Appendix 1. Jupyter notebook, python code

November 9, 2017

This is converted to PDF for sake of readability, the code itself can be found on the following github repository: https://github.com/tvanbiemen/EconOfCs

```
In [16]: #Basic packages
         import pandas as pd
         import numpy as np
         import matplotlib.pyplot as plt
         from scipy import stats
         from matplotlib_venn import venn3, venn3_circles
```

```
In [17]: #Extra packages
         import random
         import socket
         import struct
```

```
In [18]: #Dataset 1, this takes some time to load
         #The website is sometimes down..... http://downforeveryoneorjustme.com/cyb
         cybercrime = pd.read_html('http://cybercrime-tracker.net/index.php?s=0&m=4
         cybercrime = cybercrime[0] #We want the first table that is found
         cybercrime.head()
```

```
Out[18]:       -::DATE                                           -::URL  \
         0  08-11-2017               mfmqatar.com/deux/windsor/admin.php
         1  08-11-2017                            191.101.245.31/panel/
         2  08-11-2017  tapkinoski.gdn.cp-tr-1.webhostbox.net/index.php
         3  08-11-2017   finexp.us/hk/hs/HSB/config.php?account=taliban
         4  08-11-2017                     brainboom.000webhostapp.com/

                     -::IP   -::TYPE  Unnamed: 4
         0   198.38.82.246      Pony         NaN
         1             NaN   AZORult         NaN
         2    5.100.156.10     TVRAT         NaN
         3    5.206.224.14  Formbook         NaN
         4  145.14.145.219   Betabot         NaN
```

```
In [19]: #Dataset 2
         Zeus = pd.read_html('https://zeustracker.abuse.ch/monitor.php?filter=all',
         Zeus = Zeus[1] # we need the second table that is found
         Zeus.head()
```

```
Out[19]:     Dateadded  Malware                         Host      IP address  Level
         0  2017-11-07  Citadel            slap.alliancekl.com             NaN      4
         1  2017-11-06   VMZeuS  bestframingnailerreview.com  104.243.42.202      2
         2  2017-10-23  Citadel       flex.comonwealthplc.com   37.49.225.131      4
         3  2017-10-22   VMZeuS             kjkdndskjl.info             NaN      4
         4  2017-10-21  Citadel                 193.0.178.27    193.0.178.27      4

             Status Files Online          SBL Country AS number     Uptime
         0  offline            0   Not listed       -       NaN   50:10:43
         1   online            0   Not listed     NaN   AS20473   74:01:57
         2   online            0    SBL374926     NaN   AS50673  408:04:02
         3  offline            0   Not listed       -       NaN  123:58:31
         4  unknown            0   Not listed     NaN   AS57062          -
```

```
In [20]: #Dataset 3, requires a bit more cleaning
         Ransomware = pd.read_csv('https://ransomwaretracker.abuse.ch/feeds/csv/',
         iplistsplt =  Ransomware['IP address(es)'].astype(str).str.split('|')
         Ransomware['IP address(es)'] = [item[0] for item in iplistsplt]
         countrytsplt =  Ransomware['Country'].astype(str).str.split('|')
         Ransomware['Country'] = [item[0] for item in countrytsplt]
         Ransomware = Ransomware.iloc[:-1,:]
         Ransomware.tail()
```

```
Out[20]:          # Firstseen (UTC) Threat     Malware             Host  \
         13717  2015-04-15 14:00:53     C2  CryptoWall    marcortes.com
         13718  2015-03-07 13:46:58     C2  CryptoWall  drdigitalmd.com
         13719  2015-03-04 12:10:59     C2  CryptoWall    rajsima87.com
         13720  2015-03-02 04:14:59     C2  CryptoWall     jauregia.net
         13721  2015-03-02 01:18:48     C2  CryptoWall     lzclient.com

                                          URL   Status  \
         13717    http://marcortes.com/img5.php  offline
         13718  http://drdigitalmd.com/img1.php  offline
         13719    http://rajsima87.com/img2.php  offline
         13720     http://jauregia.net/img5.php  offline
         13721     http://lzclient.com/img4.php  offline

                                         Registrar   IP address(es)  ASN(s)  \
         13717                                    OVH   91.134.158.216   16276
         13718  PDR LTD. D/B/A PUBLICDOMAINREGISTRY.COM  192.210.234.140   36352
         13719                              eNom, Inc.              nan     NaN
         13720      TECNOCRATICA CENTRO DE DATOS, S.L.   185.92.246.115  201446
         13721                              eNom, Inc.              nan     NaN

               Country
         13717      FR
         13718      US
         13719     nan
```

```
13720      ES
13721     nan
```

In [21]:
```
#Create a list of random IP adresses for comparison
Random_Ips = []
n = 15000
for i in range (0,n):
    Random_Ips.append(socket.inet_ntoa(struct.pack('>I', random.randint(1,
    print(' Drawing IP no:' + str(i), end='\r')
print("Drew " +str(n)+ " random IP adresses")
Random_Ips = pd.DataFrame({'ip':Random_Ips})
```

```
Drew 15000 random IP adresses
```

In [22]:
```
#Print out the ten most commons IP adresses in the datasets
cybercrime['-::IP'].value_counts()[0:10], Zeus['IP address'].value_counts
```

Out[22]:
```
(62.109.9.188       83
 198.105.221.5      71
 174.127.78.72      66
 108.162.199.107    58
 198.176.28.49      45
 66.45.253.74       33
 172.93.106.18      33
 108.170.51.58      31
 108.61.47.186      31
 198.1.80.203       31
 Name: -::IP, dtype: int64, 104.238.158.106    17
 FastFlux Botnet    14
 141.8.226.58        9
 198.54.117.212      3
 5.9.107.19          3
 144.76.115.36       3
 66.45.245.150       2
 80.78.250.26        2
 186.250.244.100     2
 195.20.44.100       1
 Name: IP address, dtype: int64, 184.105.192.2     242
 127.0.0.1         239
 213.205.40.169    170
 195.157.15.100     84
 204.11.56.48       71
 80.150.6.138       65
 95.211.144.65      47
 112.140.42.29      47
 52.71.185.125      46
 208.100.26.234     38
 Name: IP address(es), dtype: int64)
```

```
In [23]: #Print out the ten most commons hosts in the datasets
         Zeus['Host'].value_counts()[1:10],Ransomware['Host'].value_counts()[0:10]
```

```
Out[23]: (lisovfoxcom.418.com1.ru    1
          prtscrinsertcn.net         1
          120.63.157.195             1
          atmape.ru                  1
          gyodundena.hotmail.ru      1
          trust-s-b.com              1
          dl.dropbox.com             1
          nicktung.com               1
          noonepa.tk                 1
          Name: Host, dtype: int64, bolizarsospos.com          84
          mafianeedsyouqq.com        22
          gutentagmeinliebeqq.com    21
          itsyourtimeqq.su           21
          goonwithmazerqq.com        19
          helloyoungmanqq.com        18
          facerecognition.com.ba     13
          lenovowantsyouqq.com       12
          invoiceholderqq.com        11
          thisisyourchangeqq.com     11
          Name: Host, dtype: int64)
```

```
In [24]: #Print out the ten most commons hosts in the datasets
         Zeus['Country'].value_counts()[0:10],Ransomware['Country'].value_counts()
```

```
Out[24]: (-    284
          Name: Country, dtype: int64, nan    4462
          US     3253
          DE      634
          RU      547
          NL      412
          IT      404
          GB      353
          FR      273
          CN      225
          PL      225
          Name: Country, dtype: int64)
```

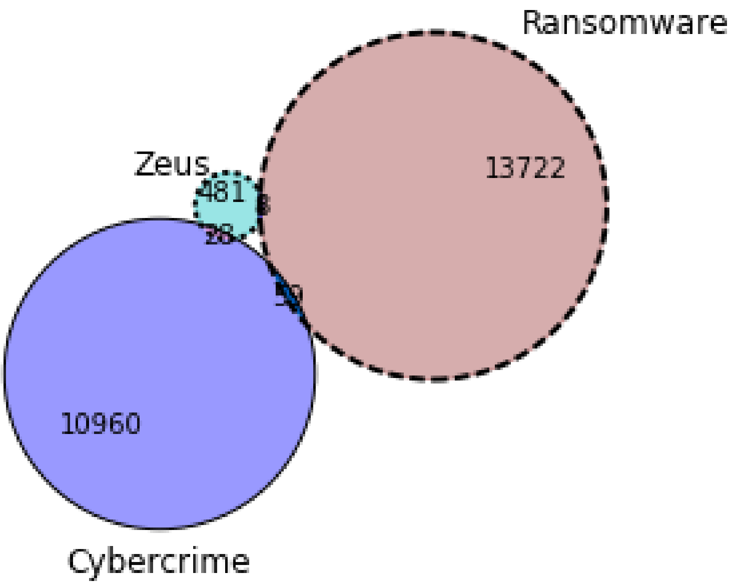
```
In [25]: #Print out the ten most common malware types in each dataset
         cybercrime['-::TYPE'].value_counts()[0:10], Zeus['Malware'].value_counts()
```

```
Out[25]: (Pony          2698
          ZeuS          2325
          Citadel       1175
          Blackhole      850
          WSO            400
          IceIX          299
```

```
 Stealer       255
 Mailer        193
 Betabot       182
 Solar         178
 Name: -::TYPE, dtype: int64, ZeuS       192
 Citadel    163
 VMZeuS      69
 KINS        46
 Ice IX      10
 Name: Malware, dtype: int64, Locky            11303
 Cerber            1573
 TeslaCrypt         477
 CryptoWall         203
 TorrentLocker      120
 PayCrypt            21
 Sage                 9
 CTB-Locker           6
 PadCrypt             4
 FAKBEN               3
 Name: Malware, dtype: int64)
```

```
In [37]: #Venn plot

         a = Zeus['IP address']
         b = Ransomware['IP address(es)']
         c = cybercrime['-::IP']

         s = (
             len(a),    # Abc
             len(b),    # aBc
             len(set.intersection(set(a), set(b))),    # ABc
             len(c),    # abC
             len(set.intersection(set(a), set(c))),    # AbC
             len(set.intersection(set(b), set(c))),  # aBC
             len(set.intersection(set(a), set(b), set(c))),   # ABC
         )
         v = venn3(subsets=s, set_labels=('Zeus', 'Ransomware', 'Cybercrime'))

         # Subset labels
         v.get_label_by_id('100').set_text(str(len(a)))
         v.get_label_by_id('010').set_text(str(len(b)))
         v.get_label_by_id('110').set_text(str(len(set.intersection(set(a), set(b))
         v.get_label_by_id('001').set_text(str(len(c)))
         v.get_label_by_id('101').set_text(str(len(set.intersection(set(a), set(c))
         v.get_label_by_id('011').set_text(str(len(set.intersection(set(b), set(c))
         #v.get_label_by_id('111').set_text(str(len(set.intersection(set(a), set(b

         # Subset colors
```

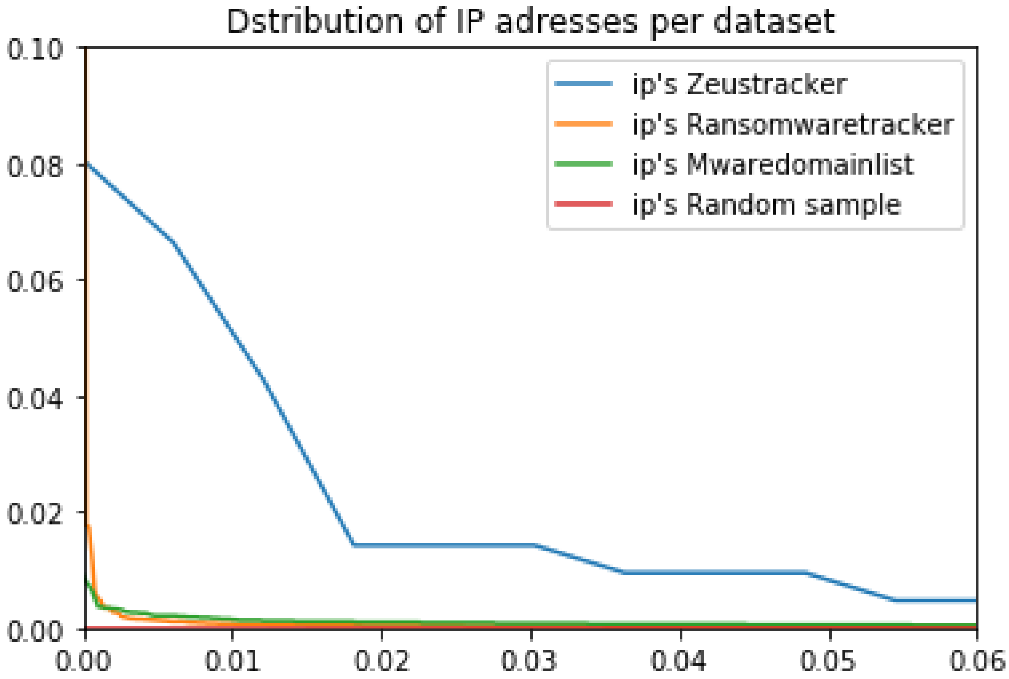
```
        v.get_patch_by_id('100').set_color('c')
        v.get_patch_by_id('010').set_color('#993333')
        v.get_patch_by_id('110').set_color('blue')

        # Subset alphas
        v.get_patch_by_id('101').set_alpha(0.4)
        v.get_patch_by_id('011').set_alpha(1.0)
        #v.get_patch_by_id('111').set_alpha(0.7)

        # Border styles
        c = venn3_circles(subsets=s, linestyle='solid')
        c[0].set_ls('dotted')  # Line style
        c[1].set_ls('dashed')
        c[2].set_lw(1.0)       # Line width
        plt.figure(figsize=(15,15))
        plt.show()
```



```
<matplotlib.figure.Figure at 0xec88290>
```

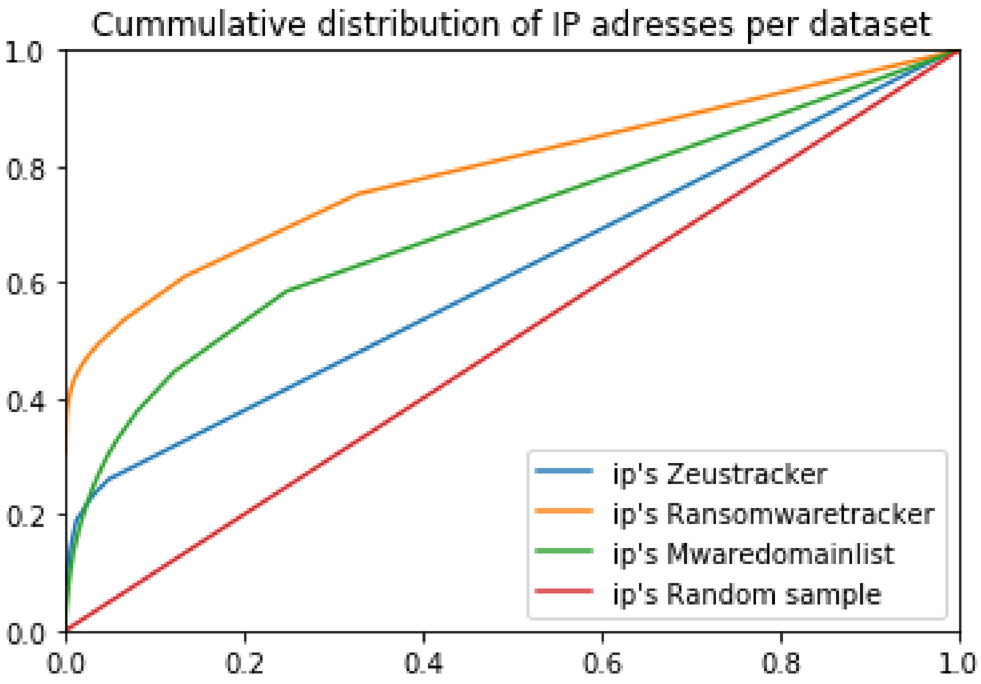
```
In [38]: def fracx(a):
             #Creates x values for plotting cumulative fractions
             a = np.array(list(range(0,len(a))))/len(a)
             return a

In [39]: a = Zeus['IP address'].value_counts(normalize=True)
         b = Ransomware['IP address(es)'].value_counts(normalize=True)
```

```
c = cybercrime['-::IP'].value_counts(normalize=True)
d = Random_Ips['ip'].value_counts(normalize=True)

ax = plt.subplot()

plt.plot(fracx(a),a, label="ip's Zeustracker")
plt.plot(fracx(b),b, label="ip's Ransomwaretracker")
plt.plot(fracx(c),c, label="ip's Mwaredomainlist")
plt.plot(fracx(d),d, label="ip's Random sample")

ax.set_xlim(0,0.06)
ax.set_ylim(0,0.1)
plt.title('Dstribution of IP adresses per dataset')

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

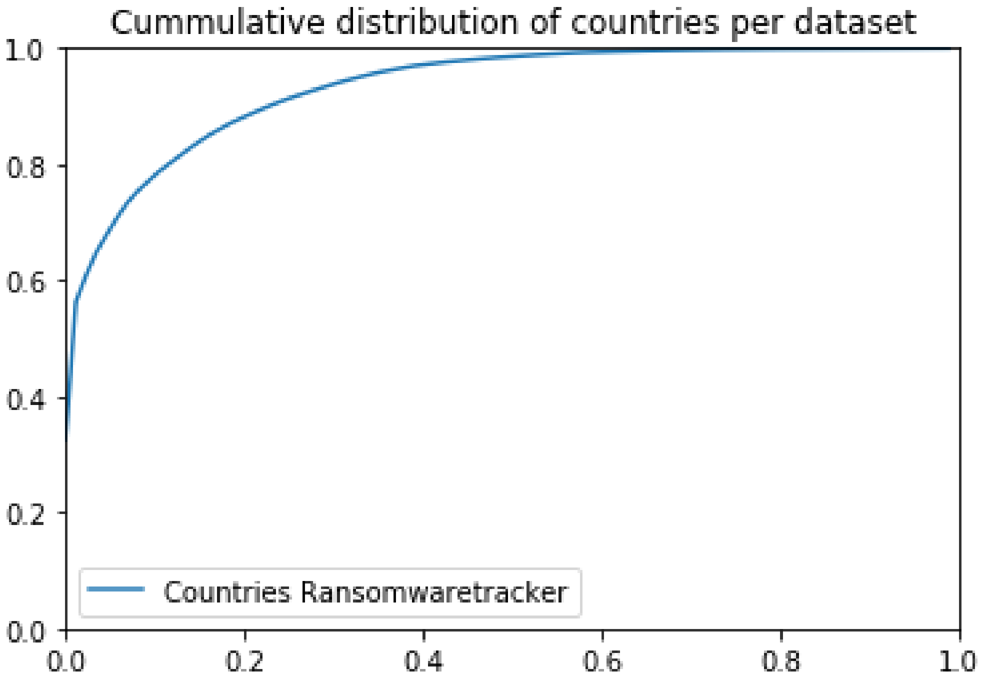


```
In [40]: a = Zeus['IP address'].value_counts(normalize=True).cumsum()
         b = Ransomware['IP address(es)'].value_counts(normalize=True).cumsum()
         c = cybercrime['-::IP'].value_counts(normalize=True).cumsum()
         d = Random_Ips['ip'].value_counts(normalize=True).cumsum()

         ax = plt.subplot()

         plt.plot(fracx(a),a, label="ip's Zeustracker")
```

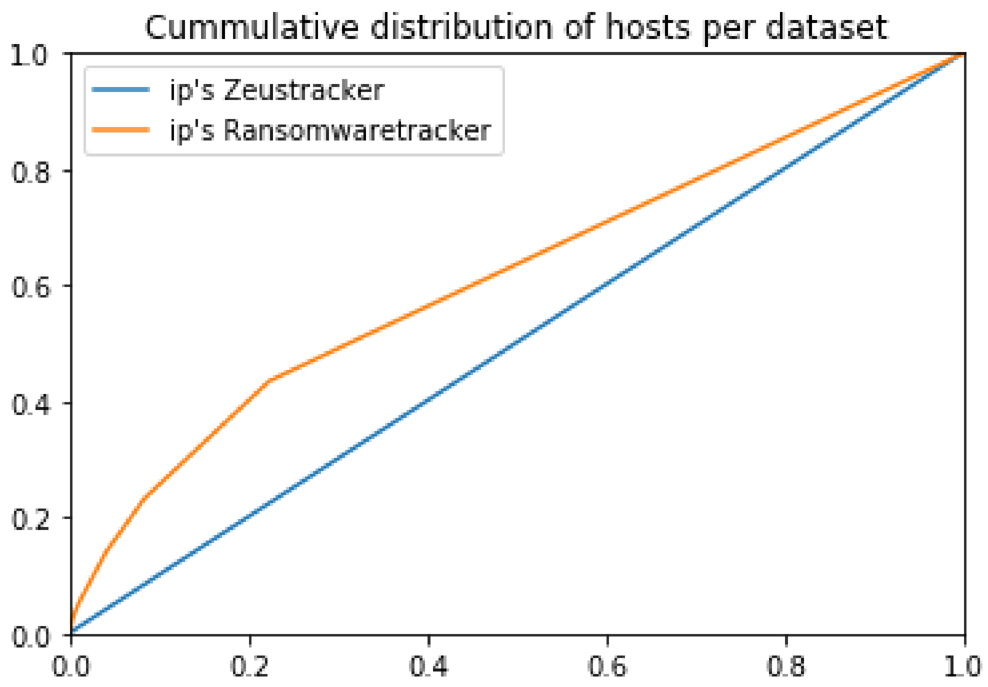
```
        plt.plot(fracx(b),b, label="ip's Ransomwaretracker")
        plt.plot(fracx(c),c, label="ip's Mwaredomainlist")
        plt.plot(fracx(d),d, label="ip's Random sample")

        ax.set_xlim(0,1)
        ax.set_ylim(0,1)
        plt.title('Cummulative distribution of IP adresses per dataset')

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



```
In [41]: # Plot the cumulative distribution of countries
         b = Ransomware['Country'].value_counts(normalize=True)
         ax = plt.subplot()


         plt.plot(fracx(b),b.cumsum(), label="Countries Ransomwaretracker")
         plt.title('Cummulative distribution of countries per dataset')

         ax.set_xlim(0,1)
         ax.set_ylim(0,1)

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



```
In [42]: a = Zeus['Host'].value_counts(normalize=True).cumsum()
         b = Ransomware['Host'].value_counts(normalize=True, dropna=False).cumsum()


         ax = plt.subplot()

         plt.plot(fracx(a),a, label="ip's Zeustracker")
         plt.plot(fracx(b),b, label="ip's Ransomwaretracker")


         ax.set_xlim(0,1)
         ax.set_ylim(0,1)
         plt.title('Cummulative distribution of hosts per dataset')

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



```
In [43]: # This function prints out the outcomes of our statistics test
         def ks_samp(a,b):
             print(stats.ks_2samp(a,b))

In [44]: a = Zeus['IP address'].value_counts(normalize=True).cumsum()
         b = Ransomware['IP address(es)'].value_counts(normalize=True).cumsum()
         c = cybercrime['-::IP'].value_counts(normalize=True).cumsum()
         d = Random_Ips['ip'].value_counts(normalize=True).cumsum()

In [45]: # Perform the statistical tests
         ks_samp(a,b) #Accept 0 hyp (from same dist.) if p>0.05
         ks_samp(b,c) #Accept 0 hyp (from same dist.) if p>0.05
         ks_samp(a,c) #Accept 0 hyp (from same dist.) if p>0.05
         ks_samp(a,d) #Accept 0 hyp (from same dist.) if p>0.05
         ks_samp(b,d) #Accept 0 hyp (from same dist.) if p>0.05
         ks_samp(c,d) #Accept 0 hyp (from same dist.) if p>0.05
```

```
Ks_2sampResult(statistic=0.36752090639330998, pvalue=1.4830729305974341e-19)
Ks_2sampResult(statistic=0.22438511318167625, pvalue=1.4387054376873975e-110)
Ks_2sampResult(statistic=0.22104204385435527, pvalue=2.4255996810306513e-07)
Ks_2sampResult(statistic=0.21211515151515151, pvalue=6.221236023578169e-07)
Ks_2sampResult(statistic=0.47685143422354104, pvalue=0.0)
Ks_2sampResult(statistic=0.33757304365318852, pvalue=0.0)
```

```
In [46]: #Calcuate the % up per country metric
         a = Ransomware[Ransomware['Status'] == 'offline'].Country.value_counts()
         b = Ransomware[Ransomware['Status'] == 'online'].Country.value_counts()
         (b/(a+b)).dropna().sort_values(ascending=False)[0:10]
```

```
Out[46]: BE    0.285714
         FI    0.250000
         GB    0.246459
         IL    0.166667
         IR    0.105263
         SK    0.090909
         AR    0.086957
         KR    0.083333
         TH    0.080882
         ID    0.072917
         Name: Country, dtype: float64
```

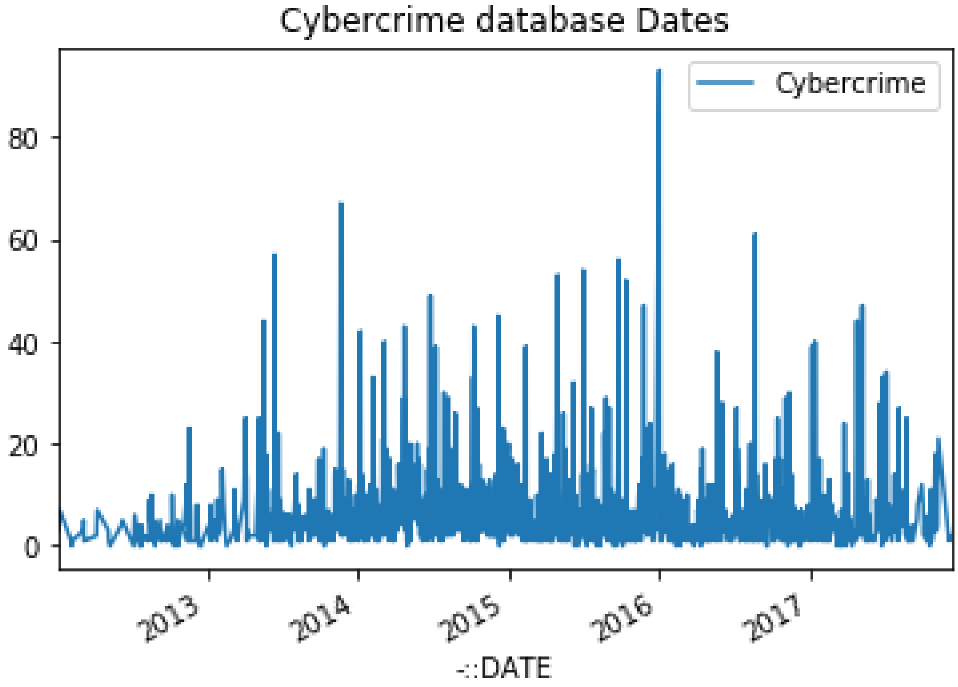
```
In [47]: #Calculate the % up per host metric
         a = Ransomware[Ransomware['Status'] == 'offline'].Host.value_counts()
         b = Ransomware[Ransomware['Status'] == 'online'].Host.value_counts()
         #c = a + b
         (b/(a+b)).dropna().sort_values(ascending=False)[0:10]
```

```
Out[47]: bolizarsospos.com                      0.964286
         wt7dzbn78.homepage.t-online.de         0.666667
         galeona.com                            0.666667
         greatgoods2.bravepages.com             0.666667
         www.resumebuddy.net                    0.500000
         3e.com.pt                              0.500000
         bptpm.sragenkab.go.id                  0.500000
         demo.evgesha.ru                        0.500000
         flax-fiber.com                         0.500000
         hjhqmbxyinislkkt.15u3kg.top            0.500000
         Name: Host, dtype: float64
```

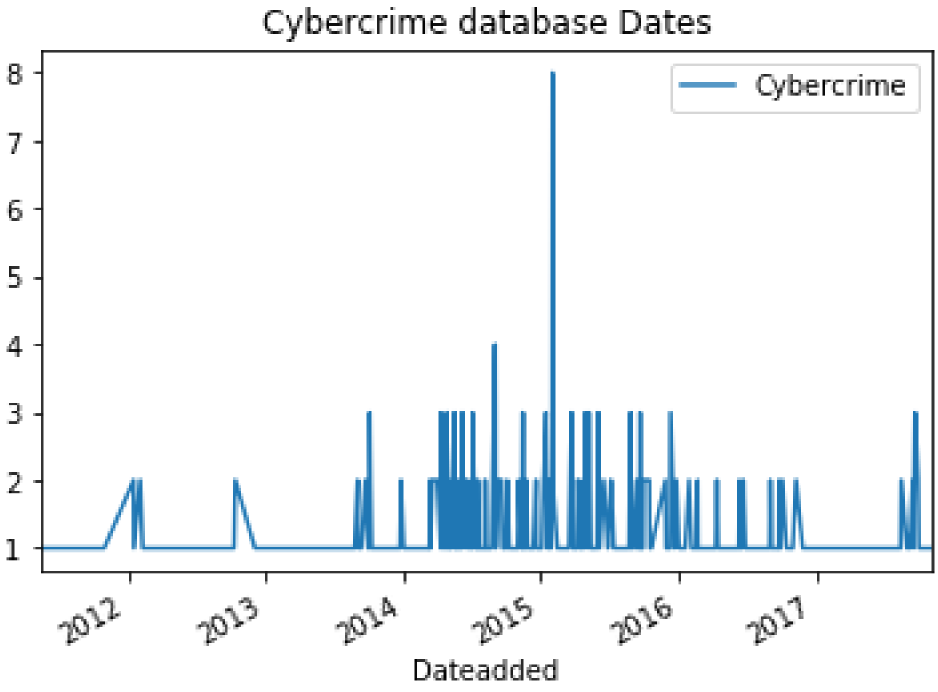
```
In [48]: # Prepare the kruskal test to see if number of ransomware per country is
         b = pd.DataFrame(Ransomware['Country'].value_counts())
         needed = ['US','DE','RU','NL','CH','CN','CA','IN','BR','TH']
         lista = b[b.index.isin(needed)].Country
         listb = [36,27,17,15,10,6,5,5,5,5]
         stats.kruskal(lista,listb) # p<0.5, so not simmilar
```

```
Out[48]: KruskalResult(statistic=14.393939393939387, pvalue=0.00014827877260963348
```

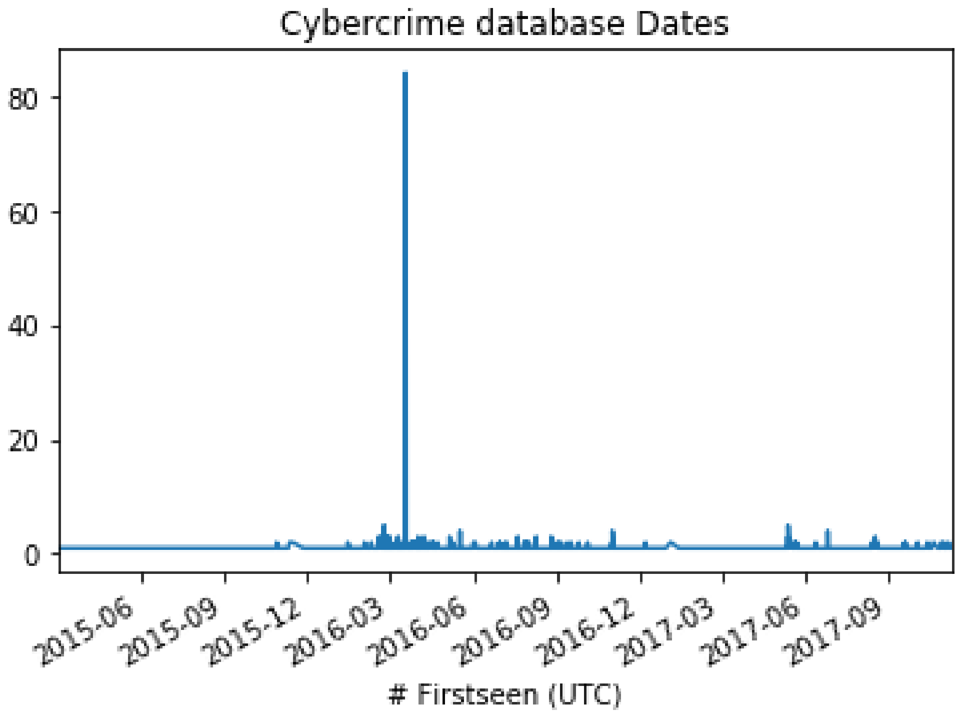
```
In [49]: #Make dates plotable
         cybercrime['-::DATE'] = pd.to_datetime(cybercrime['-::DATE'])
         Zeus['Dateadded'] = pd.to_datetime(Zeus['Dateadded'])
         Ransomware["# Firstseen (UTC)"] = pd.to_datetime(Ransomware["# Firstseen
In [50]: #Plot entries per date for Cybercrime
         cybercrime.groupby('-::DATE').count().iloc[1:,1].plot(label='Cybercrime',
         plt.legend()
         plt.show()
```



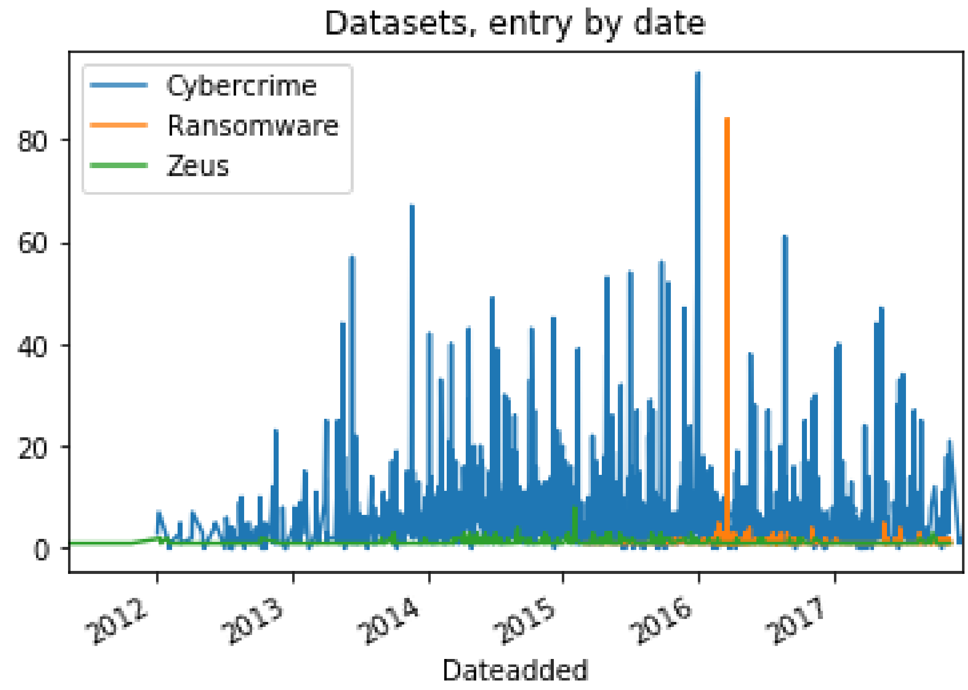
```
In [51]: #Plot entries per date for Zeus
         Zeus.groupby('Dateadded').count()['Status'].plot(label='Cybercrime', title
         plt.legend()
         plt.show()
```



```
In [52]: #Plot entries per date for Ransomware
         Ransomware.groupby("# Firstseen (UTC)").count().Status.plot(label='Cybercr
         plt.show()
```



```
In [53]: #Plot for all
         cybercrime.groupby('-::DATE').count().iloc[1:,1].plot(label='Cybercrime')
         Ransomware.groupby("# Firstseen (UTC)").count().Status.plot(label='Ransomw
         Zeus.groupby('Dateadded').count()['Status'].plot(label='Zeus', title='Data

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



```
In [ ]:
```