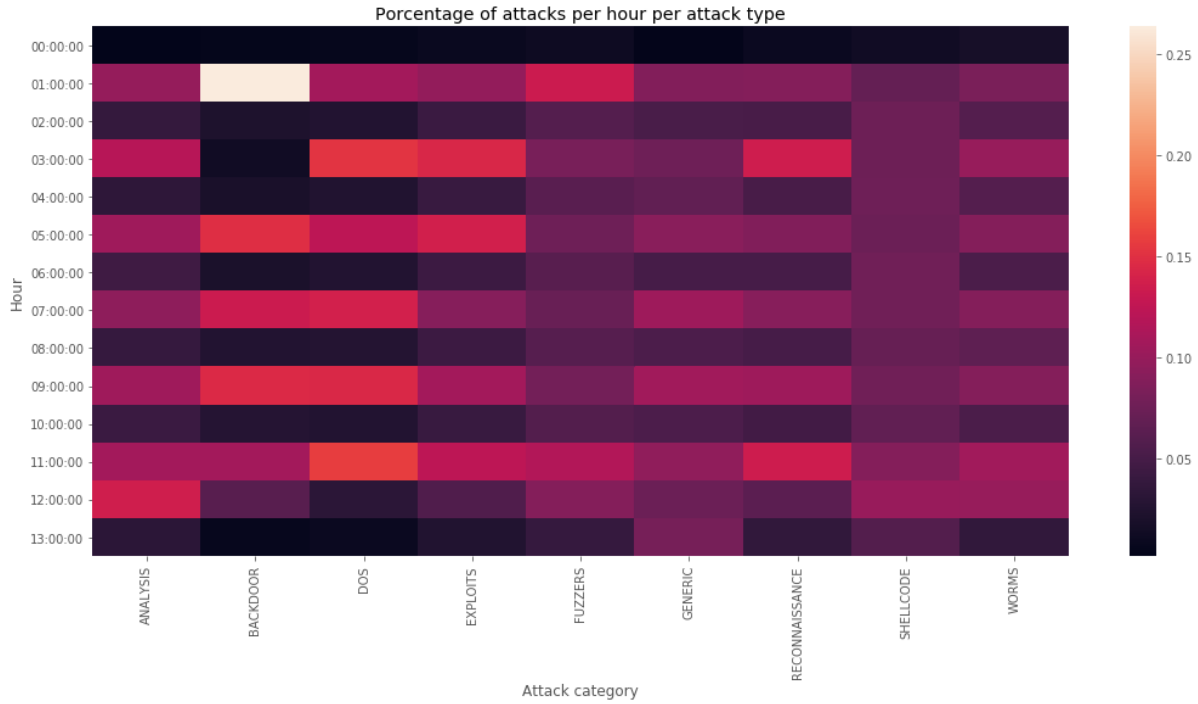
Out[67]:

Attack_category	ANALYSIS	BACKDOOR	DOS	EXPLOITS	FUZZERS	GENERIC	RECONNAISSAI
hour							
00:00:00	3	16	127	543	391	60	
01:00:00	186	1148	2640	6716	4477	1748	1
02:00:00	71	100	630	2861	1983	1031	1
03:00:00	226	60	3755	9759	2743	1513	2
04:00:00	64	87	617	2776	2090	1349	1
05:00:00	198	645	3038	9368	2536	1834	1
06:00:00	84	90	637	2968	2065	994	1
07:00:00	179	578	3390	6151	2413	2076	1
08:00:00	73	111	664	2938	2048	1081	1
09:00:00	199	635	3545	7325	2667	2108	2
10:00:00	79	121	643	2794	1981	1081	
11:00:00	203	470	3890	8461	3923	1920	2
12:00:00	257	266	778	3845	3005	1460	1
13:00:00	59	26	228	1706	1316	1605	

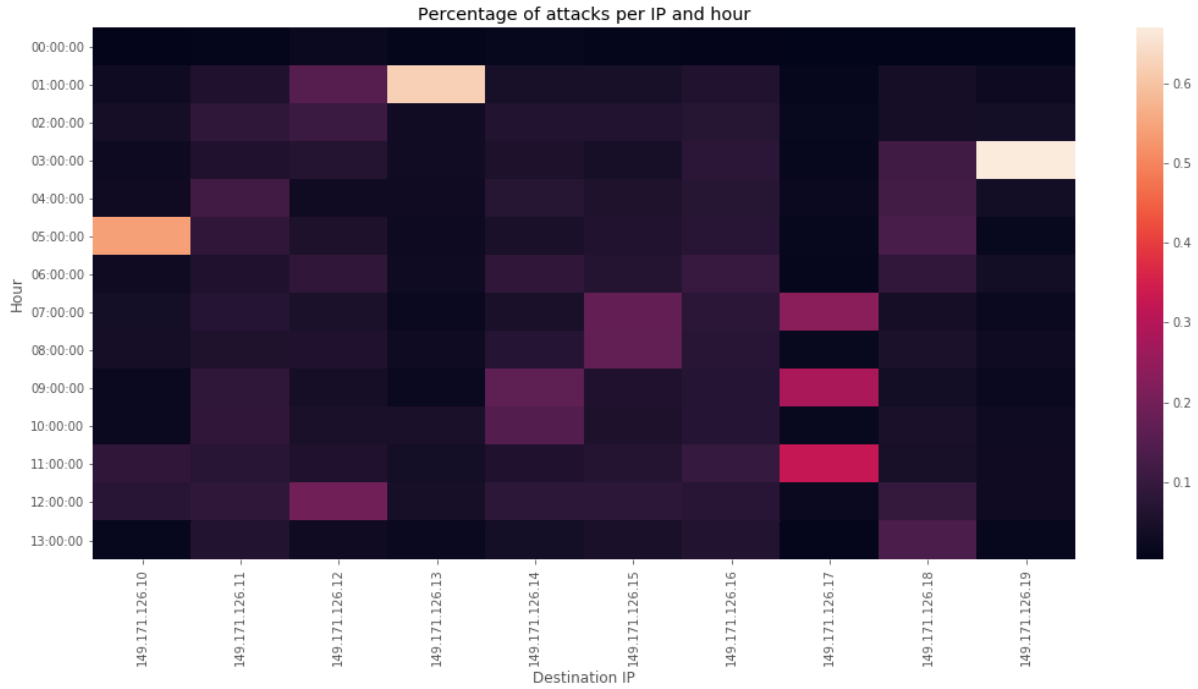
In [68]:
```
heatmap_graph(df = df_p1, xlabel = 'Attack category', ylabel = 'Hour', title =
'Number of attacks per hour and attack type')
```



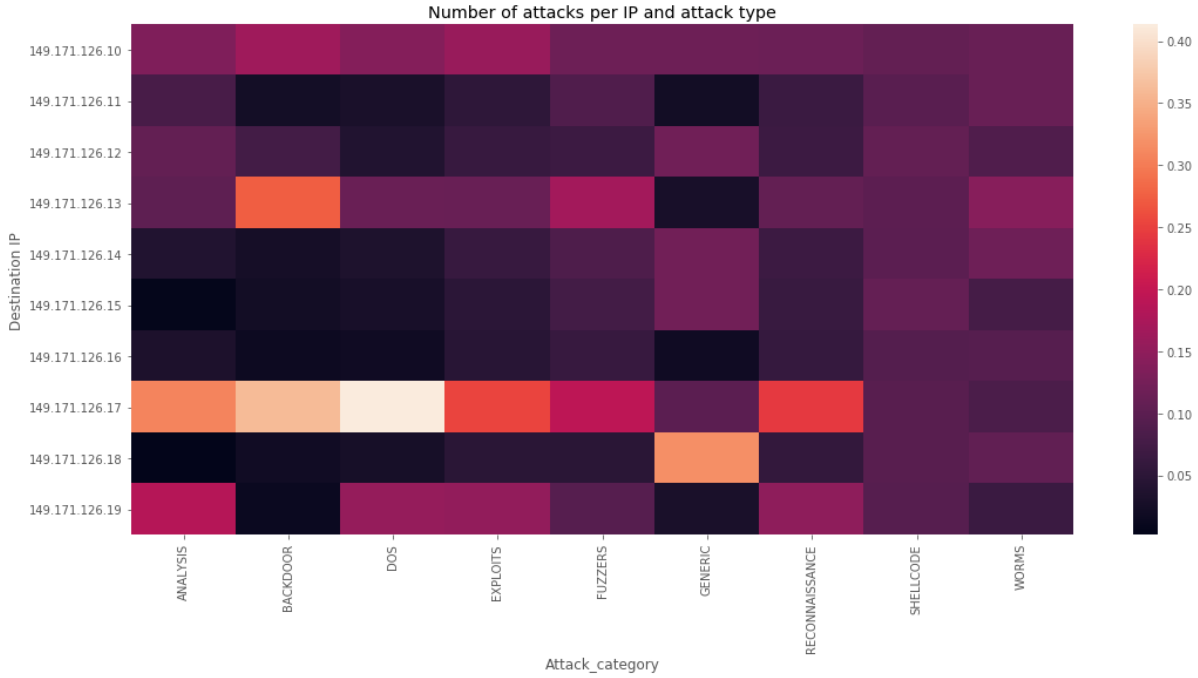
In [69]:
```
heatmap_graph(df = df_p1/df_p1.sum(), xlabel = 'Attack category', ylabel = 'Hour', title = 'Porcentage of attacks per hour per attack type')
```



In [71]:
```
df_p2 = pd.pivot_table(df_pivot, values='AttackName', index=['hour'], columns=['Destination IP'], aggfunc='count')
heatmap_graph(df = df_p2/df_p2.sum(), xlabel = 'Destination IP', ylabel = 'Hour', title = 'Percentage of attacks per IP and hour')
```



In [75]:
```
df_p3 = pd.pivot_table(df_pivot, values='AttackName', index=['Destination IP'
], columns=['Attack_category'], aggfunc='count')
heatmap_graph(df = df_p3/df_p3.sum(), xlabel = 'Attack_category', ylabel = 'De
stination IP', title = 'Number of attacks per IP and attack type')
```



Let's now look at this same relationship per attack category performing a pair-wise $T-test$:

In [77]:
```
for attack in list(newdf['Attack_category'].unique()):
    df_attack = newdf[newdf['Attack_category'] == attack].copy()
    statistic, pvalue = stats.ttest_ind(df_attack['Source Port'], df_attack['D
estination Port'], equal_var=False)
    print('p-value in T-test for ' + attack + ' attack: ' + str(pvalue))
```

```
p-value in T-test for RECONNAISSANCE attack: 0.0
p-value in T-test for EXPLOITS attack: 0.0
p-value in T-test for DOS attack: 0.0
p-value in T-test for GENERIC attack: 0.0
p-value in T-test for SHELLCODE attack: 0.3205085348227197
p-value in T-test for FUZZERS attack: 0.0
p-value in T-test for WORMS attack: 4.246722648635902e-46
p-value in T-test for BACKDOOR attack: 4.8983630604388355e-17
p-value in T-test for ANALYSIS attack: 9.319524862935004e-87
```

As can be seen, the p-values of all but one attack category are very close to 0.0. This means that the attacks have been directed to the specific ports, except for the Shellcode attacks, whose null hypothesis cannot be rejected. For this type of attack there is a defined randomness, which means that the source and destination ports have similar averages.

To verify this statement, we will make use of a contingency table which allows to relate the count of a certain pair of variables, similar to how we saw the .pivot_table()

In [79]:
```
df_crosstab = pd.crosstab(newdf['Attack_category'], newdf['Destination Port'])
df_crosstab
```

Out[79]:

Destination Port	0	10	21	22	23	25	31	42	53	67	...	65455	65460	6547
Attack_category														
ANALYSIS	1442	0	0	0	0	6	0	0	0	0	...	0	0	
BACKDOOR	4000	0	7	0	0	0	7	0	0	0	...	0	0	
DOS	20825	4	75	0	13	425	0	0	154	33	...	0	0	
EXPLOITS	40143	0	2198	14	135	4412	0	21	209	98	...	2	2	
FUZZERS	13355	0	758	0	0	0	0	0	0	0	...	0	0	
GENERIC	2612	0	26	6	0	427	0	0	13438	54	...	0	0	
RECONNAISSANCE	8324	0	0	0	7	7	0	0	41	0	...	0	0	
SHELLCODE	0	0	0	0	0	0	0	0	0	0	...	0	0	
WORMS	0	0	0	0	0	0	0	0	0	0	...	0	0	

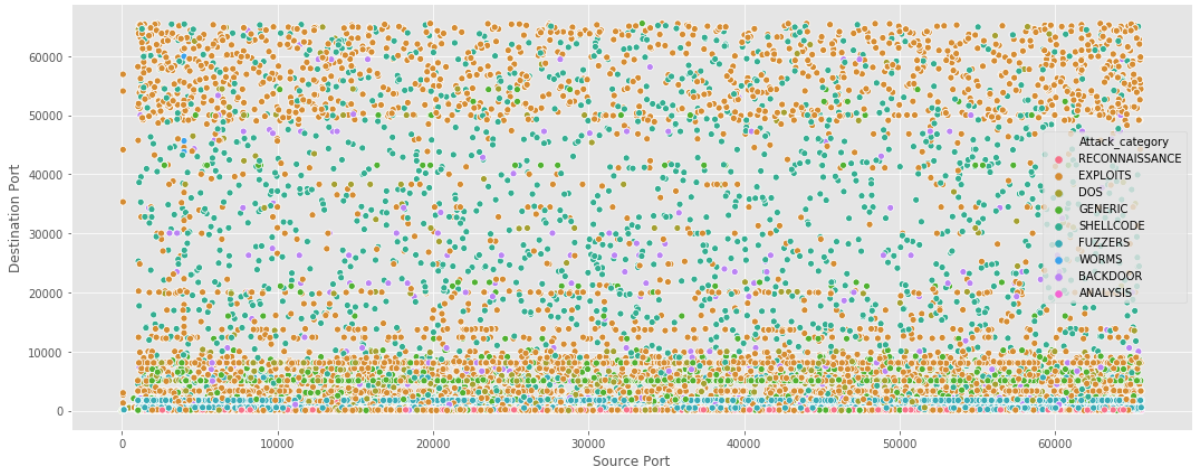
9 rows × 3182 columns

{The attack category is independent of the destination port}

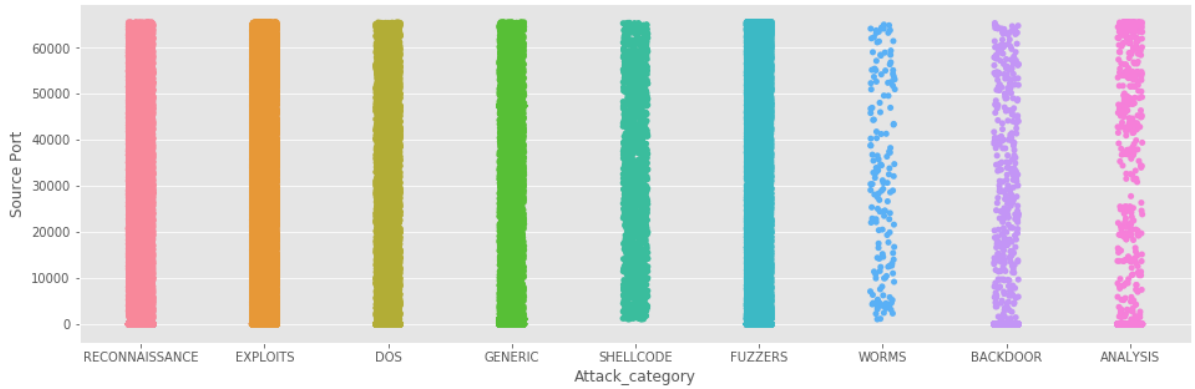
In [80]:
```
chi2, p_value, dof, expected = chi2_contingency(df_crosstab)
print("p-value of Chi-square test for Attack category vs. Destination Port =", p_value)
```

```
p-value of Chi-square test for Attack category vs. Destination Port = 0.0
```

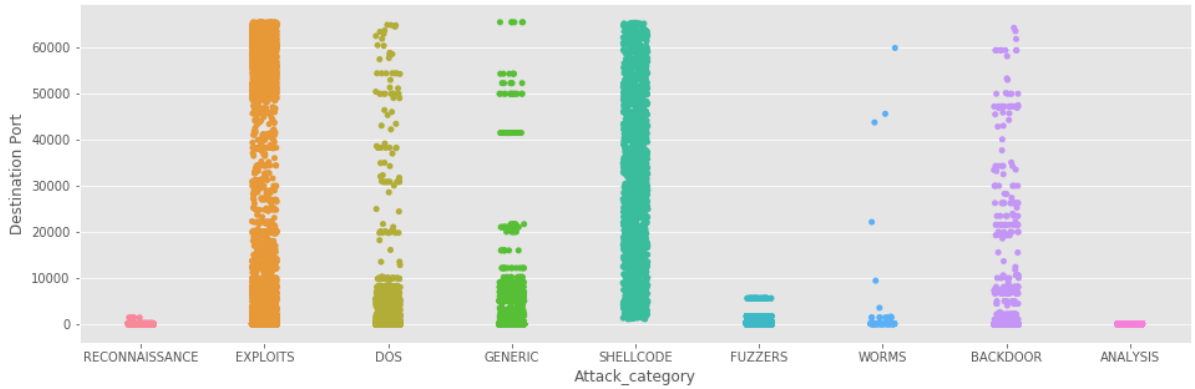
In [82]:
```
plt.figure(figsize=(18,7))
sns.scatterplot(x='Source Port',y='Destination Port', hue='Attack_category',data=newdf)
plt.show()
```



In [83]:
```
# Source ports
plt.figure(figsize=(16,5))
sns.stripplot(x='Attack_category',y='Source Port',data=newdf)
plt.show()
```



In [84]:
```
# Destination ports
plt.figure(figsize=(16,5))
sns.stripplot(x='Attack_category',y='Destination Port',data=newdf)
plt.show()
```

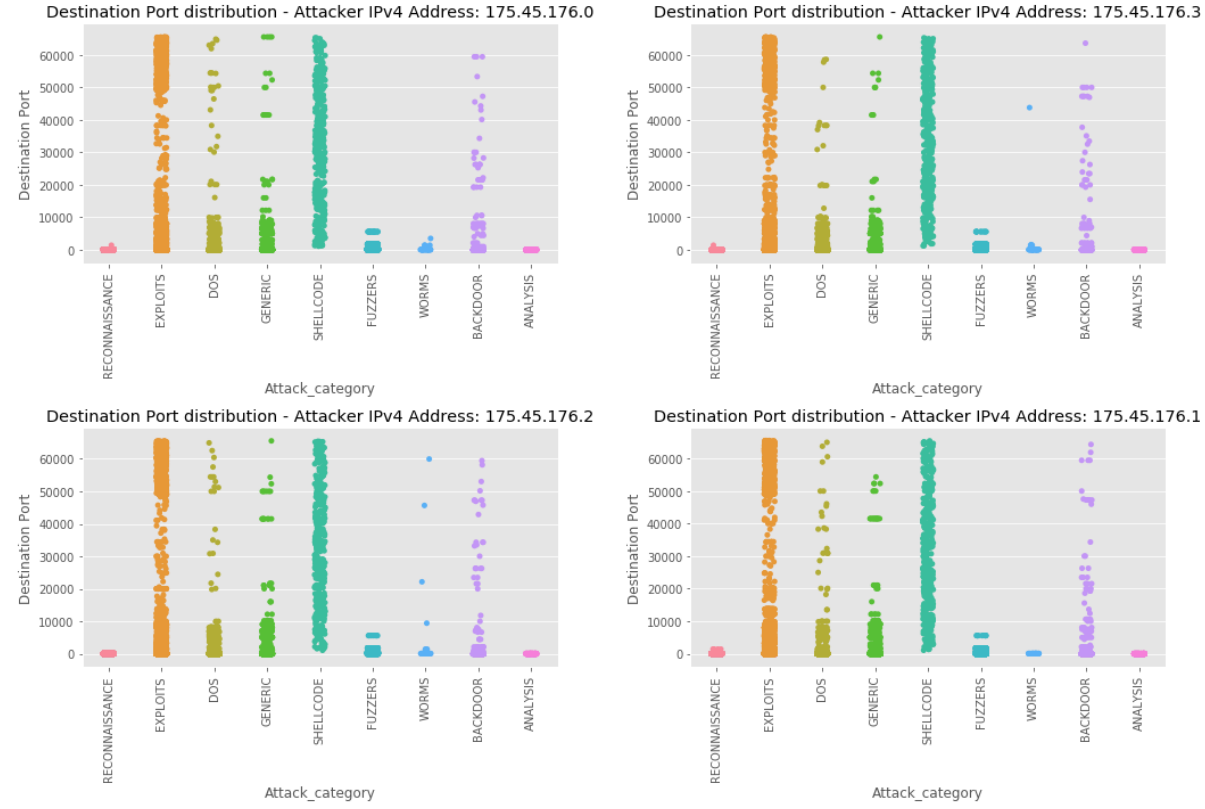


In [85]:
```
list(newdf['Source IP'].unique())
```

Out[85]:
```
['175.45.176.0', '175.45.176.3', '175.45.176.2', '175.45.176.1']
```

view of the distribution of destination ports by attack category and source IP:

In [87]:
```
ips = list(newdf['Source IP'].unique())
f, axes = plt.subplots(2, 2)
f.set_figheight(10)
f.set_figwidth(15)

labels = list(newdf['Attack_category'].unique())
for i, ip in enumerate(ips):
    sns.stripplot(x='Attack_category',y='Destination Port',data=newdf[newdf['S
ource IP'] == ip], order=labels, ax=axes[int(i/2)][i%2])
    axes[int(i/2)][i%2].set_xlabel('Attack_category')
    axes[int(i/2)][i%2].set_ylabel('Destination Port')
    axes[int(i/2)][i%2].set_title('Destination Port distribution - Attacker IP
v4 Address: ' + ip)
    axes[int(i/2)][i%2].set_xticklabels(labels,rotation=90)
plt.tight_layout()
plt.show()
```



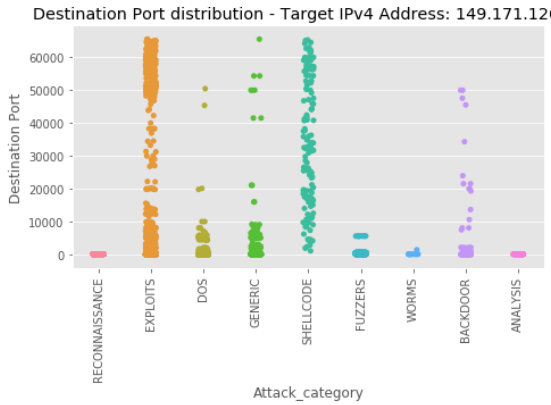
In [ ]:

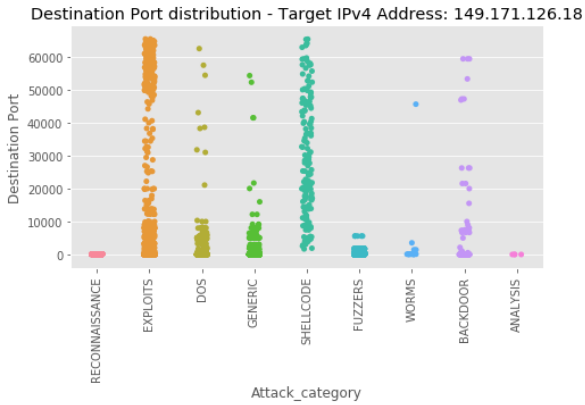
view of the distribution of destination ports by attack category and destination IP:

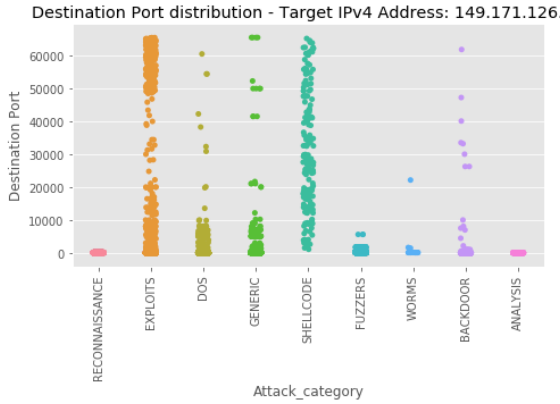
In [88]:
```
list(newdf['Destination IP'].unique())
```

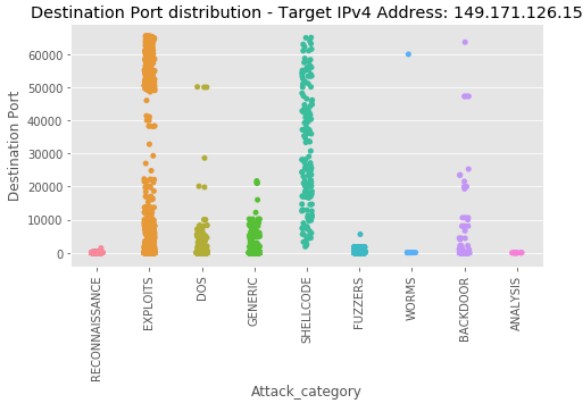
Out[88]:
```
['149.171.126.16',
 '149.171.126.18',
 '149.171.126.10',
 '149.171.126.15',
 '149.171.126.14',
 '149.171.126.12',
 '149.171.126.13',
 '149.171.126.11',
 '149.171.126.17',
 '149.171.126.19']
```

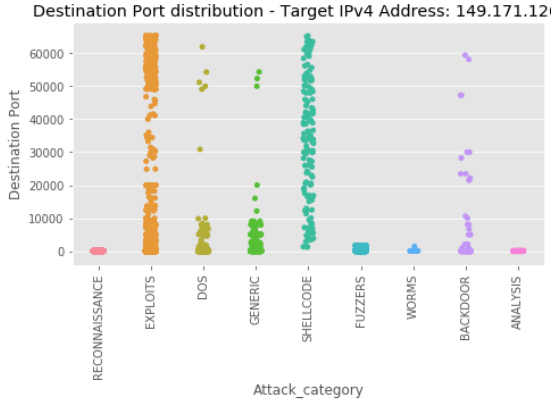
In [89]:
```
ips = list(newdf['Destination IP'].unique())
f, axes = plt.subplots(5, 2)
f.set_figheight(25)
f.set_figwidth(15)

labels = list(newdf['Attack_category'].unique())

for i, ip in enumerate(ips):
    sns.stripplot(x='Attack_category',y='Destination Port',data=newdf[newdf['D
estination IP'] == ip], order=labels, ax=axes[int(i/2)][i%2])
    axes[int(i/2)][i%2].set_xlabel('Attack_category')
    axes[int(i/2)][i%2].set_ylabel('Destination Port')
    axes[int(i/2)][i%2].set_title('Destination Port distribution - Target IPv4
Address: ' + ip)
    axes[int(i/2)][i%2].set_xticklabels(labels,rotation=90)
plt.tight_layout()
plt.show()
```

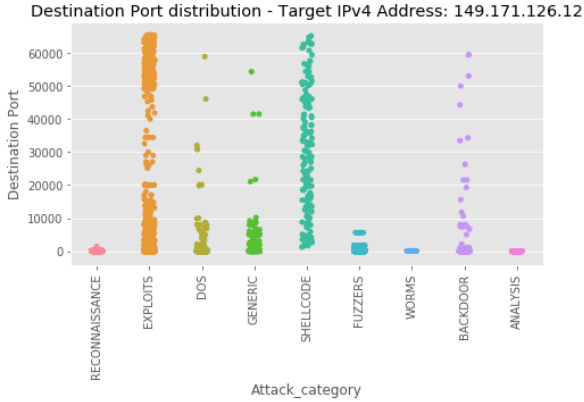

Destination Port distribution - Target IPv4 Address: 149.171.126.16
Destination Port
Attack_category
RECONNAISSANCE
EXPLOITS
DOS
GENERIC
SHELLCODE
FUZZERS
WORMS
BACKDOOR
ANALYSIS

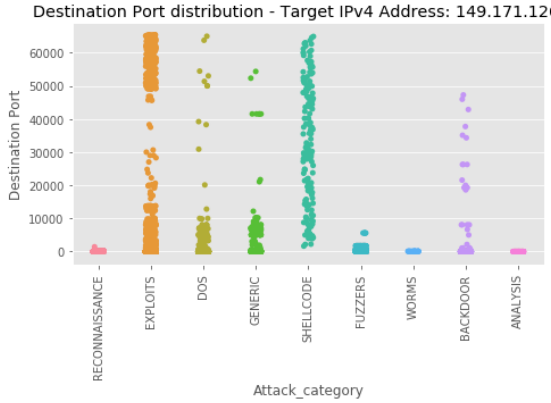

Destination Port distribution - Target IPv4 Address: 149.171.126.18
Destination Port
Attack_category
RECONNAISSANCE
EXPLOITS
DOS
GENERIC
SHELLCODE
FUZZERS
WORMS
BACKDOOR
ANALYSIS

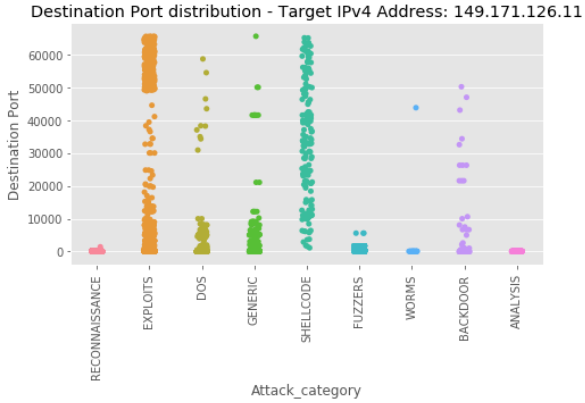

Destination Port distribution - Target IPv4 Address: 149.171.126.10
Destination Port
Attack_category
RECONNAISSANCE
EXPLOITS
DOS
GENERIC
SHELLCODE
FUZZERS
WORMS
BACKDOOR
ANALYSIS

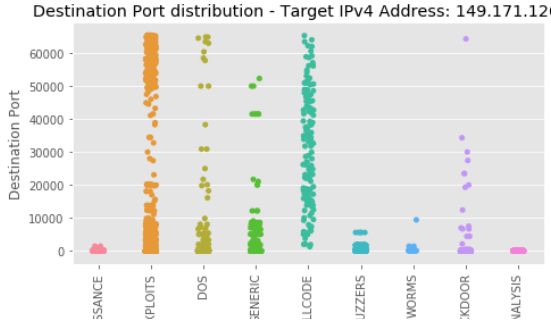

Destination Port distribution - Target IPv4 Address: 149.171.126.15
Destination Port
Attack_category
RECONNAISSANCE
EXPLOITS
DOS
GENERIC
SHELLCODE
FUZZERS
WORMS
BACKDOOR
ANALYSIS

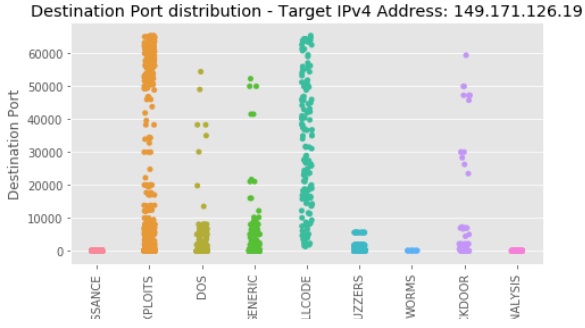

Destination Port distribution - Target IPv4 Address: 149.171.126.14
Destination Port
Attack_category
RECONNAISSANCE
EXPLOITS
DOS
GENERIC
SHELLCODE
FUZZERS
WORMS
BACKDOOR
ANALYSIS


Destination Port distribution - Target IPv4 Address: 149.171.126.12
Destination Port
Attack_category
RECONNAISSANCE
EXPLOITS
DOS
GENERIC
SHELLCODE
FUZZERS
WORMS
BACKDOOR
ANALYSIS


Destination Port distribution - Target IPv4 Address: 149.171.126.13
Destination Port
Attack_category
RECONNAISSANCE
EXPLOITS
DOS
GENERIC
SHELLCODE
FUZZERS
WORMS
BACKDOOR
ANALYSIS


Destination Port distribution - Target IPv4 Address: 149.171.126.11
Destination Port
Attack_category
RECONNAISSANCE
EXPLOITS
DOS
GENERIC
SHELLCODE
FUZZERS
WORMS
BACKDOOR
ANALYSIS


Destination Port distribution - Target IPv4 Address: 149.171.126.17
Destination Port
Attack_category


Destination Port distribution - Target IPv4 Address: 149.171.126.19
Destination Port
Attack_category

In [ ]:

In [ ]:

In [ ]: