exploration1

February 21, 2017

1 UCN Study Data Explorations

In [2]:
```
import numpy as np
import scipy as sci
import pandas as pd

import numpy as np
import seaborn as sns
import matplotlib.pyplot as plt
%matplotlib inline

from bokeh.plotting import figure, show, output_notebook
from bokeh.charts import *

from collections import defaultdict
from datetime import datetime, timedelta

from model.Base import Base
from model.User import User
from model.Device import Device
from model.DeviceTraffic import DeviceTraffic
from model.DeviceAppTraffic import DeviceAppTraffic
from model.HttpReq import HttpReq
from model.DnsReq import DnsReq
from model.Location import Location
from model.user_devices import user_devices;

from sqlalchemy import create_engine, text, func
from sqlalchemy.orm import sessionmaker
from sqlalchemy.pool import NullPool

import datautils

from IPython.display import display

output_notebook()
```

```
DB='postgresql+psycopg2:///ucnstudy'

engine = create_engine(DB, echo=False, poolclass=NullPool)
Base.metadata.bind = engine
Session = sessionmaker(bind=engine)
```

```
---------------------------------------------------------------------------

ImportError                               Traceback (most recent call last)

<ipython-input-2-705c7f2d9bf2> in <module>()
----> 1 import numpy as np
      2 import scipy as sci
      3 import pandas as pd
      4
      5 import numpy as np


ImportError: No module named numpy
```

In [1]:
```
# Traffic distribution
ses = Session()

totalbytes = ses.query(func.sum(DeviceAppTraffic.bytes_in)).scalar() + ses.query(func.su
totalpkts = ses.query(func.sum(DeviceAppTraffic.packets_in)).scalar() + ses.query(func.s

q = ses.query(DeviceAppTraffic.dstport,
              DeviceAppTraffic.service,
              func.sum(DeviceAppTraffic.bytes_in),
              func.sum(DeviceAppTraffic.bytes_out),
              func.sum(DeviceAppTraffic.packets_in),
              func.sum(DeviceAppTraffic.packets_out)).group_by(
                DeviceAppTraffic.dstport,
                DeviceAppTraffic.service).order_by(DeviceAppTraffic.dstport)

traffic = defaultdict(list)
for row in q.all():
    if (row[4]+row[5]<=10):
        continue

    traffic['port'].append(row[0])
    traffic['service'].append(str(row[1]))
    traffic['bytes_in'].append(row[2])
    traffic['bytes_out'].append(row[3])
    traffic['pkts_in'].append(row[4])
    traffic['pkts_out'].append(row[5])
```

```
            traffic['bytes'].append(row[2]+row[3])
            traffic['pkts'].append(row[4]+row[5])
            traffic['bytes (%)'].append((row[2]+row[3])*100.0/totalbytes)
            traffic['pkts (%)'].append((row[4]+row[5])*100.0/totalpkts)

        ses.close()

        tdf = pd.DataFrame(traffic)
        tdf = tdf.sort_values('bytes', ascending=False)
        display(tdf.loc[:100,])


        ---------------------------------------------------------------------------

        NameError                                 Traceback (most recent call last)

        <ipython-input-1-df19a26abd04> in <module>()
          1 # Traffic distribution
    ----> 2 ses = Session()
          3
          4 totalbytes = ses.query(func.sum(DeviceAppTraffic.bytes_in)).scalar() + ses.query(fun
          5 totalpkts = ses.query(func.sum(DeviceAppTraffic.packets_in)).scalar() + ses.query(fu


        NameError: name 'Session' is not defined


In [94]: # TODO: need to reimport the data!!

         # User Agents
         ses = Session()

         q = ses.query(HttpReq.req_ua,func.count(HttpReq.id)).group_by(HttpReq.req_ua)

         ua = defaultdict(list)
         for row in q.all():
             ua['ua'].append(str(row[0]))
             ua['reqs'].append(row[1])

         ses.close()

         uadf = pd.DataFrame(ua)
         uadf = uadf.sort_values('reqs', ascending=False)
         display(uadf)

       reqs    ua
0   1677594  None
```

In [ ]:
```
# DNS vs HTTP

ses = Session()

# dnsreq -> delay to the first matching http req (or -1 if not found)
dnstofirsthttp = {}
for d in ses.query(Device).all():

    dnsreqs = ses.query(DnsReq.id, DnsReq.ts, DnsReq.query, DnsReq.ans_ttl).filter(
        DnsReq.devid==d.id).order_by(DnsReq.query, DnsReq.ts).all()
    total = len(dnsreqs)

    httpreqs = ses.query(HttpReq.ts, HttpReq.req_url_host).filter(
        HttpReq.devid==d.id).order_by(HttpReq.req_url_host, HttpReq.ts).all()

    print 'processing',str(d),total,'dns requests',len(httpreqs),'http reqs'
    if (total == 0):
        continue

    countmatch = 0
    for (reqid,ts,domain,ttls) in dnsreqs:
        dnstofirsthttp[reqid] = -1

        # rewind to the matching domain in the sorted http reqs
        while (len(httpreqs) > 0 and httpreqs[0][1] < domain):
            httpreqs.pop(0)

        # find the matching http req
        if (len(httpreqs)>0 and httpreqs[0][1] == domain):
            # rewind to the next possible http req
            while (len(httpreqs)>0 and httpreqs[0][0]<ts):
                httpreqs.pop(0)

            if (len(httpreqs)>0):
                delay = (httpreqs[0][0] - ts).total_seconds()
                if (ttls==None or len(ttls)==0 or delay<=ttls[0]):
                    dnstofirsthttp[reqid] = delay
                    countmatch += 1
                    httpreqs.pop(0)

    print 'matching http',countmatch,
    print '[',(countmatch*1.0/total)*100.0,'%]',
    print 'others (https ?)',total-countmatch,
    print '[',((total-countmatch)*1.0/total)*100.0,'%]'


matched = [v for v in dnstofirsthttp.values() if v >= 0]
print 'total reqs',len(dnstofirsthttp.values()),
```

```
print 'total matching http',len(matched),
print '[',(len(matched)*1.0/len(dnstofirsthttp.values()))*100.0,'%]',
print 'total others (https ?)',len(dnstofirsthttp.values())-len(matched),
print '[',((len(dnstofirsthttp.values())-len(matched))*1.0/len(dnstofirsthttp.values()))

sns.set(style="whitegrid", context="notebook")

f, ax1 = plt.subplots(1, 1, figsize=(5, 5))
(x,y) = datautils.aecdf(matched)
ax1.plot(x,y, '-', lw=2)
ax1.set_title('Time to first HTTP request')
ax1.set_ylabel('CDF')
ax1.set_xscale('log')
ax1.set_xlabel('delay')
ax1.set_xticks([0.001,0.1,1,60,3600,24*3600])
ax1.set_xticklabels(['1ms','100ms','1s','1min','1h','1day'])

plt.tight_layout()
plt.show()

ses.close()
```

1.1 Basic Stats

Looking at the number of participants and amount of data (duration, bytes, packets, URLs, locations etc).

```
In [77]: utable = defaultdict(list)
         idx = []

         ses = Session()
         for u in ses.query(User).all():
             idx.append(u.id)
             utable['country'].append(u.country)
             utable['username'].append(u.username)
             notshared = [str(d.id) for d in u.devices if not d.shared]
             utable['devices_perso'].append(len(notshared))
             utable['devices_shared'].append(len(u.devices)-len(notshared))

             # just look at personal devices for now
             devids = ",".join(notshared)
             sqlq = """SELECT count(*),min(ts),max(ts),sum(packets_in),sum(packets_out),sum(byte

             res = ses.execute(text(sqlq)).fetchone()
             if (res != None and res[0]!=None and res[0]>0):
                 (active,firstbyte,lastbyte,totalpkts_in,totalpkts_out,totalbytes_in,totalbytes_
                 utable['totaltime (d)'].append((lastbyte-firstbyte).total_seconds()/(24*3600.0)
                 utable['activetime (min)'].append(active/60.0)
```

```
                utable['pkts [in/out]'].append((totalpkts_in,totalpkts_out))
                utable['MB [in/out]'].append((totalbytes_in/(1024.0*1024.0),totalbytes_out/(102
            else:
                utable['totaltime (d)'].append(0.0)
                utable['activetime (min)'].append(0.0)
                utable['pkts [in/out]'].append((0,0))
                utable['MB [in/out]'].append((0,0))

            sqlq = """SELECT count(*) FROM dnsreqs where devid IN (%s)"""%(devids)
            res = ses.execute(text(sqlq)).fetchone()
            if (res != None and res[0]!=None):
                utable['dns'].append(res[0])
            else:
                utable['dns'].append(0)

            sqlq = """SELECT count(*) FROM httpreqs2 where devid IN (%s)"""%(devids)
            res = ses.execute(text(sqlq)).fetchone()
            if (res != None and res[0]!=None):
                utable['http'].append(res[0])
            else:
                utable['http'].append(0)


        df = pd.DataFrame(utable, index=idx)
        ses.close()
```

In [78]:
```
from IPython.display import display
display(df.sort_values('activetime (min)', ascending=False))
```

	MB [in/out]	activetime (min)	country	\
15	(13566.7371969, 1604.47465611)	4464.016667	uk	
13	(7200.36581135, 1018.97597122)	2066.233333	uk	
18	(3532.2018137, 1102.41533947)	1725.633333	uk	
25	(2107.20948505, 246.590632439)	705.516667	uk	
24	(220.844079971, 65.5123653412)	624.333333	uk	
16	(2752.20203876, 189.982741356)	547.200000	uk	
21	(698.285132408, 155.425772667)	518.583333	uk	
23	(1704.27509785, 121.32196331)	424.233333	uk	
14	(3350.75111485, 174.474637985)	381.483333	uk	
2	(746.565511703, 79.08091259)	345.800000	fr	
1	(6.12571430206, 1.36167430878)	179.416667	fr	
19	(333.000788689, 32.8927869797)	161.850000	uk	
4	(8.11959457397, 1.69482898712)	144.133333	fr	
20	(106.823967934, 48.102432251)	133.300000	uk	
3	(4.63907527924, 0.935205459595)	116.550000	fr	
26	(327.974438667, 35.126490593)	111.633333	uk	
7	(23.1252641678, 7.83344173431)	110.850000	fr	
17	(412.120593071, 17.8190164566)	94.266667	uk	

```
5            (184.95570755, 26.3952550888)         58.300000      fr
22          (40.0078611374, 5.41309165955)         56.066667      uk
8           (571.149705887, 36.5790491104)         11.783333      fr
11         (30.2905817032, 0.751399040222)          3.000000      fr
10  (4.19616699219e-05, 9.91821289062e-05)          0.016667      fr
9                                  (0, 0)          0.000000      fr
6                                  (0, 0)          0.000000      fr

    devices_perso  devices_shared    dns    http        pkts [in/out]  \
15              3               0  37877  239918  (12027193, 6081142)
13              3               0  63931  108197   (7707672, 5520195)
18              2               0  21114   26700   (3990863, 3273754)
25              1               2  47394   27237   (2266489, 1799738)
24              1               1  10497    1976     (264418, 263341)
16              3               0  23574  221583   (2449681, 1265188)
21              1               2  19145    7524     (891012, 802743)
23              2               0  12568   14538   (1641929, 1154729)
14              2               0   2983    8780   (2462506, 2241076)
2               2               0   7033   31147     (622162, 448138)
1               1               0  21602       7       (21652, 21688)
19              3               0   1837    1562     (305611, 165272)
4               1               0  26139    9133       (26676, 26982)
20              2               0   1535    9888     (148285, 182769)
3               1               0  15015    1807       (15126, 15162)
26              1               0   1027    5950     (295151, 128388)
7               2               0   8342   24710       (58623, 59507)
17              1               1   1961    4351     (348551, 183907)
5               2               0   2832  275904     (195705, 164947)
22              2               0    795    3297       (58110, 56679)
8               2               0    368  632515     (334682, 236761)
11              1               0    138    2196       (24190, 10687)
10              2               0      0    6567               (1, 2)
9               2               0      0       8               (0, 0)
6               1               0      0     170               (0, 0)

    totaltime (d)              username
15      44.857627         clifford.wife
13      30.358947            neenagupta
18      34.840336         michaelbrogan
25      25.658333         bowen.husband
24      27.064039  barnesldavid.husband
16      13.157847              kemianny
21      35.943981            bowen.wife
23      56.084329      clifford.husband
14      14.459792             chrismaley
2       91.480347                salmita
1       40.970000                norelie
19      10.583889              harrison
```

```
4       67.054109              carmelia
20      10.665544                 gluch
3      103.103345               jasivan
26       1.331447     bridgeman.husband
7       67.513576            bencardino
17      22.374907     barnesldavid.wife
5       67.459421               sormain
22      38.229711        bridgeman.wife
8       67.705984               shelter
11      55.208935                 majid
10       0.000000              filiatre
9        0.000000                 desir
6        0.000000              francois
```

In [4]:
```
sns.set(style="white", context="notebook")

df = pd.DataFrame(utable, index=idx)
df['totaltraffic'] = list([t[0]+t[1] for t in df.loc[:,'MB [in/out]']])

dffr = df[df['country']=='fr'].sort_values('totaltime (d)', ascending=False)
dffr['uid'] = list(range(len(dffr.index)))
dfuk = df[df['country']=='uk'].sort_values('totaltime (d)', ascending=False)
dfuk['uid'] = list(range(len(dfuk.index)))

f, ((ax1, ax2), (ax3, ax4), (ax5, ax6), (ax7, ax8), (ax9, ax10)) = plt.subplots(5, 2, fi

# first row is the total time / user
for (dframe,ax,title) in ((dffr,ax1,"France"),(dfuk,ax2,"UK")):
    sns.barplot(data=dframe, x='uid', y='totaltime (d)', palette="BuGn_d", ax=ax)
    ax.set_ylabel("Duration (days)")
    ax.set_xlabel("")
    ax.set_title(title)

# 2nd is the time with some traffic
for (dframe,ax,title) in ((dffr,ax3,"France"),(dfuk,ax4,"UK")):
    sns.barplot(data=dframe, x='uid', y='activetime (min)', palette="BuGn_d", ax=ax)
    ax.set_yscale('log')
    ax.set_ylabel("Total Active")
    ax.set_yticks([1,60,24*60])
    ax.set_yticklabels(['1min','1h','1day'])
    ax.set_xlabel("")

# 3rd is the total amount of traffic (bytes in/out)
for (dframe,ax,title) in ((dffr,ax5,"France"),(dfuk,ax6,"UK")):
    sns.barplot(data=dframe, x='uid', y='totaltraffic', palette="BuGn_d", ax=ax)
    ax.set_yscale('log')
    ax.set_ylabel("Total traffic")
```

```
        ax.set_yticks([0.001,1.0,1000.0])
        ax.set_yticklabels(['1KB','1MB','1GB'])
        ax.set_xlabel("User")

    for (dframe,ax,title) in ((dffr,ax7,"France"),(dfuk,ax8,"UK")):
        sns.barplot(data=dframe, x='uid', y='dns', palette="BuGn_d", ax=ax)
        ax.set_yscale('log')
        ax.set_ylabel("DNS requests")
        ax.set_xlabel("User")

    for (dframe,ax,title) in ((dffr,ax9,"France"),(dfuk,ax10,"UK")):
        sns.barplot(data=dframe, x='uid', y='http', palette="BuGn_d", ax=ax)
        ax.set_yscale('log')
        ax.set_ylabel("HTTP requests")
        ax.set_xlabel("User")

    sns.despine()
    plt.tight_layout()


    ---------------------------------------------------------------------------

    NameError                                 Traceback (most recent call last)

    <ipython-input-4-4270051e7010> in <module>()
----> 1 sns.set(style="white", context="notebook")
      2
      3 df = pd.DataFrame(utable, index=idx)
      4 df['totaltraffic'] = list([t[0]+t[1] for t in df.loc[:,'MB [in/out]']])
      5


    NameError: name 'sns' is not defined
```

1.2 User Selection

Based on the above graphs, we will consider the top-7 users from France, and top-10 from UK. The users 11-13 in UK send quite some traffic but are only present few days during the expreriment ..

1.3 User Activity

- Focus only on periods of traffic (by definition this is when we have data, and we know something)
- Try to define 'user activity' as a period of continuous events (http,dns,network traffic, ..)

```
In [83]: colors = sns.color_palette('muted')
         sns.set_style("whitegrid")
```

```
markers = ['x','*','+','s','c']

dffr = df[df['country']=='fr'].sort_values('activetime (min)', ascending=False)
dfuk = df[df['country']=='uk'].sort_values('activetime (min)', ascending=False)

ses = Session()
for uname in list(dffr.loc[:,'username']) + list(dfuk.loc[:,'username']):
    u = ses.query(User).filter(User.username==uname).one()

    devids = ",".join([str(d.id) for d in u.devices if not d.shared])

    devs = {}
    for d in u.devices:
        devs[d.id] = d.platform

    xstart = None
    xend = None
    samples = 0

    x = defaultdict(list)
    y = defaultdict(list)
    sqlq = """SELECT ts,devid FROM devicetraffic WHERE devid IN (%s) ORDER BY ts"""%(de
    for row in ses.execute(text(sqlq)):
        ts = datautils.utctocc(row['ts'], u.country)

        if (xstart == None):
            xstart = ts
            xend = ts
        xstart = xstart if xstart < ts else ts
        xend = xend if xend > ts else ts

        x[row['devid']].append(ts)
        y[row['devid']].append(ts.hour+ts.minute/60.0)
        samples += 1

    # ignore users with less than 5min of observed traffic
    if (xstart == None or samples < 300):
        continue

    f, (ax1, ax2, ax3, ax4) = plt.subplots(4, 1, figsize=(12, 8), sharex=True)
    for i,devid in enumerate([d.id for d in u.devices if not d.shared]):
        ax1.scatter(x[devid], y[devid], marker=markers[i], color=colors[i], label='%s [

    ax1.set_title('Device Traffic [user=%s]'%(uname))
    ax1.set_ylim((0,24))
    ax1.set_ylabel('Hour of Day')
    ax1.set_xlim(xstart,xend)
    ax1.legend(loc='best')
```

```
x = defaultdict(list)
y = defaultdict(list)
sqlq = """SELECT ts,devid FROM dnsreqs WHERE devid IN (%s) ORDER BY ts"""%(devids)
for row in ses.execute(text(sqlq)):
    ts = datautils.utctocc(row['ts'], u.country)
    x[row['devid']].append(ts)
    y[row['devid']].append(ts.hour+ts.minute/60.0)

for i,devid in enumerate([d.id for d in u.devices if not d.shared]):
    ax2.scatter(x[devid], y[devid], marker=markers[i], color=colors[i], label='%s [
ax2.set_title('DNS requests')
ax2.set_ylabel('Hour of Day')
ax2.set_ylim((0,24))
ax2.legend(loc='best')

x = defaultdict(list)
y = defaultdict(list)
sqlq = """SELECT ts,devid FROM httpreqs2 WHERE devid IN (%s) ORDER BY ts"""%(devids
for row in ses.execute(text(sqlq)):
    ts = datautils.utctocc(row['ts'], u.country)
    x[row['devid']].append(ts)
    y[row['devid']].append(ts.hour+ts.minute/60.0)

for i,devid in enumerate([d.id for d in u.devices if not d.shared]):
    ax3.scatter(x[devid], y[devid], marker=markers[i], color=colors[i], label='%s [
ax3.set_title('HTTP Requests')
ax3.set_ylabel('Hour of Day')
ax3.set_xlim(xstart,xend)
ax3.set_ylim((0,24))
ax3.legend(loc='best')

# filter urls
x = defaultdict(list)
y = defaultdict(list)
sqlq = """SELECT ts,devid FROM httpreqs2 WHERE devid IN (%s) AND user_url = 't' ORD
for row in ses.execute(text(sqlq)):
    ts = datautils.utctocc(row['ts'], u.country)
    x[row['devid']].append(ts)
    y[row['devid']].append(ts.hour+ts.minute/60.0)

for i,devid in enumerate([d.id for d in u.devices if not d.shared]):
    ax4.scatter(x[devid], y[devid], marker=markers[i], color=colors[i], label='%s [
ax4.set_title('Filtered HTTP Requests')
ax4.set_ylabel('Hour of Day')
ax4.set_xlim(xstart,xend)
ax4.set_ylim((0,24))
ax4.legend(loc='best')
```

```
plt.tight_layout()
plt.show()

# inter-event times
iat = []

sqlq = """SELECT ts,lag(ts) OVER (ORDER BY ts) FROM \
(SELECT ts FROM dnsreqs WHERE devid IN (%s) UNION ALL \
 SELECT ts FROM httpreqs2 WHERE devid IN (%s) AND user_url = 't') \
AS events"""%(devids,devids)

for row in ses.execute(text(sqlq)):
    if (row[1]==None):
        continue
    iat.append((row[0]-row[1]).total_seconds())

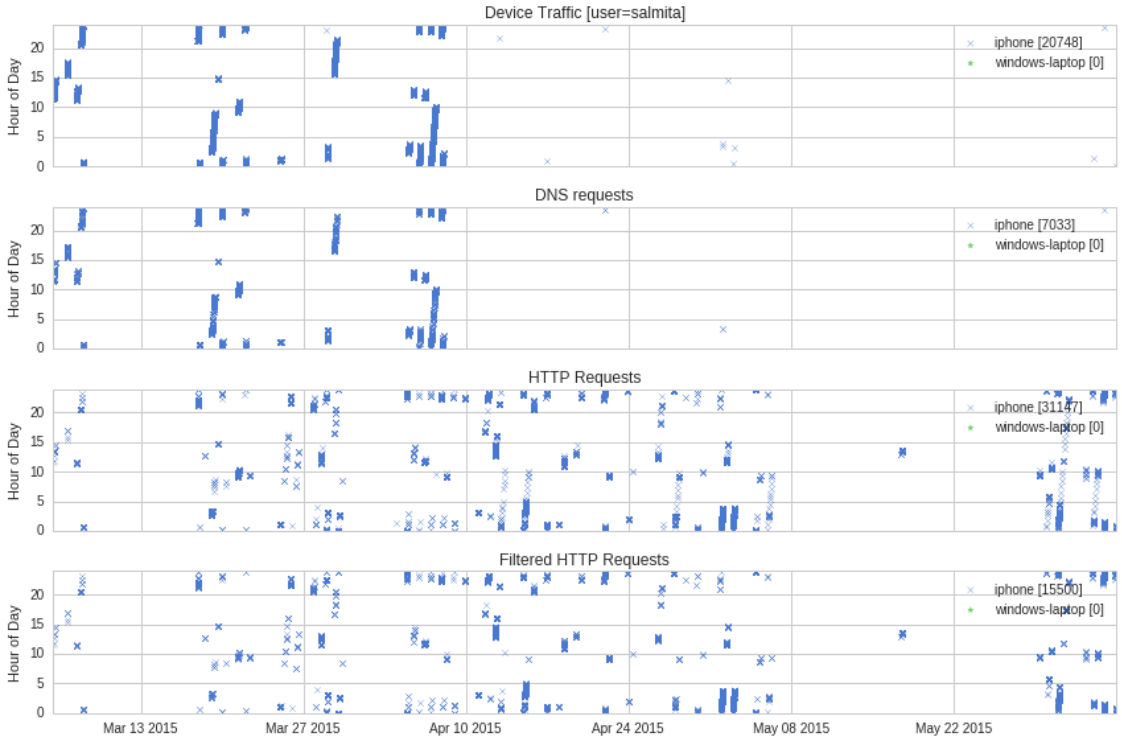
f, (ax1, ax2, ax3) = plt.subplots(1, 3, figsize=(12, 4))
(x,y) = datautils.aecdf(iat)
ax1.plot(x,y, '-', lw=2, color=colors[0])
ax1.set_title('Inter-Event Time [user=%s, events=%d]'%(uname, len(x)))
ax1.set_ylabel('CDF')
ax1.set_xscale('log')
ax1.set_xlabel('seconds')
ax1.set_xticks([0.001,1,60,3600,24*3600])
ax1.set_xticklabels(['1ms','1s','1min','1h','1day'])
ax2.set_xlim(0.001,max(iat))

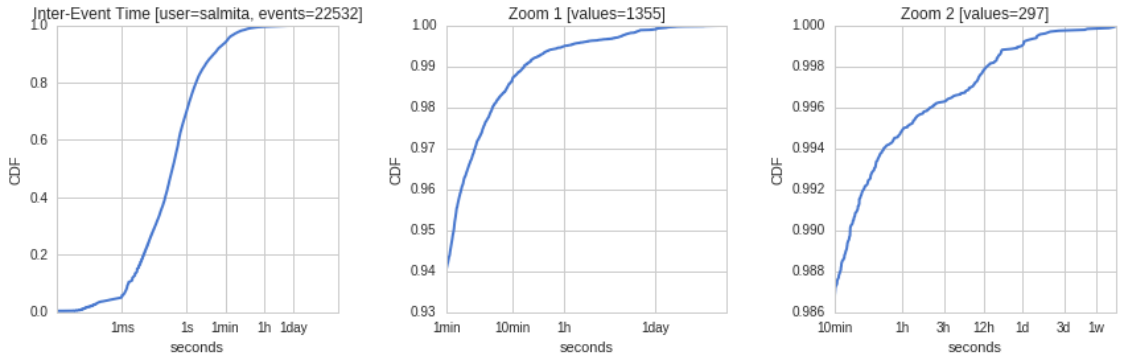
xp = filter(lambda v : v>=60, x)
ax2.plot(xp,y[-len(xp):], '-', lw=2, color=colors[0])
ax2.set_title('Zoom 1 [values=%d]'%(len(xp)))
ax2.set_ylabel('CDF')
ax2.set_xscale('log')
ax2.set_xlabel('seconds')
ax2.set_xticks([60,600,3600,24*3600])
ax2.set_xticklabels(['1min','10min','1h','1day'])
ax2.set_xlim(60,max(iat))

xp = filter(lambda v : v>=600, x)
ax3.plot(xp,y[-len(xp):], '-', lw=2, color=colors[0])
ax3.set_title('Zoom 2 [values=%d]'%(len(xp)))
ax3.set_ylabel('CDF')
ax3.set_xscale('log')
ax3.set_xlabel('seconds')
ax3.set_xticks([600,3600,3*3600,12*2600,24*3600,3*24*3600,7*24*3600])
ax3.set_xticklabels(['10min','1h','3h','12h','1d','3d','1w'])
ax3.set_xlim(600,max(iat))
```

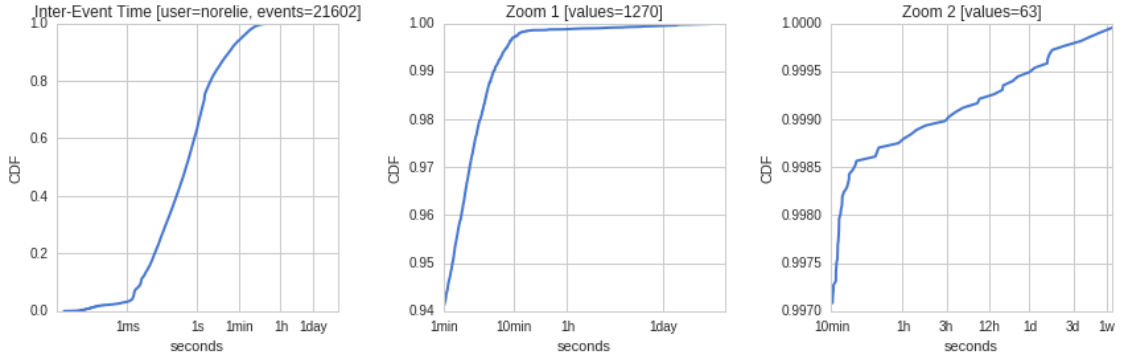
```
        plt.tight_layout()
        plt.show()

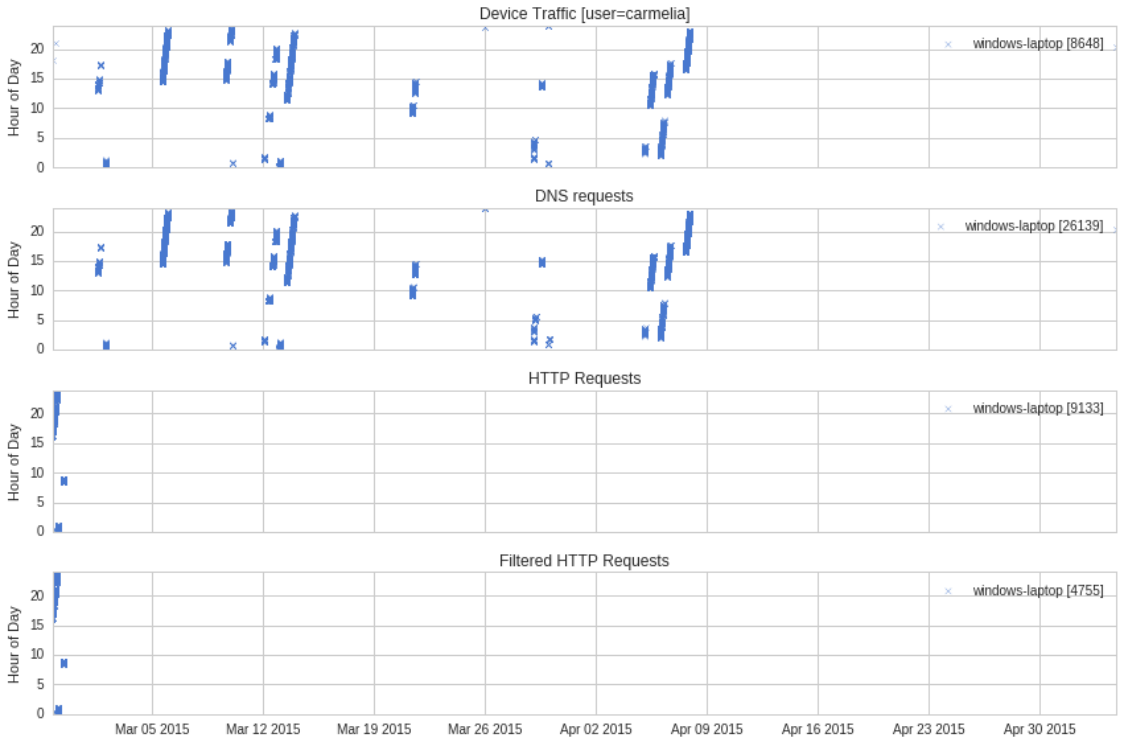
    ses.close()
```

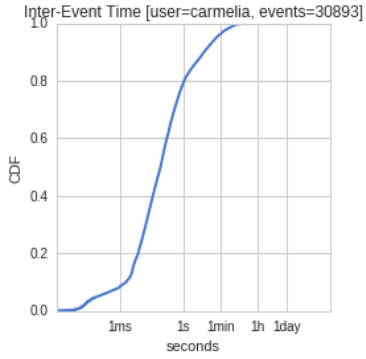


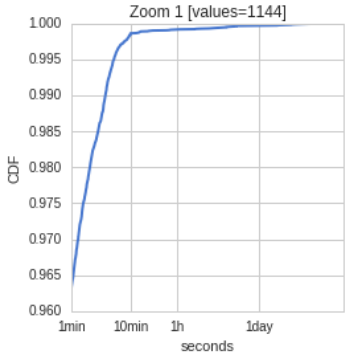


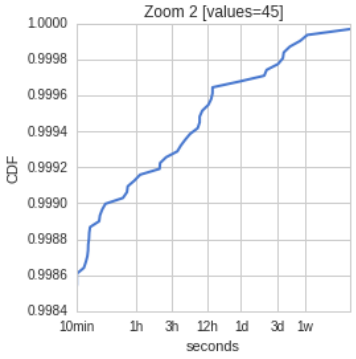

Device Traffic [user=norelie]
windows-laptop [10765]
Hour of Day
DNS requests
windows-laptop [21602]
HTTP Requests
windows-laptop [7]
Filtered HTTP Requests
windows-laptop [1]
Mar 09 2015
Mar 16 2015
Mar 23 2015
Mar 30 2015
Apr 06 2015
Apr 13 2015

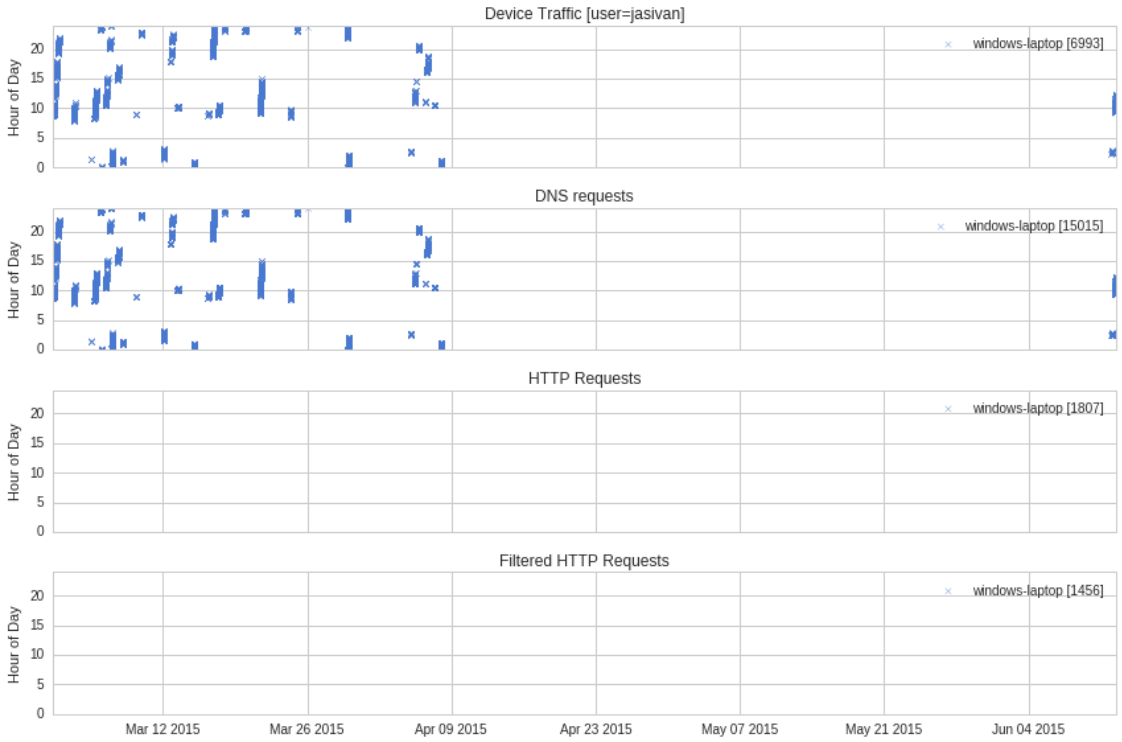

Inter-Event Time [user=norelie, events=21602]
CDF
seconds
Zoom 1 [values=1270]
Zoom 2 [values=63]

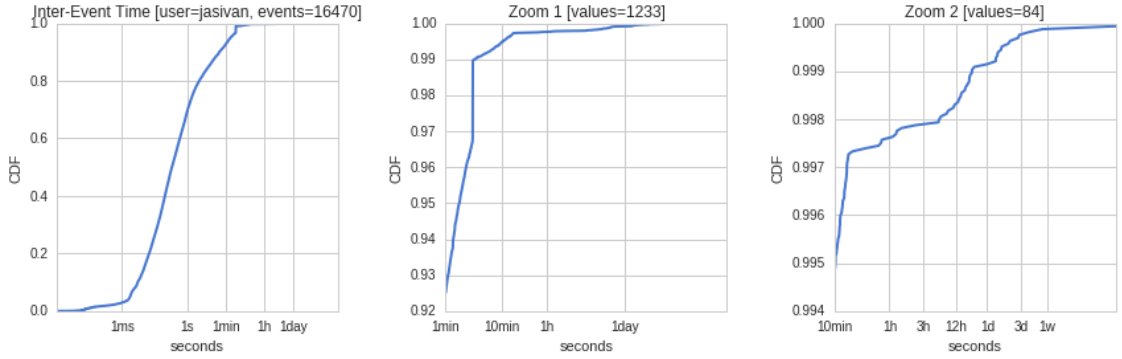

Device Traffic [user=carmelia]
windows-laptop [8648]
DNS requests
windows-laptop [26139]
HTTP Requests
windows-laptop [9133]
Filtered HTTP Requests
windows-laptop [4755]
Hour of Day
Mar 05 2015
Mar 12 2015
Mar 19 2015
Mar 26 2015
Apr 02 2015
Apr 09 2015
Apr 16 2015
Apr 23 2015
Apr 30 2015

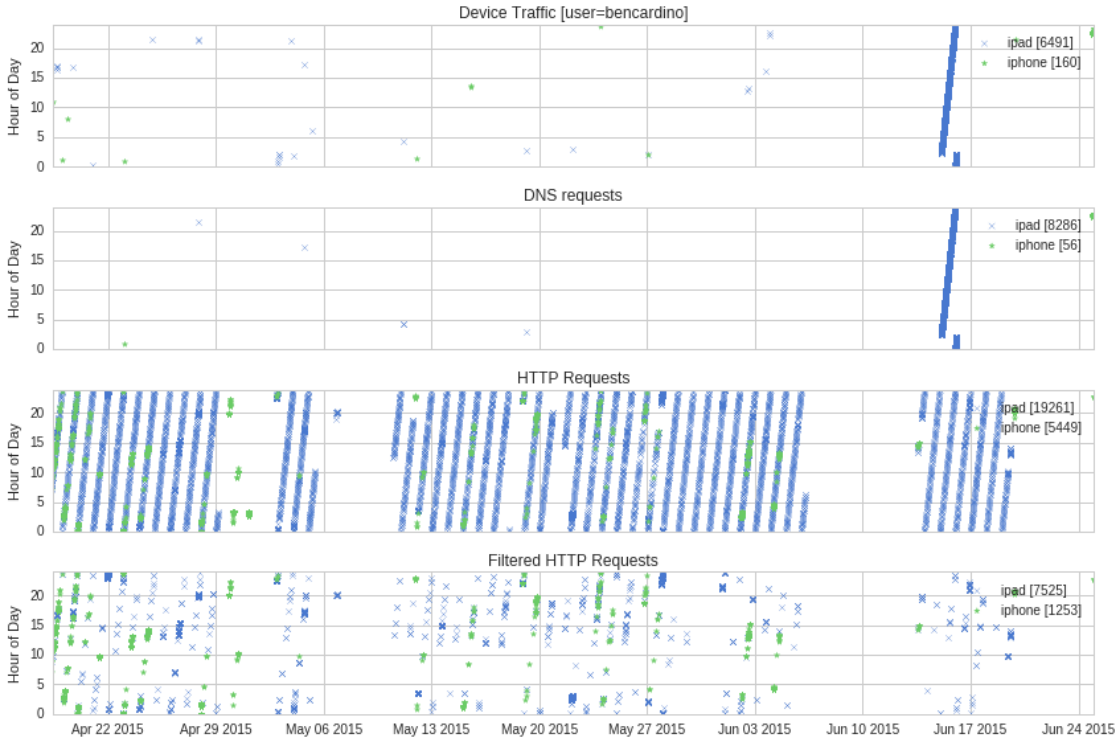

Inter-Event Time [user=carmelia, events=30893]
CDF
1ms
1s
1min
1h
1day
seconds

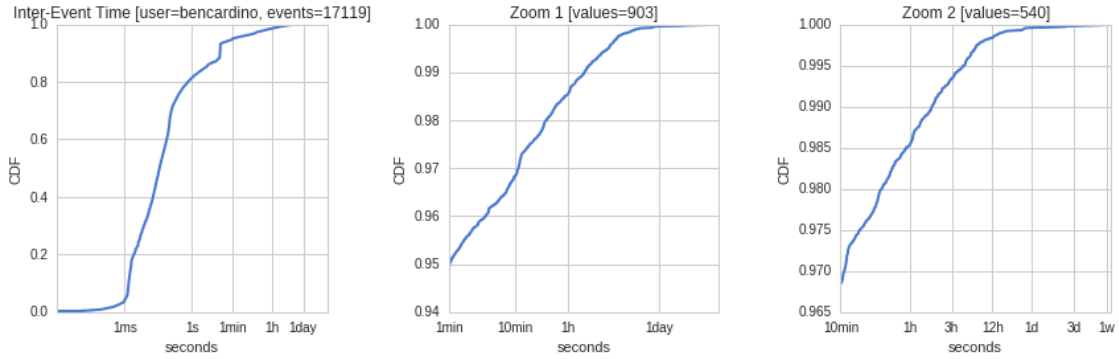

Zoom 1 [values=1144]
CDF
1min
10min
1h
1day
seconds


Zoom 2 [values=45]
CDF
10min
1h
3h
12h
1d
3d
1w
seconds

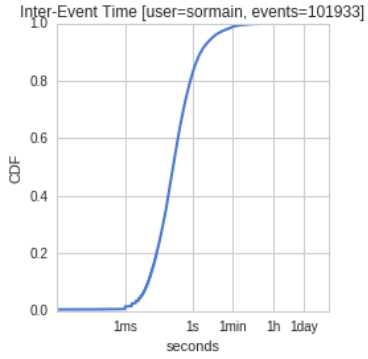

Device Traffic [user=jasivan]
windows-laptop [6993]
DNS requests
windows-laptop [15015]
HTTP Requests
windows-laptop [1807]
Filtered HTTP Requests
windows-laptop [1456]
Hour of Day
Mar 12 2015
Mar 26 2015
Apr 09 2015
Apr 23 2015
May 07 2015
May 21 2015
Jun 04 2015

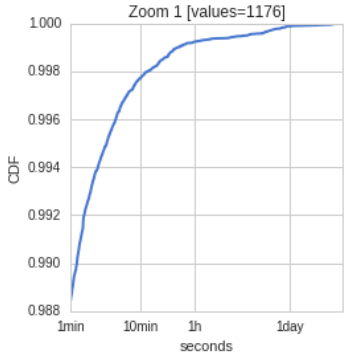

Inter-Event Time [user=jasivan, events=16470]
CDF
1ms
1s
1min
1h
1day
seconds
Zoom 1 [values=1233]
1min
10min
1h
1day
Zoom 2 [values=84]
10min
1h
3h
12h
1d
3d
1w

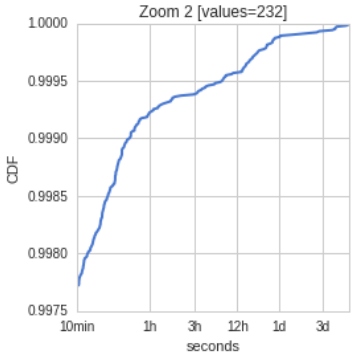

Device Traffic [user=bencardino]
Hour of Day
ipad [6491]
iphone [160]
DNS requests
ipad [8286]
iphone [56]
HTTP Requests
ipad [19261]
iphone [5449]
Filtered HTTP Requests
ipad [7525]
iphone [1253]
Apr 22 2015
Apr 29 2015
May 06 2015
May 13 2015
May 20 2015
May 27 2015
Jun 03 2015
Jun 10 2015
Jun 17 2015
Jun 24 2015

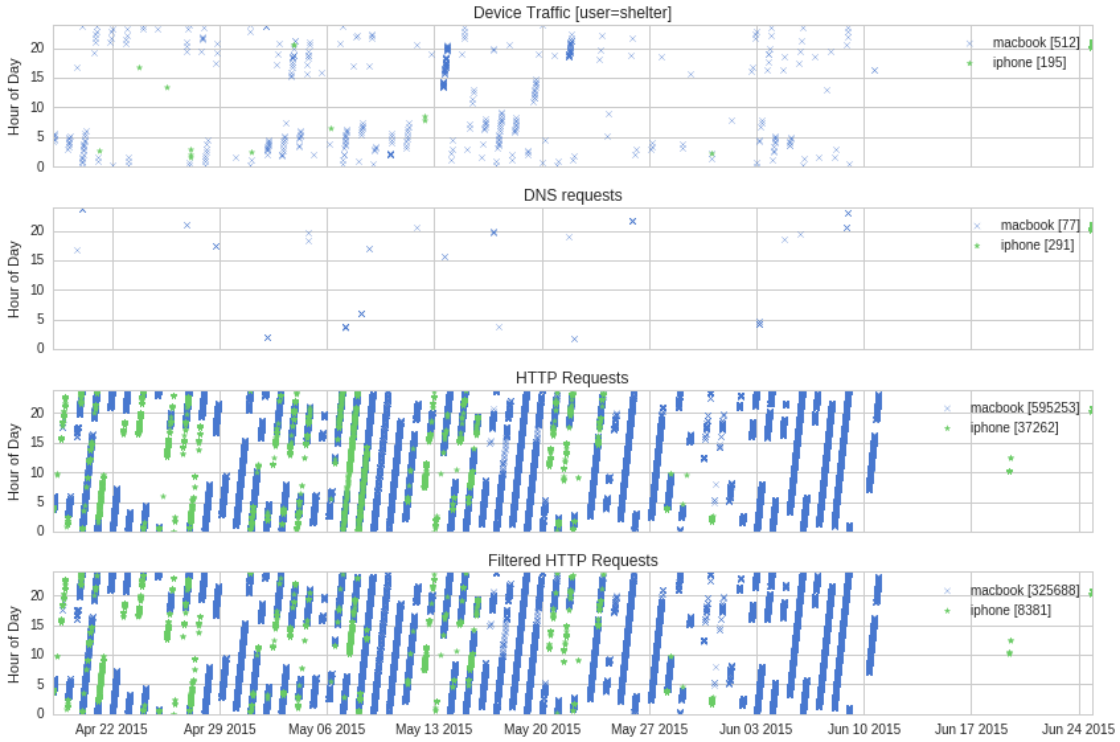

Inter-Event Time [user=bencardino, events=17119]
CDF
1ms
1s
1min
1h
1day
seconds
Zoom 1 [values=903]
1min
10min
1h
1day
Zoom 2 [values=540]
10min
1h
3h
12h
1d
3d
1w

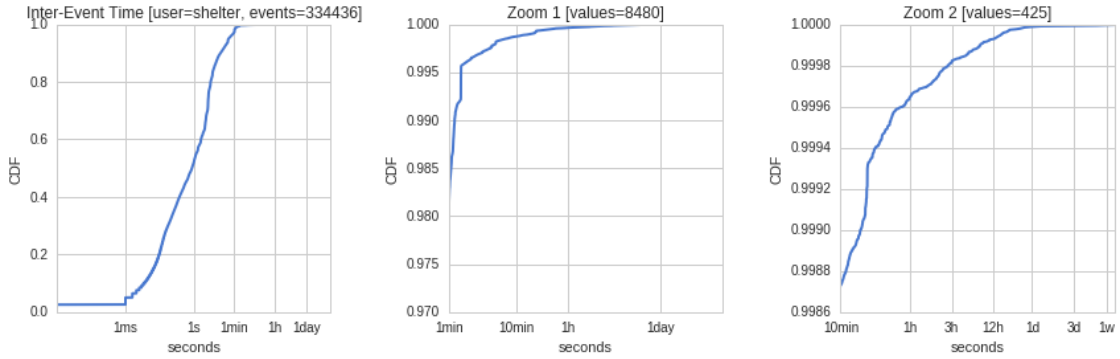

Device Traffic [user=sormain]
Hour of Day
android-phone [2]
macbook [3496]
DNS requests
android-phone [0]
macbook [2832]
HTTP Requests
android-phone [1703]
macbook [274201]
Filtered HTTP Requests
android-phone [858]
macbook [98244]
Apr 22 2015
Apr 29 2015
May 06 2015
May 13 2015
May 20 2015
May 27 2015
Jun 03 2015
Jun 10 2015
Jun 17 2015
Jun 24 2015

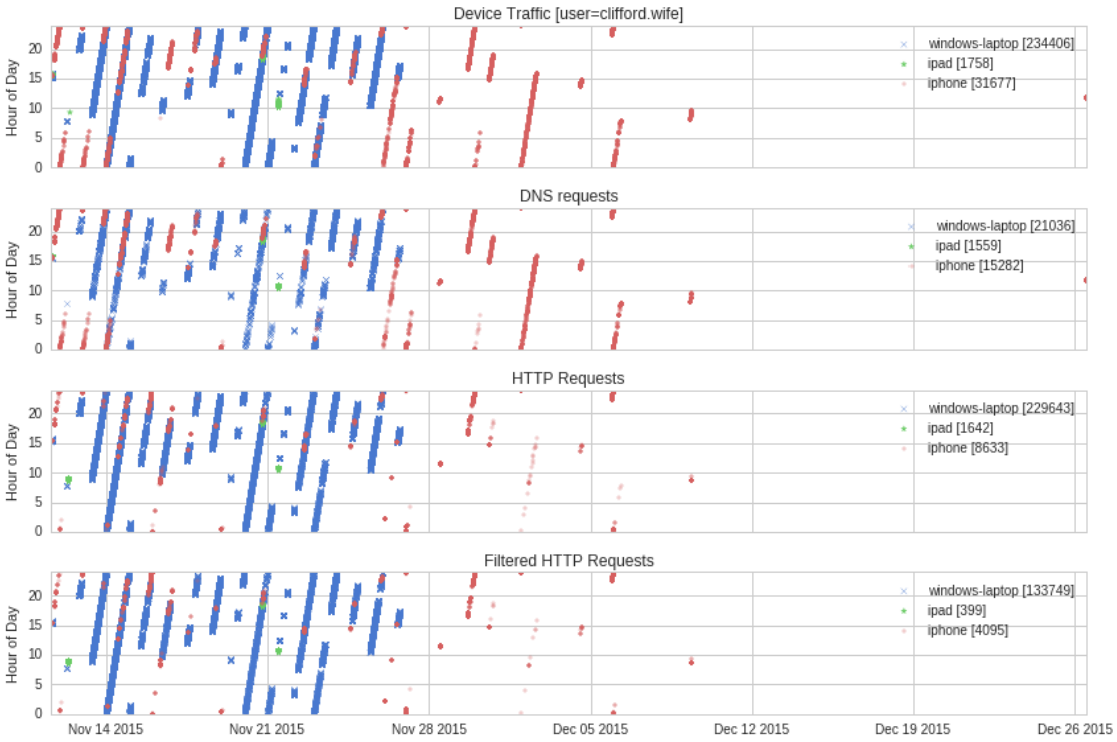

Inter-Event Time [user=sormain, events=101933]
CDF
1ms
1s
1min
1h
1day
seconds

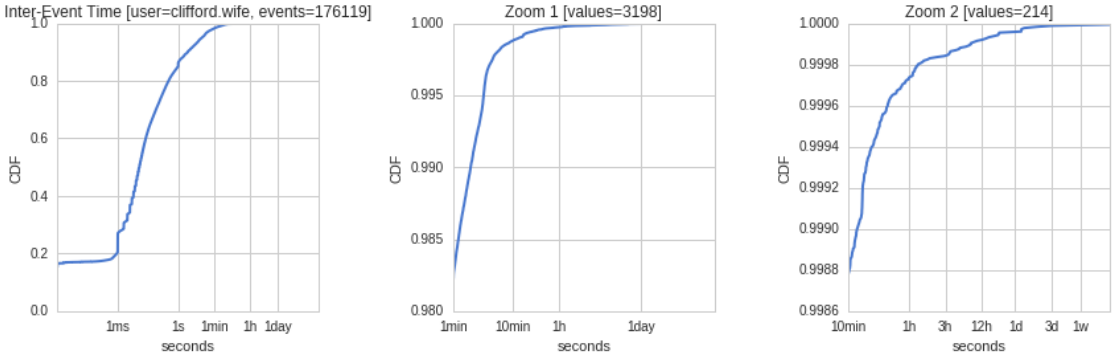

Zoom 1 [values=1176]
CDF
1min
10min
1h
1day
seconds

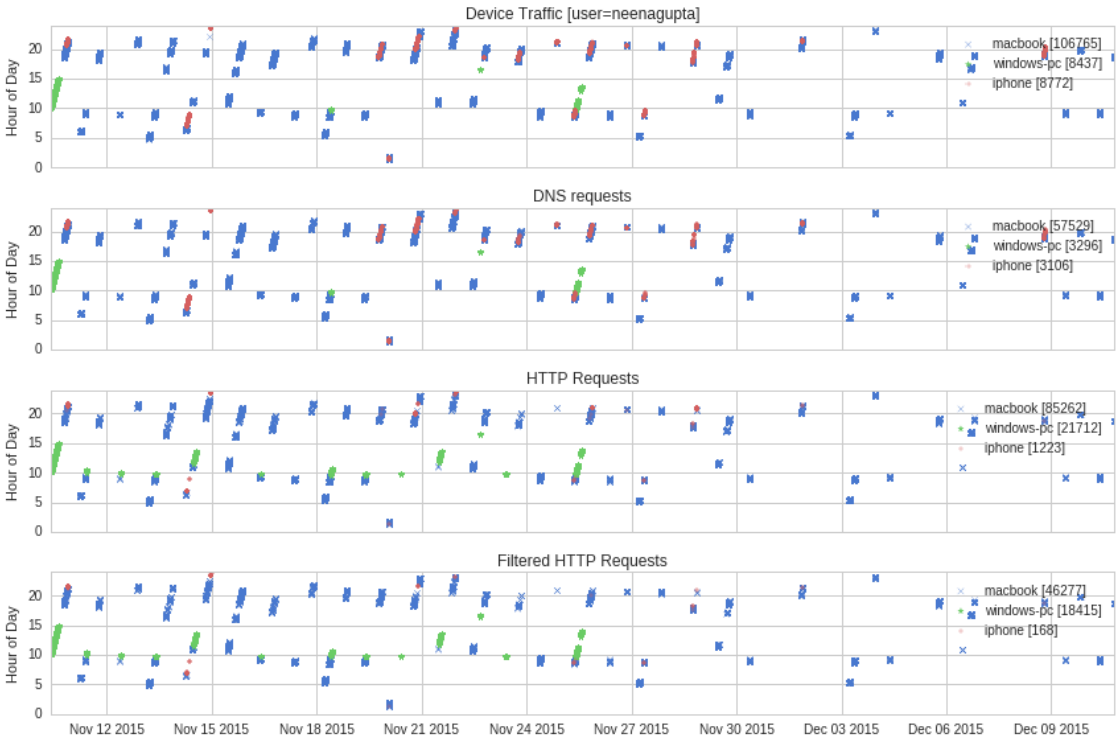

Zoom 2 [values=232]
CDF
10min
1h
3h
12h
1d
3d
seconds

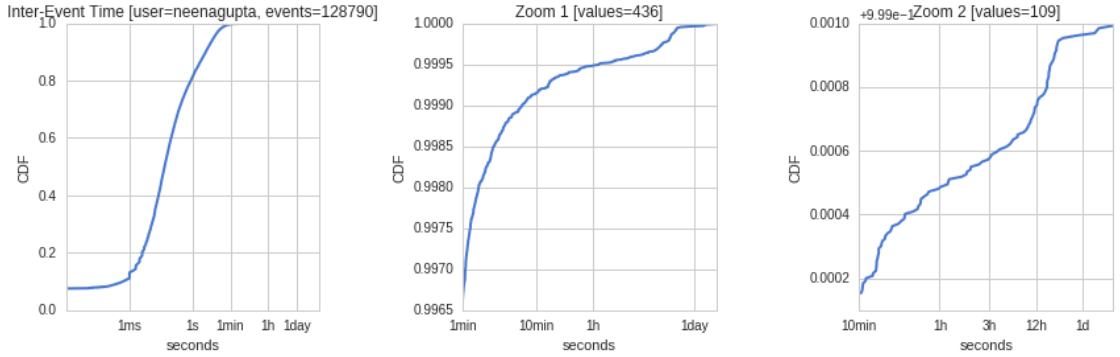

Device Traffic [user=shelter]
macbook [512]
iphone [195]
DNS requests
macbook [77]
iphone [291]
HTTP Requests
macbook [595253]
iphone [37262]
Filtered HTTP Requests
macbook [325688]
iphone [8381]
Hour of Day
Apr 22 2015
Apr 29 2015
May 06 2015
May 13 2015
May 20 2015
May 27 2015
Jun 03 2015
Jun 10 2015
Jun 17 2015
Jun 24 2015


Inter-Event Time [user=shelter, events=334436]
Zoom 1 [values=8480]
Zoom 2 [values=425]
CDF
seconds
1ms
1s
1min
1h
1day
10min
3h
12h
1d
3d
1w

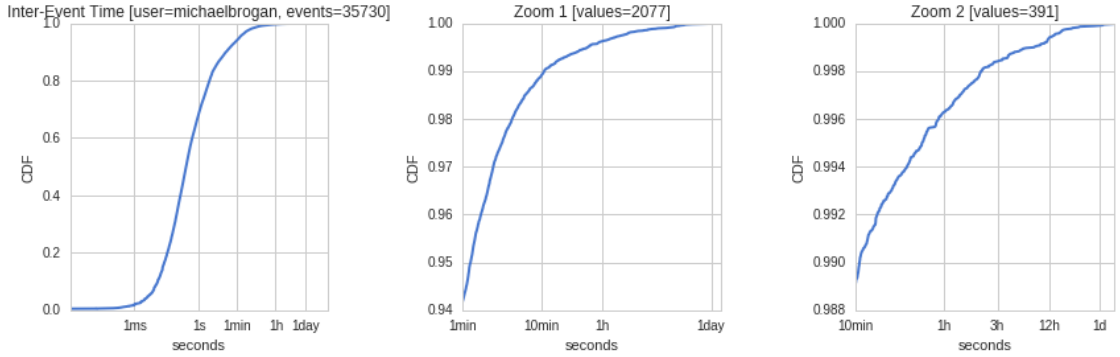

Device Traffic [user=clifford.wife]
Hour of Day
windows-laptop [234406]
ipad [1758]
iphone [31677]
DNS requests
windows-laptop [21036]
ipad [1559]
iphone [15282]
HTTP Requests
windows-laptop [229643]
ipad [1642]
iphone [8633]
Filtered HTTP Requests
windows-laptop [133749]
ipad [399]
iphone [4095]
Nov 14 2015
Nov 21 2015
Nov 28 2015
Dec 05 2015
Dec 12 2015
Dec 19 2015
Dec 26 2015

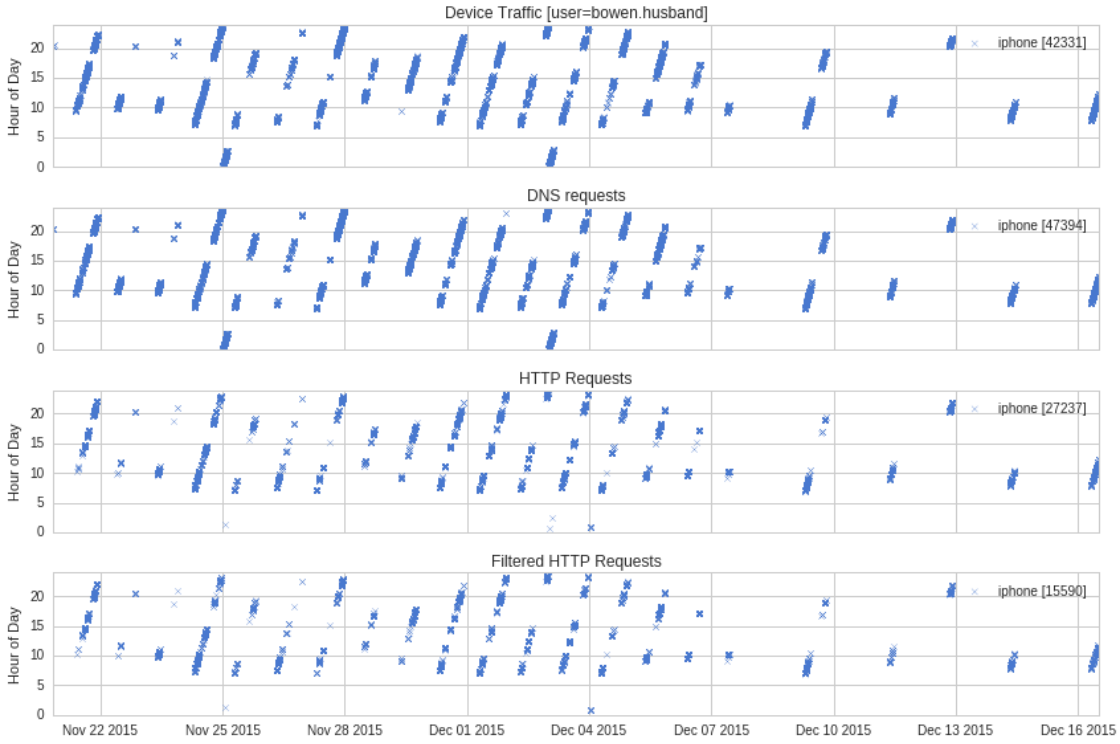

Inter-Event Time [user=clifford.wife, events=176119]
CDF
1ms
1s
1min
1h
1day
seconds
Zoom 1 [values=3198]
10min
Zoom 2 [values=214]
3h
12h
1d
3d
1w

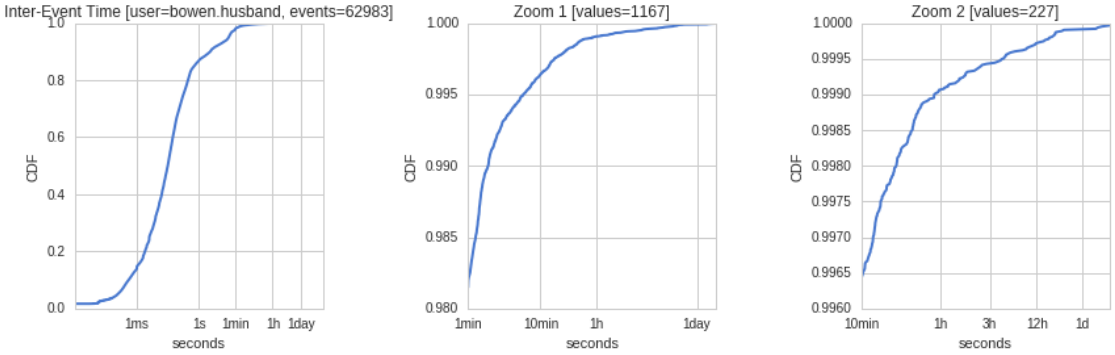

Device Traffic [user=neenagupta]
Hour of Day
macbook [106765]
windows-pc [8437]
iphone [8772]
DNS requests
macbook [57529]
windows-pc [3296]
iphone [3106]
HTTP Requests
macbook [85262]
windows-pc [21712]
iphone [1223]
Filtered HTTP Requests
macbook [46277]
windows-pc [18415]
iphone [168]
Nov 12 2015
Nov 15 2015
Nov 18 2015
Nov 21 2015
Nov 24 2015
Nov 27 2015
Nov 30 2015
Dec 03 2015
Dec 06 2015
Dec 09 2015

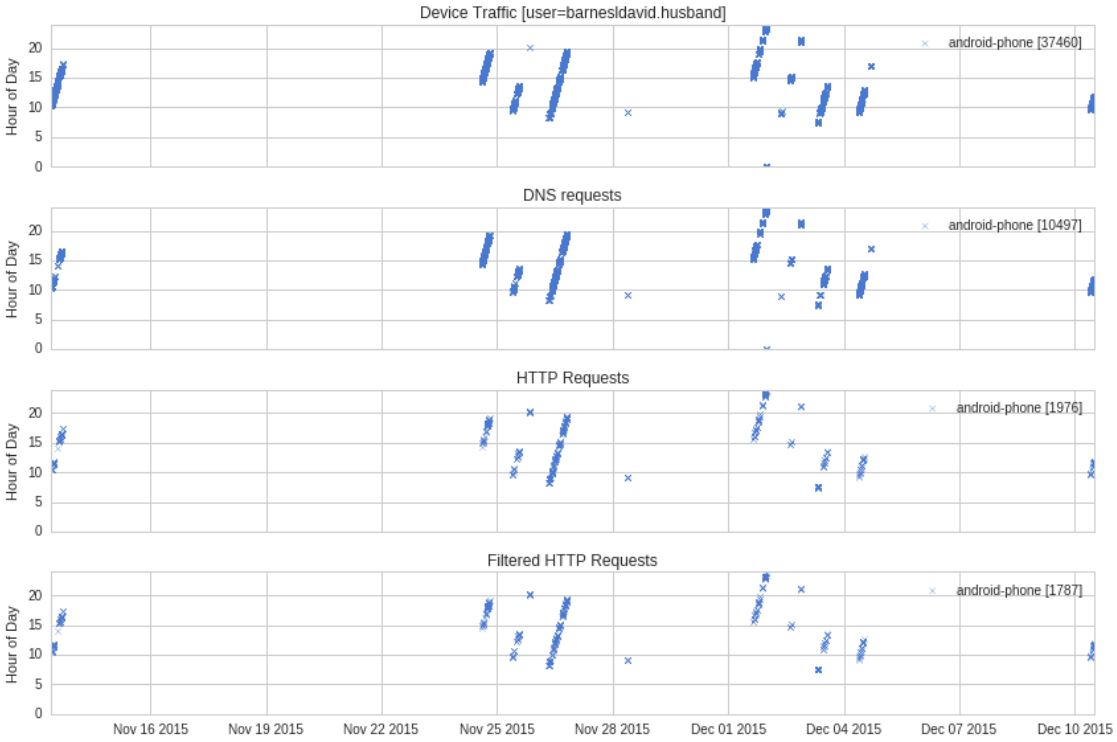

Inter-Event Time [user=neenagupta, events=128790]
CDF
1ms
1s
1min
1h
1day
seconds
Zoom 1 [values=436]
1min
10min
1h
1day
seconds
+9.99e−1
Zoom 2 [values=109]
10min
1h
3h
12h
1d
seconds

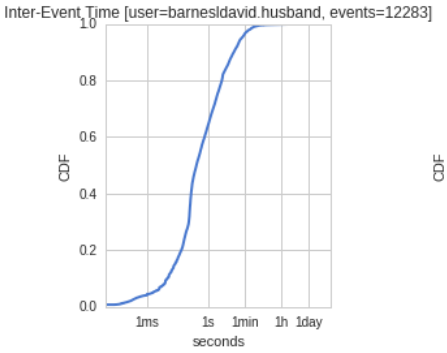

Device Traffic [user=michaelbrogan]
Hour of Day
iphone [0]
windows-laptop [103538]
DNS requests
iphone [0]
windows-laptop [21114]
HTTP Requests
iphone [0]
windows-laptop [26700]
Filtered HTTP Requests
iphone [0]
windows-laptop [14617]
Nov 19 2015
Nov 26 2015
Dec 03 2015
Dec 10 2015
Dec 17 2015

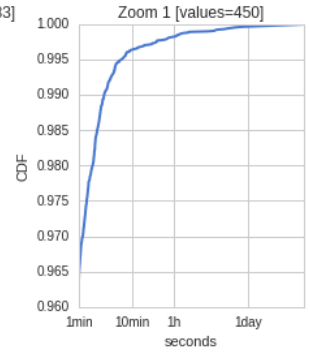

Inter-Event Time [user=michaelbrogan, events=35730]
CDF
1ms
1s
1min
1h
1day
seconds
Zoom 1 [values=2077]
1min
10min
1h
1day
seconds
Zoom 2 [values=391]
10min
1h
3h
12h
1d
seconds

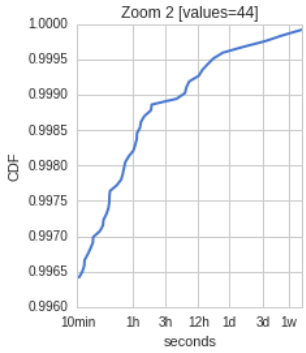

Device Traffic [user=bowen.husband]
iphone [42331]
DNS requests
iphone [47394]
HTTP Requests
iphone [27237]
Filtered HTTP Requests
iphone [15590]
Hour of Day
Nov 22 2015
Nov 25 2015
Nov 28 2015
Dec 01 2015
Dec 04 2015
Dec 07 2015
Dec 10 2015
Dec 13 2015
Dec 16 2015


Inter-Event Time [user=bowen.husband, events=62983]
CDF
1ms
1s
1min
1h
1day
seconds
Zoom 1 [values=1167]
1min
10min
1h
1day
seconds
Zoom 2 [values=227]
10min
1h
3h
12h
1d
seconds

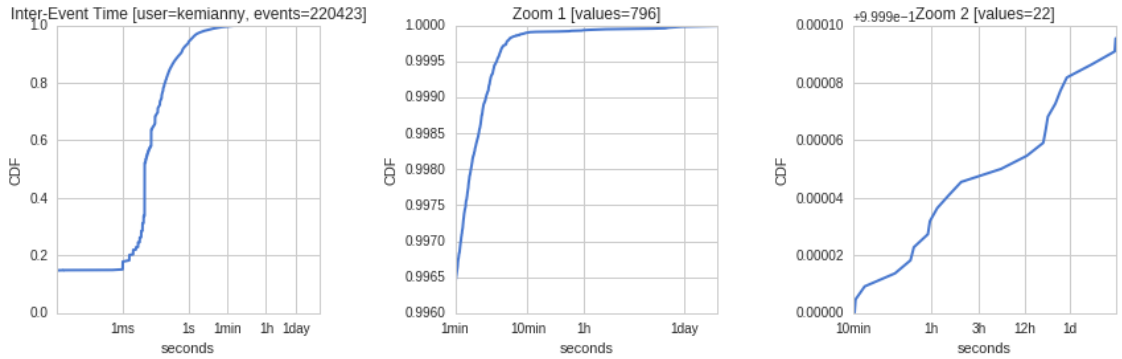

Device Traffic [user=barnesldavid.husband]
android-phone [37460]
DNS requests
android-phone [10497]
HTTP Requests
android-phone [1976]
Filtered HTTP Requests
android-phone [1787]
Hour of Day
0
5
10
15
20
Nov 16 2015
Nov 19 2015
Nov 22 2015
Nov 25 2015
Nov 28 2015
Dec 01 2015
Dec 04 2015
Dec 07 2015
Dec 10 2015

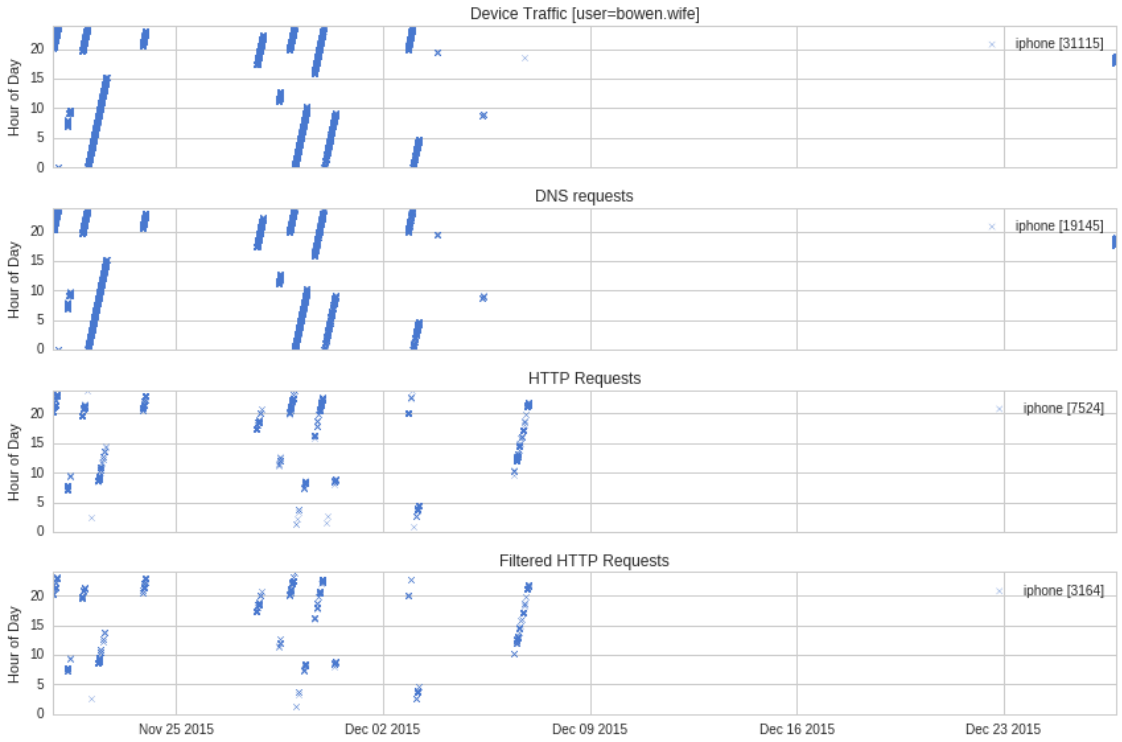

Inter-Event Time [user=barnesldavid.husband, events=12283]
CDF
0.0
0.2
0.4
0.6
0.8
1.0
1ms
1s
1min
1h
1day
seconds

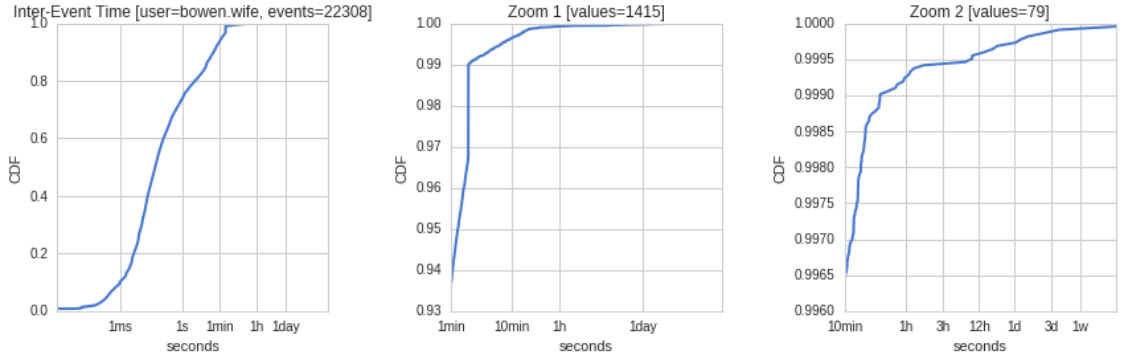

Zoom 1 [values=450]
CDF
0.960
0.965
0.970
0.975
0.980
0.985
0.990
0.995
1.000
1min
10min
1h
1day
seconds


Zoom 2 [values=44]
CDF
0.9960
0.9965
0.9970
0.9975
0.9980
0.9985
0.9990
0.9995
1.0000
10min
1h
3h
12h
1d
3d
1w
seconds

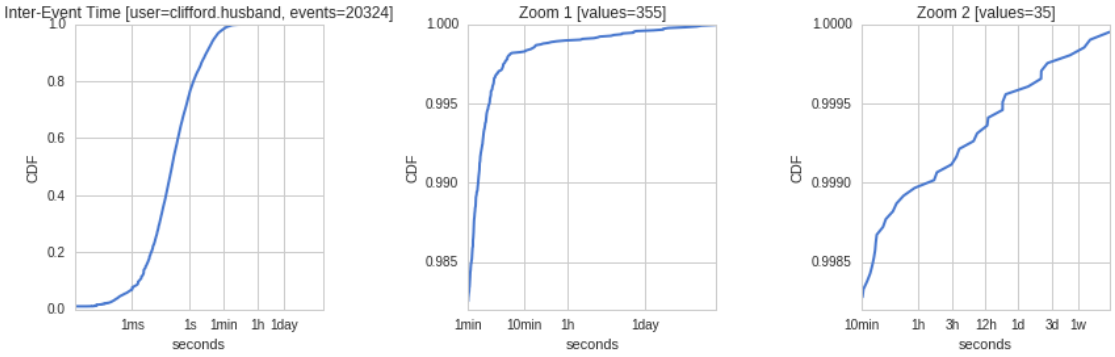

Device Traffic [user=kemianny]
Hour of Day
android-tablet [0]
windows-laptop [32832]
android-phone [0]
DNS requests
windows-laptop [23574]
HTTP Requests
windows-laptop [221583]
Filtered HTTP Requests
windows-laptop [196850]
Nov 14 2015
Nov 16 2015
Nov 18 2015
Nov 20 2015
Nov 22 2015
Nov 24 2015
Nov 26 2015

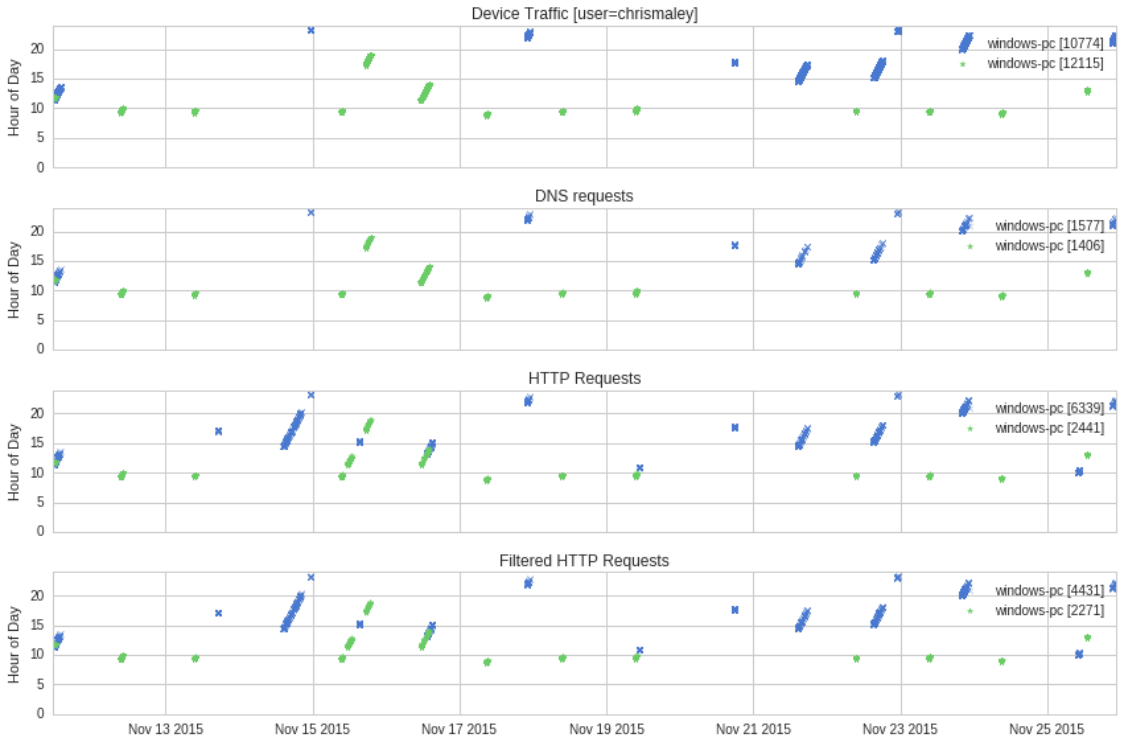

Inter-Event Time [user=kemianny, events=220423]
CDF
1ms
1s
1min
1h
1day
seconds
Zoom 1 [values=796]
10min
Zoom 2 [values=22]
+9.999e−1
3h
12h
1d

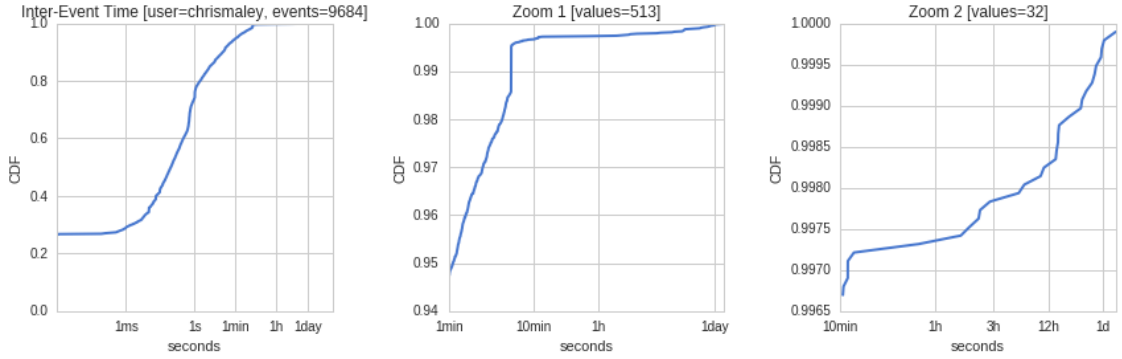

Device Traffic [user=bowen.wife]
iphone [31115]
DNS requests
iphone [19145]
HTTP Requests
iphone [7524]
Filtered HTTP Requests
iphone [3164]
Hour of Day
Nov 25 2015
Dec 02 2015
Dec 09 2015
Dec 16 2015
Dec 23 2015

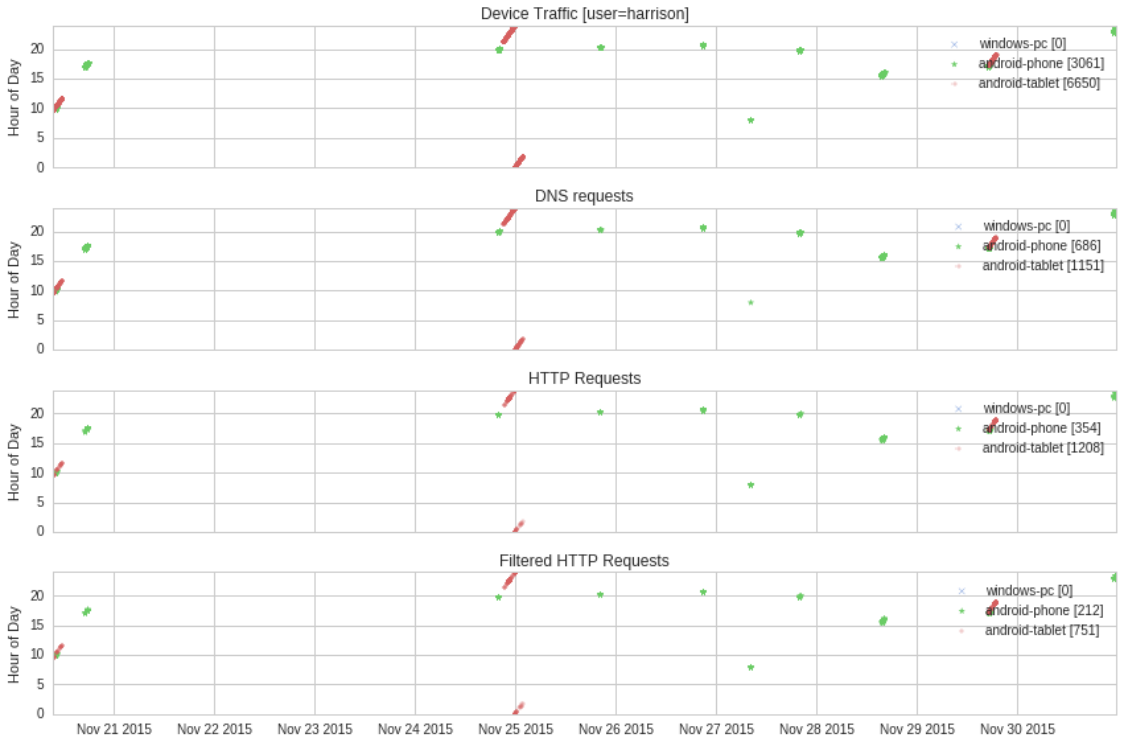

Inter-Event Time [user=bowen.wife, events=22308]
Zoom 1 [values=1415]
Zoom 2 [values=79]
CDF
seconds
1ms
1s
1min
1h
1day
10min
3h
12h
1d
3d
1w

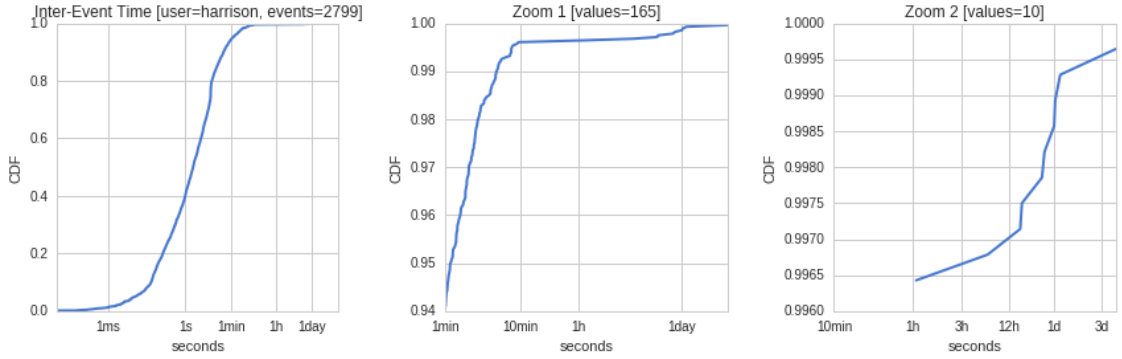

Device Traffic [user=clifford.husband]
macbook [24043]
iphone [1411]
DNS requests
macbook [12044]
iphone [524]
HTTP Requests
macbook [13761]
iphone [777]
Filtered HTTP Requests
macbook [7278]
iphone [479]
Hour of Day
Nov 17 2015
Nov 24 2015
Dec 01 2015
Dec 08 2015
Dec 15 2015
Dec 22 2015
Dec 29 2015
Jan 05 2016


Inter-Event Time [user=clifford.husband, events=20324]
Zoom 1 [values=355]
Zoom 2 [values=35]
CDF
seconds
1ms
1s
1min
1h
1day
10min
3h
12h
1d
3d
1w

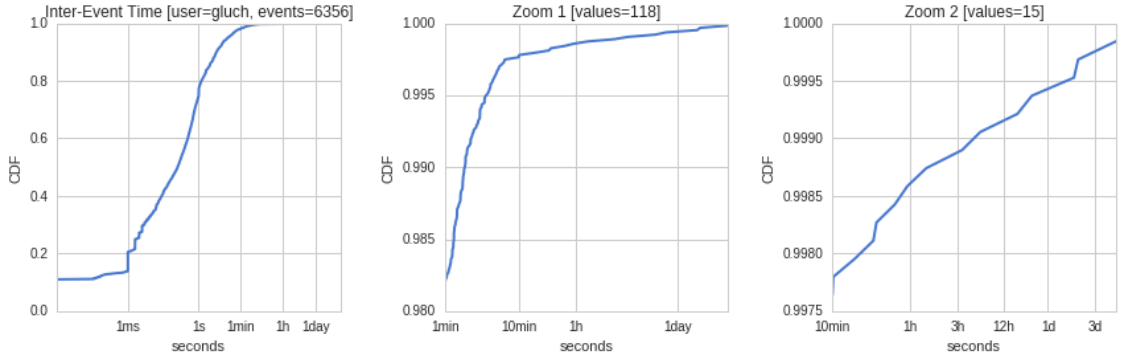

Device Traffic [user=chrismaley]
Hour of Day
windows-pc [10774]
windows-pc [12115]
DNS requests
windows-pc [1577]
windows-pc [1406]
HTTP Requests
windows-pc [6339]
windows-pc [2441]
Filtered HTTP Requests
windows-pc [4431]
windows-pc [2271]
Nov 13 2015
Nov 15 2015
Nov 17 2015
Nov 19 2015
Nov 21 2015
Nov 23 2015
Nov 25 2015

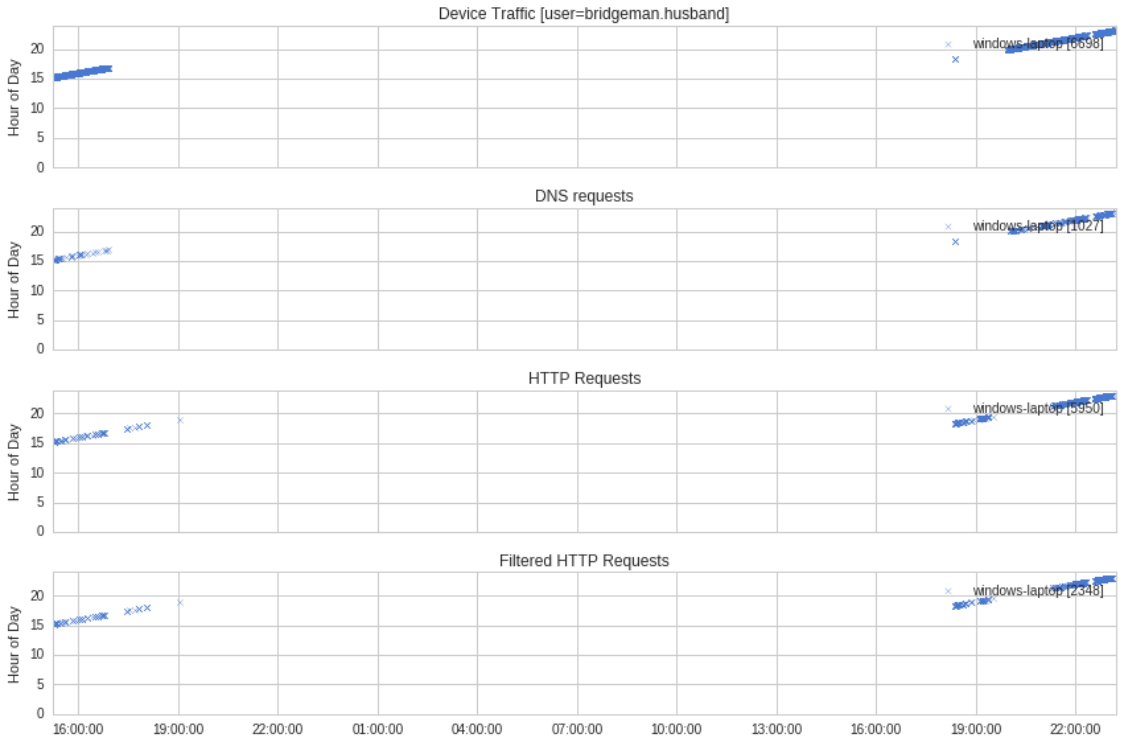

Inter-Event Time [user=chrismaley, events=9684]
CDF
1ms
1s
1min
1h
1day
seconds
Zoom 1 [values=513]
1min
10min
1h
1day
Zoom 2 [values=32]
10min
1h
3h
12h
1d

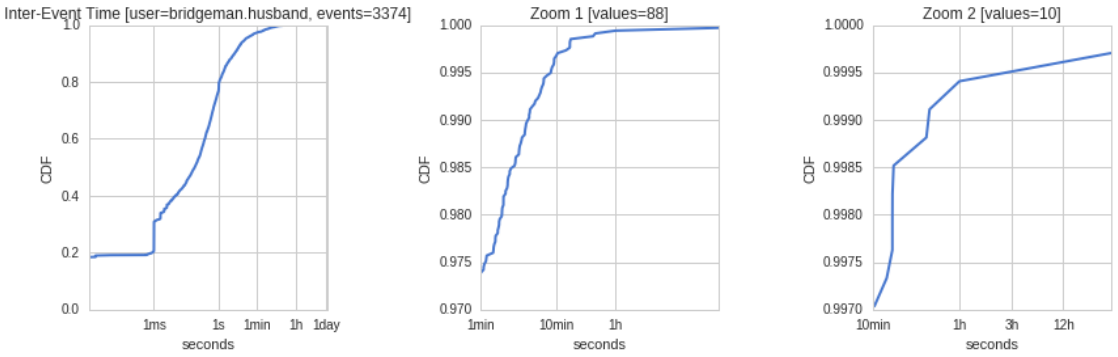

Device Traffic [user=harrison]
windows-pc [0]
android-phone [3061]
android-tablet [6650]
DNS requests
windows-pc [0]
android-phone [686]
android-tablet [1151]
HTTP Requests
windows-pc [0]
android-phone [354]
android-tablet [1208]
Filtered HTTP Requests
windows-pc [0]
android-phone [212]
android-tablet [751]
Hour of Day
Nov 21 2015
Nov 22 2015
Nov 23 2015
Nov 24 2015
Nov 25 2015
Nov 26 2015
Nov 27 2015
Nov 28 2015
Nov 29 2015
Nov 30 2015

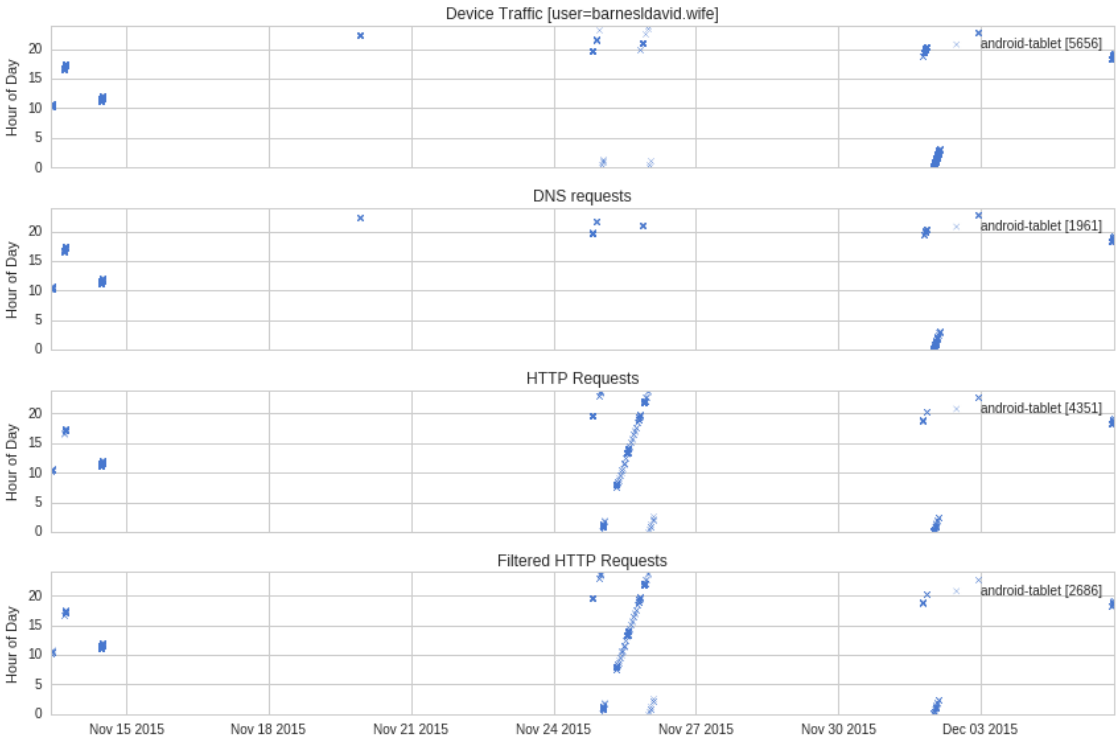

Inter-Event Time [user=harrison, events=2799]
CDF
1ms
1s
1min
1h
1day
seconds
Zoom 1 [values=165]
CDF
1min
10min
1h
1day
seconds
Zoom 2 [values=10]
CDF
10min
1h
3h
12h
1d
3d
seconds

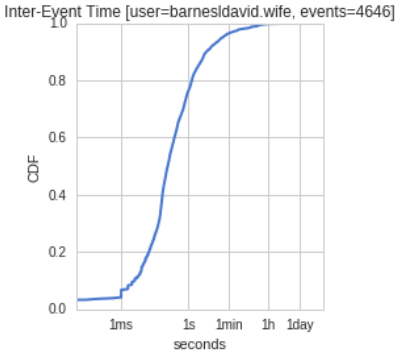

Device Traffic [user=gluch]
android-phone [188]
windows-laptop [7810]
DNS requests
android-phone [131]
windows-laptop [1404]
HTTP Requests
android-phone [217]
windows-laptop [9671]
Filtered HTTP Requests
android-phone [64]
windows-laptop [4758]
Hour of Day
Nov 21 2015
Nov 22 2015
Nov 23 2015
Nov 24 2015
Nov 25 2015
Nov 26 2015
Nov 27 2015
Nov 28 2015
Nov 29 2015
Nov 30 2015
Dec 01 2015

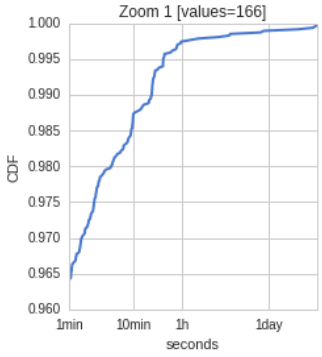

Inter-Event Time [user=gluch, events=6356]
CDF
1ms
1s
1min
1h
1day
seconds
Zoom 1 [values=118]
1min
10min
1h
1day
seconds
Zoom 2 [values=15]
10min
1h
3h
12h
1d
3d
seconds

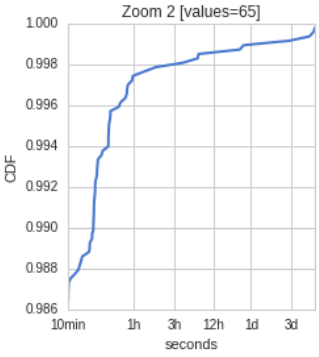

Device Traffic [user=bridgeman.husband]
windows-laptop [6698]
DNS requests
windows-laptop [1027]
HTTP Requests
windows-laptop [5950]
Filtered HTTP Requests
windows-laptop [2348]
Hour of Day
0
5
10
15
20
16:00:00
19:00:00
22:00:00
01:00:00
04:00:00
07:00:00
10:00:00
13:00:00
16:00:00
19:00:00
22:00:00

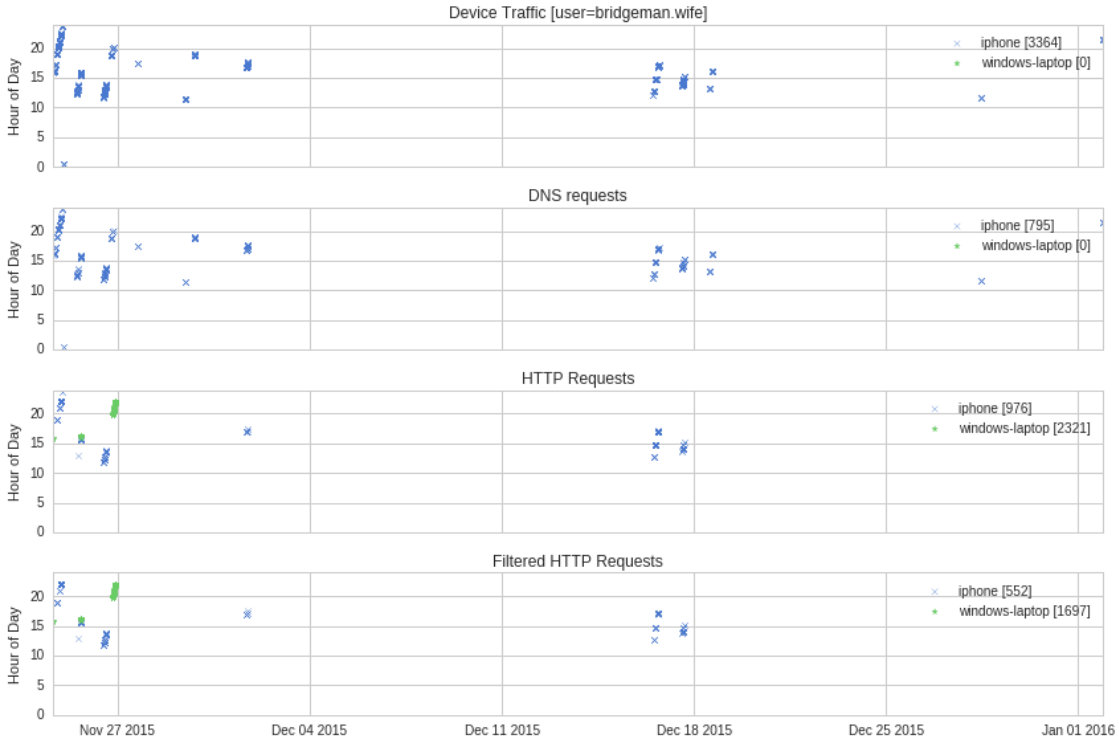

Inter-Event Time [user=bridgeman.husband, events=3374]
CDF
0.0
0.2
0.4
0.6
0.8
1.0
1ms
1s
1min
1h
1day
seconds
Zoom 1 [values=88]
0.970
0.975
0.980
0.985
0.990
0.995
1.000
1min
10min
1h
Zoom 2 [values=10]
0.9970
0.9975
0.9980
0.9985
0.9990
0.9995
1.0000
10min
1h
3h
12h

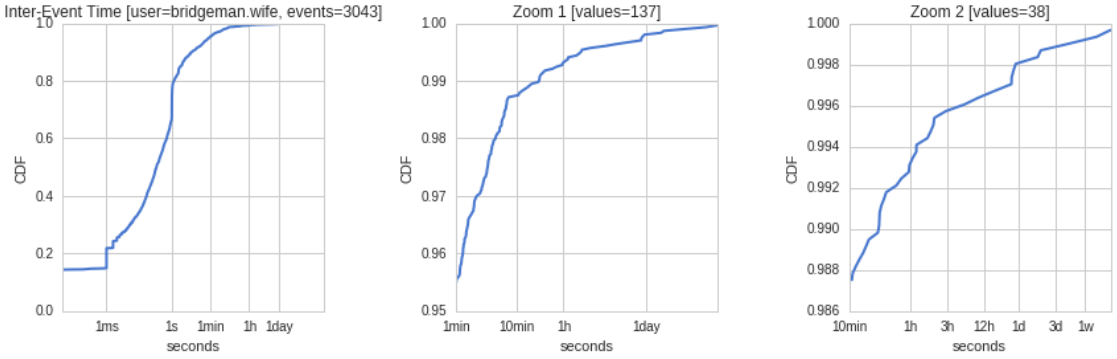

Device Traffic [user=barnesldavid.wife]
android-tablet [5656]
DNS requests
android-tablet [1961]
HTTP Requests
android-tablet [4351]
Filtered HTTP Requests
android-tablet [2686]
Hour of Day
Nov 15 2015
Nov 18 2015
Nov 21 2015
Nov 24 2015
Nov 27 2015
Nov 30 2015
Dec 03 2015


Inter-Event Time [user=barnesldavid.wife, events=4646]
CDF
1ms
1s
1min
1h
1day
seconds


Zoom 1 [values=166]
CDF
1min
10min
1h
1day
seconds


Zoom 2 [values=65]
CDF
10min
1h
3h
12h
1d
3d
seconds






```
In [ ]: ses = Session()

        # minutes
        BINSIZE=120

        weekdata = []
        for uid in sorted(usertraffic, key=lambda x : usertraffic[x], reverse=True):
            weektotal = 0.0
            weekdays = {}
```

```
    for k in range(0,7*24*60,BINSIZE):
        k = k/BINSIZE
        weekdays[k] = 0.0

    q = ses.query(DeviceAppTraffic.ts,
                  DeviceAppTraffic.bytes_in,
                  DeviceAppTraffic.bytes_out).filter(
                    DeviceAppTraffic.devid.in_(devsperuser[uid]))

    for (ts,byin,byout) in q.all():
        bytes = 0
        if (byin!=None):
            bytes += byin
        if (byout!=None):
            bytes += byout

        timeofday = ts.weekday()*24*60 + ts.hour*60 + ts.minute
        binidx = timeofday/BINSIZE

        weekdays[binidx] += bytes
        weektotal += bytes

    # to % of bytes
    for k in range(0,7*24*60,BINSIZE):
        k = k/BINSIZE
        if (weektotal>0):
            weekdays[k] = 100.0*(weekdays[k]*1.0/weektotal)

    weekdata.append(weekdays.values())

cmap = sns.dark_palette("#ffffff", as_cmap=True, reverse=True)
f, ax = plt.subplots(1, 1, figsize=(12, 4))
ax = sns.heatmap(weekdata,
                 cmap=cmap,
                 vmin=0,
                 vmax=100.0,
                 linewidths=.5,
                 xticklabels=12,
                 yticklabels=False)

ax.set_title("Network Activity")
ax.set_ylabel("Participant")
ax.set_xlabel("")
ax.set_xticklabels(['Mon','Tue','Wed','Thu','Fri','Sat','Sun'], rotation=0)
plt.show()

# TODO: app activity
```

```
        ses.close()

In [ ]: ses = Session()

        # uid => total traffic
        usertraffic = {}
        for uid in devsperuser:
            usertraffic[uid] = 0.0

            q = ses.query(func.sum(DeviceAppTraffic.bytes_in),
                          func.sum(DeviceAppTraffic.bytes_out),
                          func.sum(DeviceAppTraffic.packets_in),
                          func.sum(DeviceAppTraffic.packets_out)).filter(
                            DeviceAppTraffic.devid.in_(devsperuser[uid]))

            for row in q.all():
                if (row[0]==None or row[1]==None or row[0]+row[1]==0):
                    continue
                usertraffic[uid] += row[0]*1.0
                usertraffic[uid] += row[1]*1.0

        print usertraffic.keys()

        cmap = sns.dark_palette("#ffffff", as_cmap=True, reverse=True)

        # minutes
        BINSIZE=60

        weekdata = []
        wedata = []
        alldata = []

        for uid in sorted(usertraffic, key=lambda x : usertraffic[x], reverse=True):
            weektotal = 0.0
            wetotal = 0.0
            alltotal = 0.0
            weekdays = {}
            weekend = {}
            alldays = {}
            for k in range(0,24*60,BINSIZE):
                k = k/BINSIZE
                weekdays[k] = 0.0
                weekend[k] = 0.0
                alldays[k] = 0.0

            q = ses.query(DeviceAppTraffic.ts,
                          DeviceAppTraffic.bytes_in,
                          DeviceAppTraffic.bytes_out).filter(
```

```
                    DeviceAppTraffic.devid.in_(devsperuser[uid]))

    for (ts,byin,byout) in q.all():
        bytes = 0
        if (byin!=None):
            bytes += byin
        if (byout!=None):
            bytes += byout

        timeofday = ts.hour*60 + ts.minute
        binidx = timeofday/BINSIZE

        if (ts.weekday() == 5 or ts.weekday() == 6):
            weekend[binidx] += bytes
            wetotal += bytes
        else:
            weekdays[binidx] += bytes
            weektotal += bytes

        alldays[binidx] += bytes
        alltotal += bytes

    # to % of bytes
    for k in range(0,24*60,BINSIZE):
        k = k/BINSIZE
        if (weektotal>0):
            weekdays[k] = 100.0*(weekdays[k]*1.0/weektotal)
        if (wetotal>0):
            weekend[k] = 100.0*(weekend[k]*1.0/wetotal)
        if (alltotal>0):
            alldays[k] = 100.0*(alldays[k]*1.0/alltotal)

    weekdata.append(weekdays.values())
    wedata.append(weekend.values())
    alldata.append(alldays.values())

# Network Activity Heatmap [weekday|weekend]: x: time-of-day, y: user, intensity: % of t
ax = sns.heatmap(weekdata,
                 cmap=cmap,
                 square=True,
                 vmin=0,
                 vmax=100.0,
                 linewidths=.5,
                 yticklabels=False)
ax.set_title("Network Activity During Week Days")
ax.set_ylabel("Participant")
ax.set_xlabel("Hour-of-day")
plt.show()
```

```
ax = sns.heatmap(wedata,
                 cmap=cmap,
                 square=True,
                 vmin=0,
                 vmax=100.0,
                 linewidths=.5,
                 yticklabels=False)
ax.set_title("Network Activity During Weekends")
ax.set_ylabel("Participant")
ax.set_xlabel("Hour-of-day")
plt.show()

ax = sns.heatmap(alldata,
                 cmap=cmap,
                 square=True,
                 vmin=0,
                 vmax=100.0,
                 linewidths=.5,
                 yticklabels=False)
ax.set_title("Network Activity")
ax.set_ylabel("Participant")
ax.set_xlabel("Hour-of-day")
plt.show()

# App (DNS+HTTP) Activity Heatmap [weekday|weekend]: x: time-of-day, y: user, intensity:

weekdata = []
wedata = []
alldata = []

for uid in sorted(usertraffic, key=lambda x : usertraffic[x], reverse=True):
    weektotal = 0.0
    wetotal = 0.0
    alltotal = 0.0
    weekdays = {}
    weekend = {}
    alldays = {}
    for k in range(0,24*60,BINSIZE):
        k = k/BINSIZE
        weekdays[k] = 0.0
        weekend[k] = 0.0
        alldays[k] = 0.0

    q = ses.query(HttpReq.ts).filter(
                    HttpReq.devid.in_(devsperuser[uid])).filter(
                    HttpReq.user_url==True)
    for row in q.all():
```

```
            ts = row[0]
            timeofday = ts.hour*60 + ts.minute
            binidx = timeofday/BINSIZE

            if (ts.weekday() == 5 or ts.weekday() == 6):
                weekend[binidx] += 1
                wetotal += 1
            else:
                weekdays[binidx] += 1
                weektotal += 1

            alldays[binidx] += 1
            alltotal += 1

        q = ses.query(DnsReq.ts).filter(
                        DnsReq.devid.in_(devsperuser[uid])).filter(
                        DnsReq.user_req==True)
        for row in q.all():
            ts = row[0]
            timeofday = ts.hour*60 + ts.minute
            binidx = timeofday/BINSIZE

            if (ts.weekday() == 5 or ts.weekday() == 6):
                weekend[binidx] += 1
                wetotal += 1
            else:
                weekdays[binidx] += 1
                weektotal += 1

            alldays[binidx] += 1
            alltotal += 1


        # to % of bytes
        for k in range(0,24*60,BINSIZE):
            k = k/BINSIZE
            if (weektotal>0):
                weekdays[k] = 100.0*(weekdays[k]*1.0/weektotal)
            if (wetotal>0):
                weekend[k] = 100.0*(weekend[k]*1.0/wetotal)
            if (alltotal>0):
                alldays[k] = 100.0*(alldays[k]*1.0/alltotal)

        weekdata.append(weekdays.values())
        wedata.append(weekend.values())
        alldata.append(alldays.values())

    # User App Activity Heatmap [weekday|weekend]: x: time-of-day, y: user, intensity: % of
```

```
ax = sns.heatmap(weekdata,
                 cmap=cmap,
                 square=True,
                 vmin=0,
                 vmax=100.0,
                 linewidths=.5,
                 yticklabels=False)
ax.set_title("User Activity During Week Days")
ax.set_ylabel("Participant")
ax.set_xlabel("Hour-of-day")
plt.show()

ax = sns.heatmap(wedata,
                 cmap=cmap,
                 square=True,
                 vmin=0,
                 vmax=100.0,
                 linewidths=.5,
                 yticklabels=False)
ax.set_title("User Activity During Weekends")
ax.set_ylabel("Participant")
ax.set_xlabel("Hour-of-day")
plt.show()

ax = sns.heatmap(alldata,
                 cmap=cmap,
                 square=True,
                 vmin=0,
                 vmax=100.0,
                 linewidths=.5,
                 yticklabels=False)
ax.set_title("User Activity")
ax.set_ylabel("Participant")
ax.set_xlabel("Hour-of-day")
plt.show()

ses.close()
```

1.4 User Activity

Activity = period of events that occur < 10min apart. Properties:

- Time of day
- Duration (start - end)
- Device(s) - could span multiple devices
- Network(s)
- Where ? Should I guess be limited to a single location (ignore mobility for now ?)
- What ? Set of unique domain names

- Apps ? Set of unique user agents (or list of running / active apps from hostview or android)

```
In [89]: # top users based on above graphs
         frusers = ['salmita', 'bencardino','sormain', 'shelter', 'norelie']
         ukusers = ['neenagupta', 'michaelbrogan', 'chrismaley', 'clifford.wife', 'bowen.husband

         # build per user activities: username - > list of tuples (starttime, endtime)
         activities = defaultdict(list)

         # in seconds (10min)
         inactivitylim = 600
         minduration = 1.0
         minevents = 2

         ses = Session()
         for uname in list(frusers) + list(ukusers):
             u = ses.query(User).filter(User.username==uname).one()
             devids = ",".join([str(d.id) for d in u.devices if not d.shared])

             sqlq = """SELECT ts,lag(ts) OVER (ORDER BY ts) FROM \
             (SELECT ts FROM dnsreqs WHERE devid IN (%s) UNION ALL \
              SELECT ts FROM httpreqs2 WHERE devid IN (%s) AND user_url = 't') \
             AS events"""%(devids,devids)

             start = None
             last = None
             ecnt = 0
             for row in ses.execute(text(sqlq)):
                 if (row[1]==None):
                     start = row[0]
                     last = start
                     continue

                 dur = (row[1]-start).total_seconds()
                 if ((row[0]-row[1]).total_seconds() > activitylim):
                     if (dur >= minduration and ecnt > minevents):
                         activities[uname].append((start,row[1],dur,ecnt))
                     start = row[0]
                     ecnt = 0
                 last = row[0]
                 ecnt += 1

             dur = (last-start).total_seconds()
             if (dur >= minduration and ecnt > minevents):
                 activities[uname].append((start,last,dur,ecnt))

             # duration CDF
             (x,y) = datautils.aecdf([t[2] for t in activities[uname]])
```

```
f, (ax1, ax2, ax3) = plt.subplots(1, 3, figsize=(15, 4))
ax1.plot(x,y, '-', lw=2, color=colors[0])
ax1.set_title('Activities [user=%s, count=%d]'%(uname, len(x)))
ax1.set_ylabel('CDF')
ax1.set_xscale('log')
ax1.set_xlabel('Duration')
ax1.set_xticks([1,60,3600,24*3600])
ax1.set_xticklabels(['1s','1min','1h','1day'])

# num events
ecnt = np.array(sorted([t[3] for t in activities[uname]], reverse=True))

sns.distplot(ecnt, ax=ax2, color=colors[1], kde=False)
ax2.set_title('Histogram of events per activity')
ax2.set_xlabel('Number of Events')

data = [(t[2],t[3]) for t in activities[uname]]

maxdur = max([t[0] for t in data])
maxcnt = max([t[1] for t in data])

ax3.set_title('Correlation')
ax3.scatter([t[0] for t in data], [t[1] for t in data], marker='*', color=colors[2]

ax3.set_xscale('log')
ax3.set_xlabel('Duration')
ax3.set_xticks([1,60,3600,24*3600])
ax3.set_xticklabels(['1s','1min','1h','1day'])

ax3.set_ylabel('Events')
ax3.set_ylim(0,maxcnt)

plt.show()

# color activity per device
devs = {}
for d in u.devices:
    if (d.shared):
        continue
    devs[d.id] = d.platform

# devid => activities
data = defaultdict(list)
for t in activities[uname]:
    # devices that sent http reqs during this activity
    q1 = ses.query(HttpReq.devid).filter(HttpReq.devid.in_(devs.keys()),
                                         HttpReq.user_url==True,
```

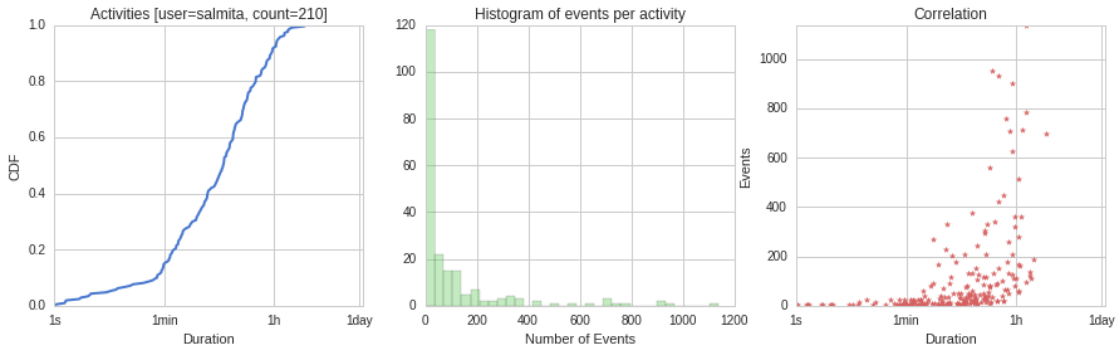
```
                                                HttpReq.ts >= t[0],
                                                HttpReq.ts < t[1])
            # devices that sent dns reqs during this activity
            q2 = ses.query(DnsReq.devid).filter(DnsReq.devid.in_(devs.keys()),
                                                DnsReq.ts >= t[0],
                                                DnsReq.ts < t[1])
            # all unique devices
            for d in q1.union(q2).all():
                data[d[0]].append((t[0],t[2],t[3]))

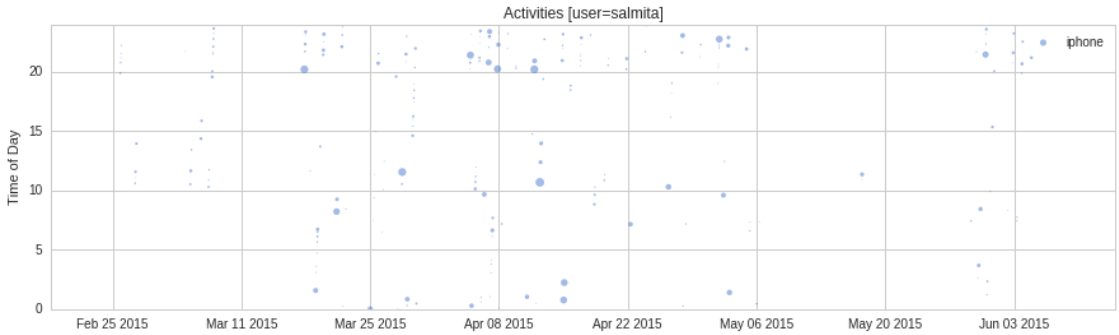
    f, (ax1) = plt.subplots(1, 1, figsize=(15, 4))

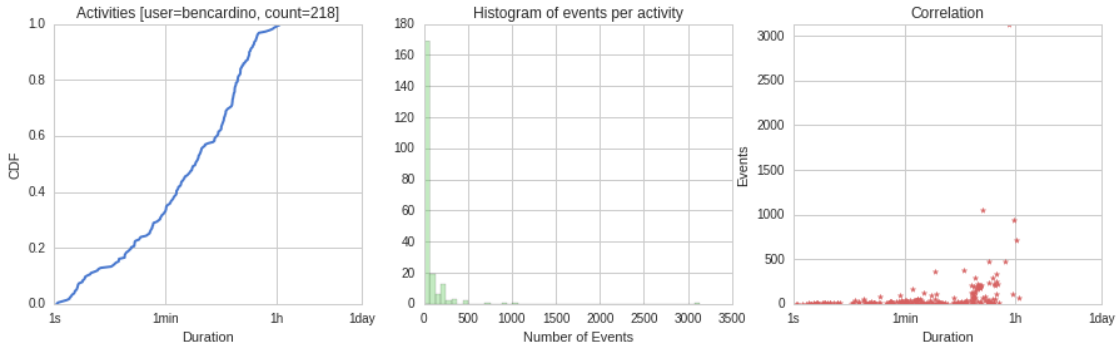
    for idx,devid in enumerate(data.keys()):
        x = [t[0] for t in data[devid]] # starttime
        y = [t[0].hour + t[0].minute/60.0 for t in data[devid]] # hour-of-day
        sizes = [(t[2]*400.0)/maxdur for t in data[devid]] # scale size of the marker t

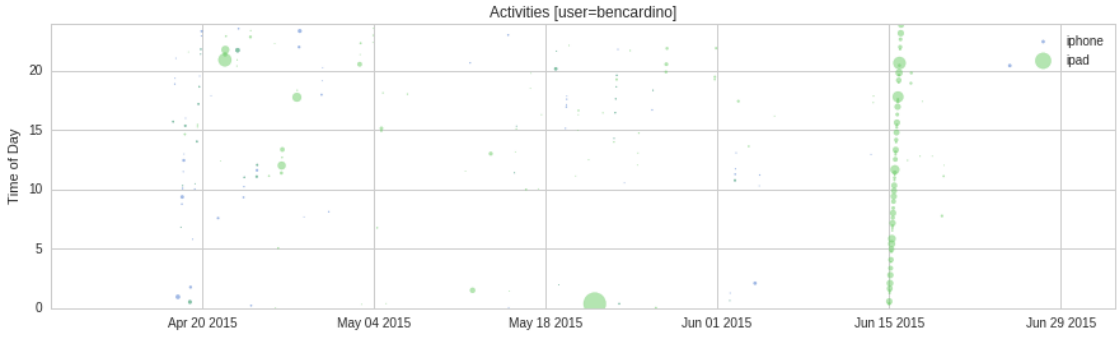
        ax1.scatter(x, y, alpha=0.5, color=colors[idx], s=sizes, label="%s"%devs[devid]

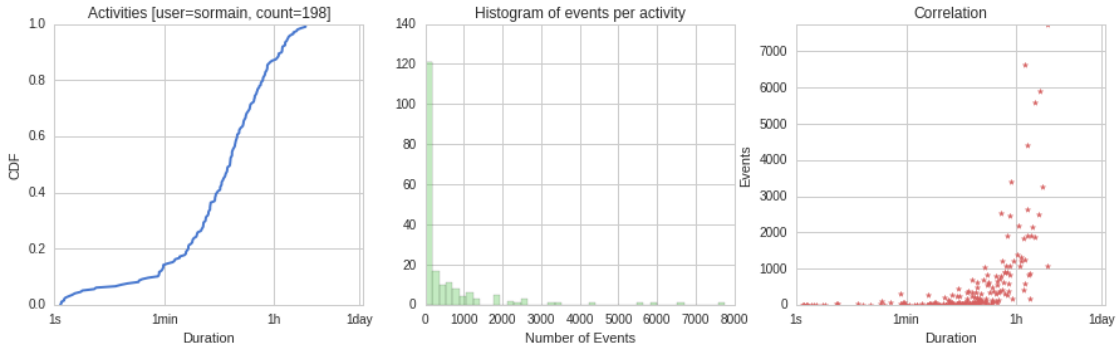
    ax1.set_title('Activities [user=%s]'%(uname))
    ax1.set_ylabel('Time of Day')
    ax1.set_ylim(0,24)
    ax1.legend(loc='best')
ses.close()
```

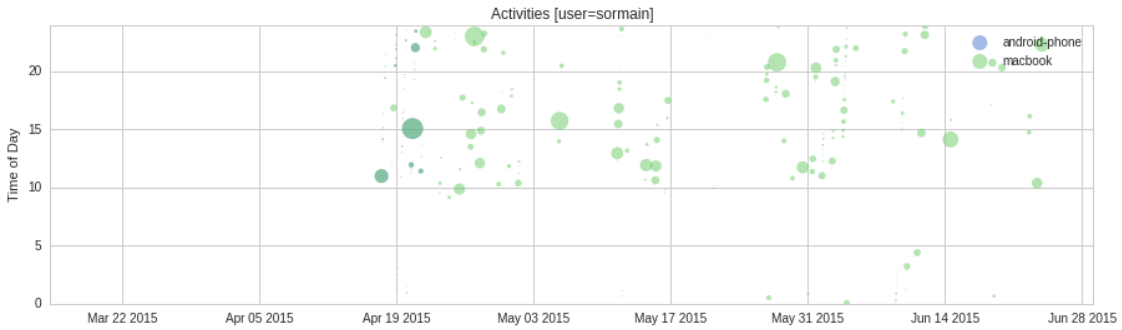


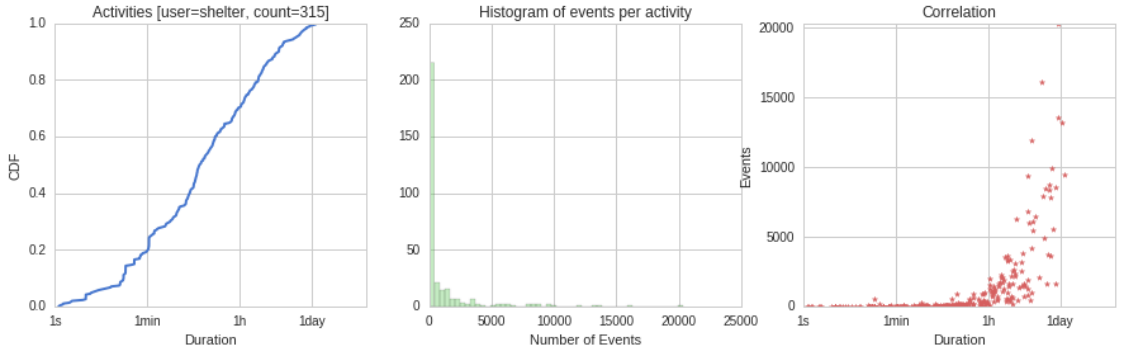


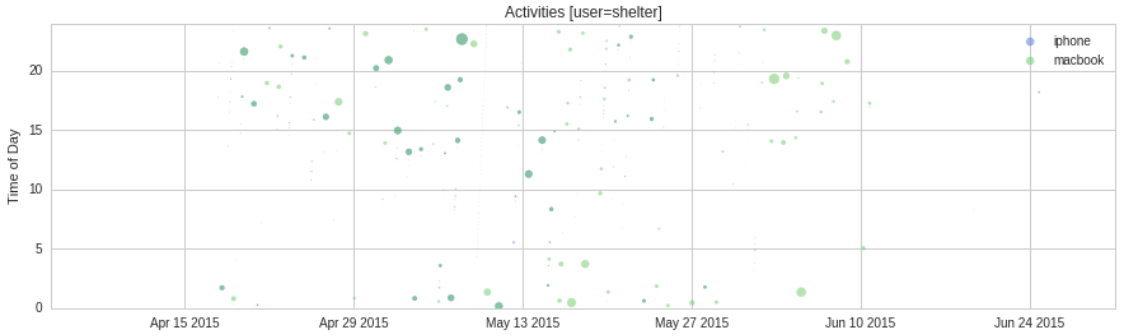

Activities [user=bencardino, count=218]
CDF
Duration
1s
1min
1h
1day
Histogram of events per activity
Number of Events
Correlation
Events
Duration

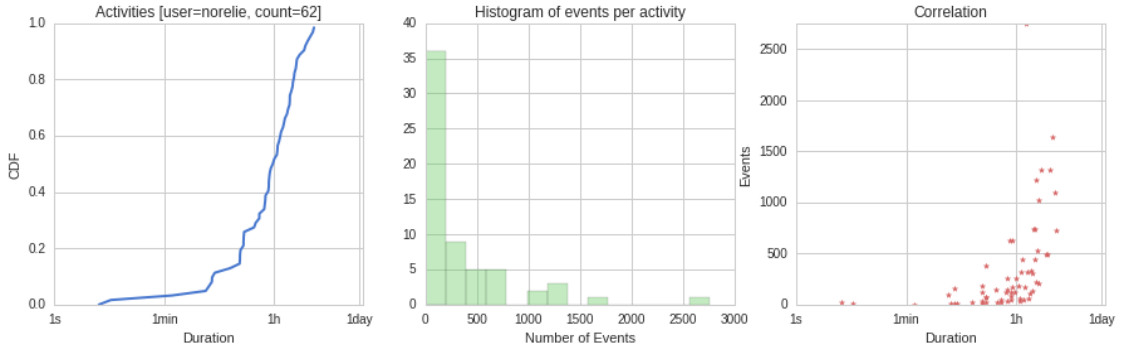

Activities [user=bencardino]
Time of Day
iphone
ipad
Apr 20 2015
May 04 2015
May 18 2015
Jun 01 2015
Jun 15 2015
Jun 29 2015

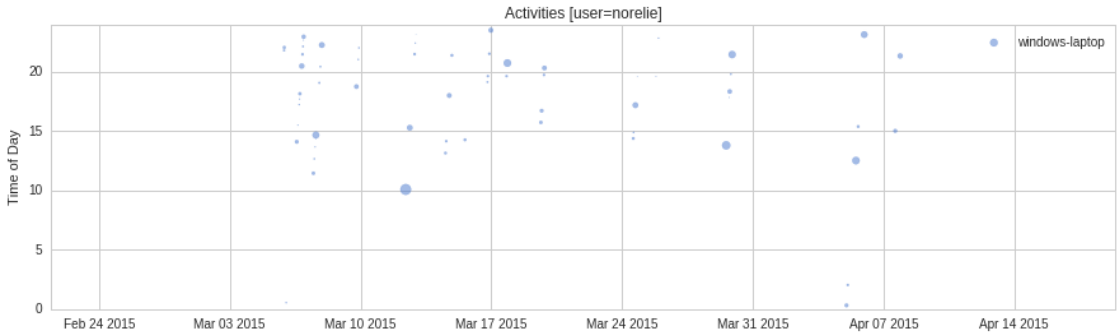

Activities [user=sormain, count=198]
CDF
Duration
1s
1min
1h
1day
Histogram of events per activity
Number of Events
Correlation
Events
Duration

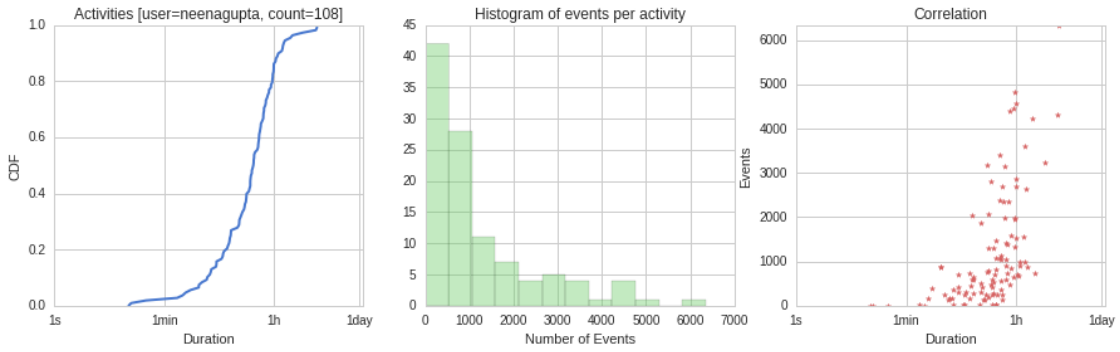

Activities [user=sormain]
android-phone
macbook
Time of Day
0
5
10
15
20
Mar 22 2015
Apr 05 2015
Apr 19 2015
May 03 2015
May 17 2015
May 31 2015
Jun 14 2015
Jun 28 2015

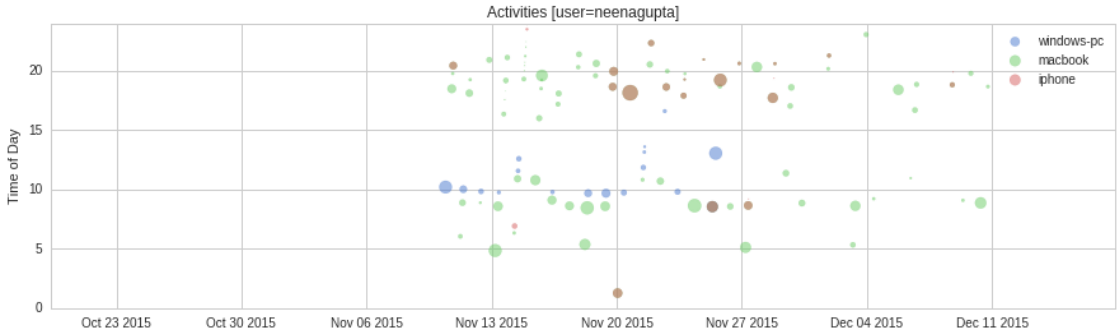

Activities [user=shelter, count=315]
CDF
Duration
1s
1min
1h
1day
Histogram of events per activity
Number of Events
Correlation
Events
Duration

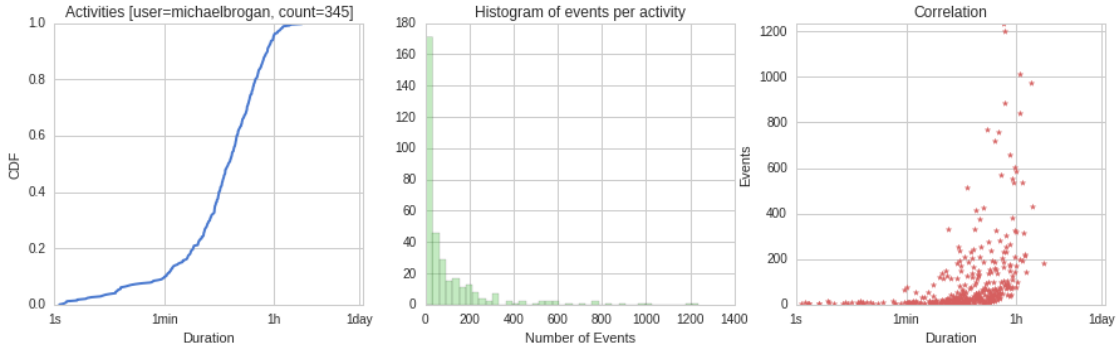

Activities [user=shelter]
iphone
macbook
Time of Day
Apr 15 2015
Apr 29 2015
May 13 2015
May 27 2015
Jun 10 2015
Jun 24 2015

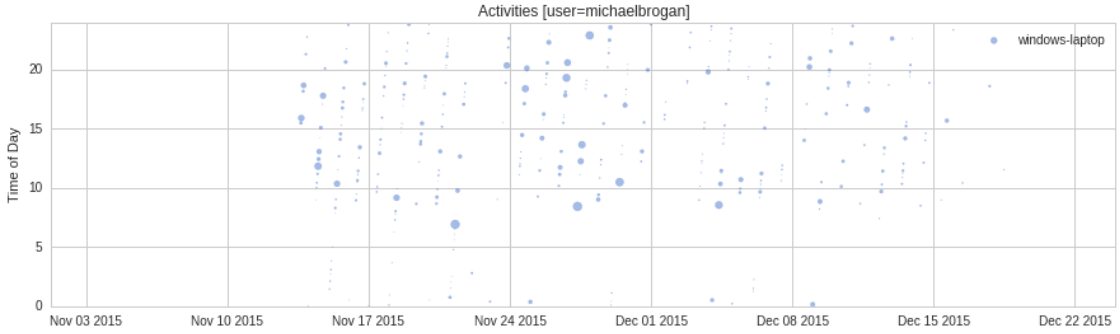

Activities [user=norelie, count=62]
CDF
Duration
Histogram of events per activity
Number of Events
Correlation
Events
Duration

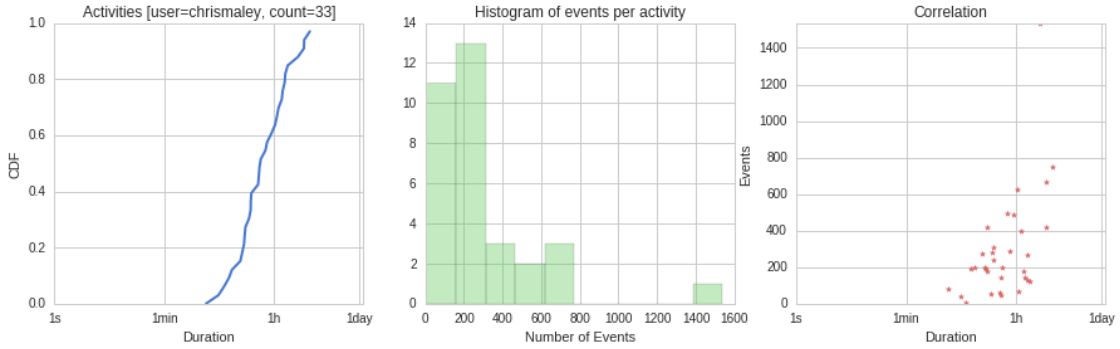

Activities [user=norelie]
windows-laptop
Time of Day
0
5
10
15
20
Feb 24 2015
Mar 03 2015
Mar 10 2015
Mar 17 2015
Mar 24 2015
Mar 31 2015
Apr 07 2015
Apr 14 2015

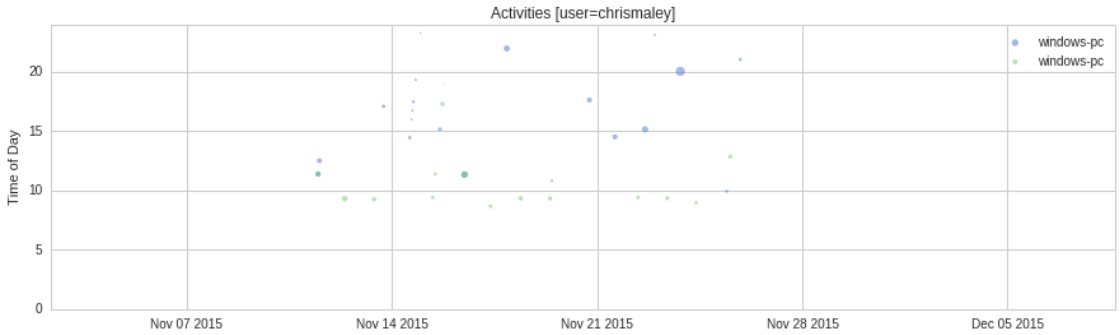

Activities [user=neenagupta, count=108]
CDF
0.0
0.2
0.4
0.6
0.8
1.0
1s
1min
1h
1day
Duration
Histogram of events per activity
0
5
10
15
20
25
30
35
40
45
0
1000
2000
3000
4000
5000
6000
7000
Number of Events
Correlation
Events
0
1000
2000
3000
4000
5000
6000
1s
1min
1h
1day
Duration

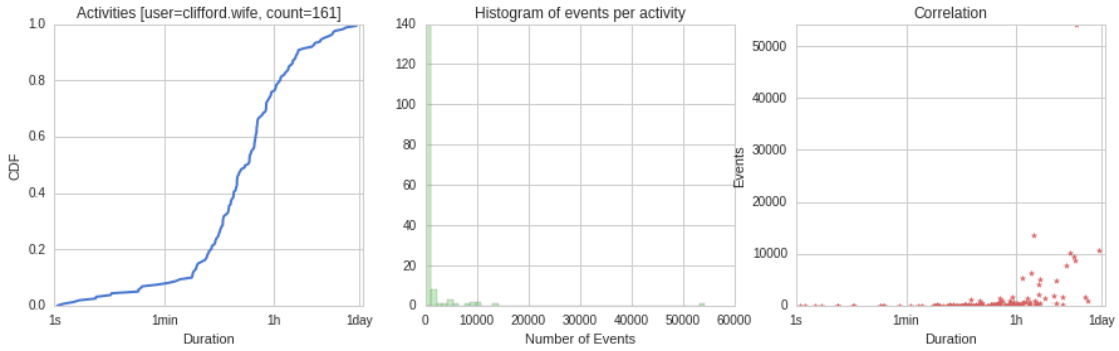

Activities [user=neenagupta]
windows-pc
macbook
iphone
Time of Day
0
5
10
15
20
Oct 23 2015
Oct 30 2015
Nov 06 2015
Nov 13 2015
Nov 20 2015
Nov 27 2015
Dec 04 2015
Dec 11 2015

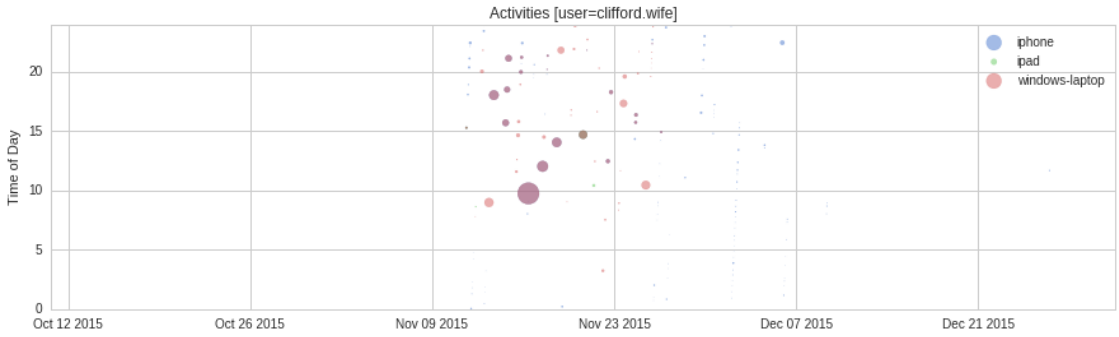

Activities [user=michaelbrogan, count=345]
CDF
Duration
1s
1min
1h
1day
Histogram of events per activity
Number of Events
Correlation
Events
Duration

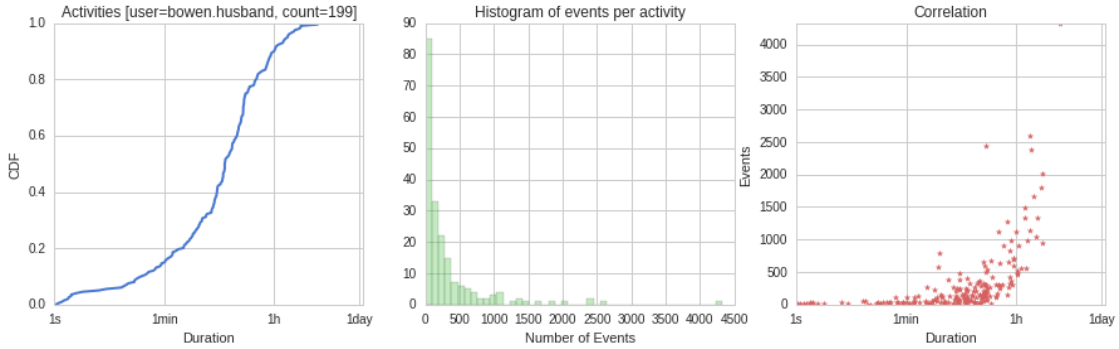

Activities [user=michaelbrogan]
windows-laptop
Time of Day
Nov 03 2015
Nov 10 2015
Nov 17 2015
Nov 24 2015
Dec 01 2015
Dec 08 2015
Dec 15 2015
Dec 22 2015

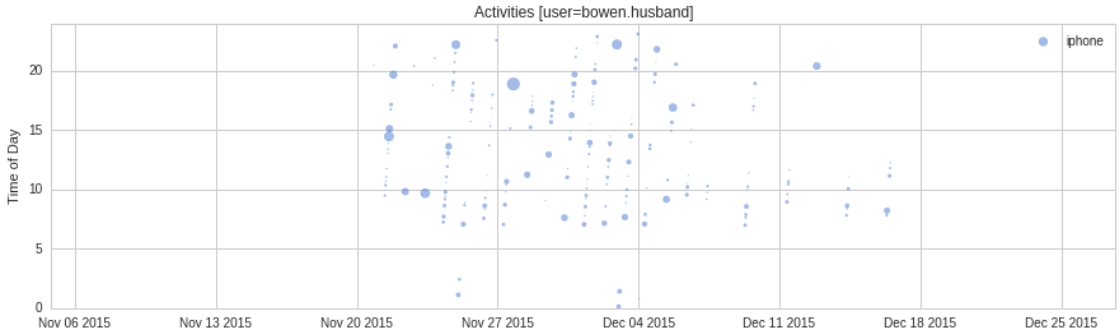

Activities [user=chrismaley, count=33]
CDF
Duration
1s
1min
1h
1day
Histogram of events per activity
Number of Events
Correlation
Events
Duration

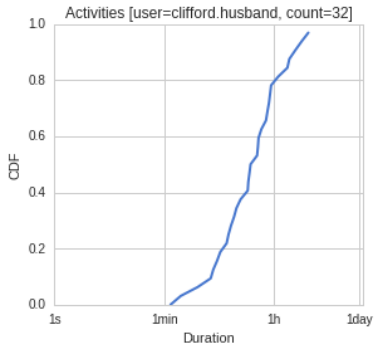

Activities [user=chrismaley]
windows-pc
windows-pc
Time of Day
Nov 07 2015
Nov 14 2015
Nov 21 2015
Nov 28 2015
Dec 05 2015

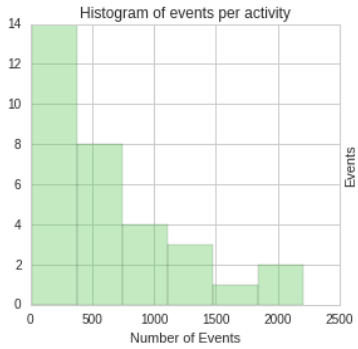

Activities [user=clifford.wife, count=161]
CDF
Duration
1s
1min
1h
1day
Histogram of events per activity
Number of Events
Correlation
Events
Duration

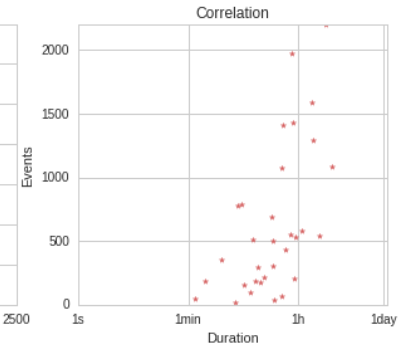

Activities [user=clifford.wife]
Time of Day
Oct 12 2015
Oct 26 2015
Nov 09 2015
Nov 23 2015
Dec 07 2015
Dec 21 2015
iphone
ipad
windows-laptop

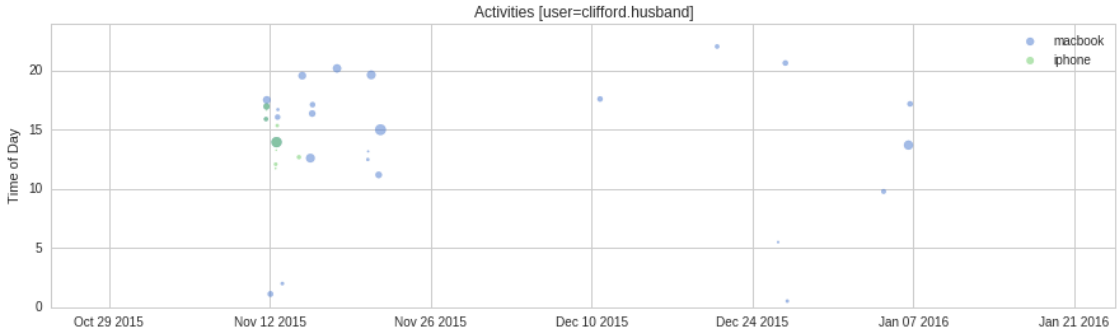

Activities [user=bowen.husband, count=199]
CDF
Duration
1s
1min
1h
1day
Histogram of events per activity
Number of Events
Correlation
Events
Duration

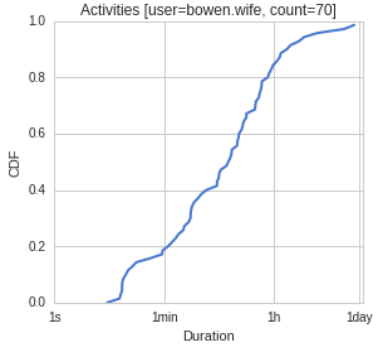

Activities [user=bowen.husband]
iphone
Time of Day
0
5
10
15
20
Nov 06 2015
Nov 13 2015
Nov 20 2015
Nov 27 2015
Dec 04 2015
Dec 11 2015
Dec 18 2015
Dec 25 2015

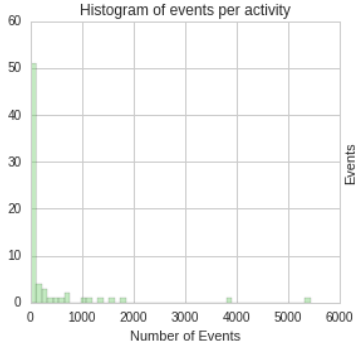

Activities [user=clifford.husband, count=32]
CDF
0.0
0.2
0.4
0.6
0.8
1.0
1s
1min
1h
1day
Duration

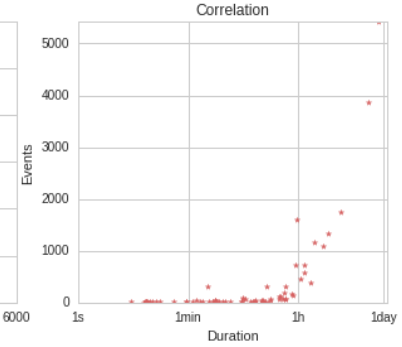

Histogram of events per activity
0
2
4
6
8
10
12
14
0
500
1000
1500
2000
2500
Number of Events

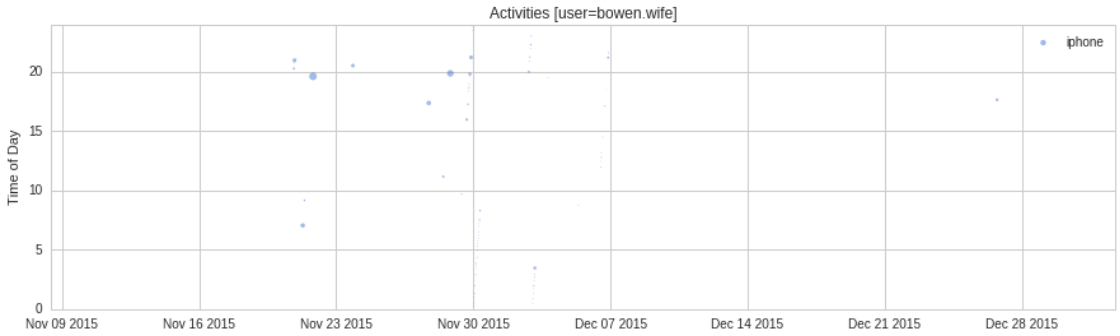

Correlation
Events
0
500
1000
1500
2000
1s
1min
1h
1day
Duration

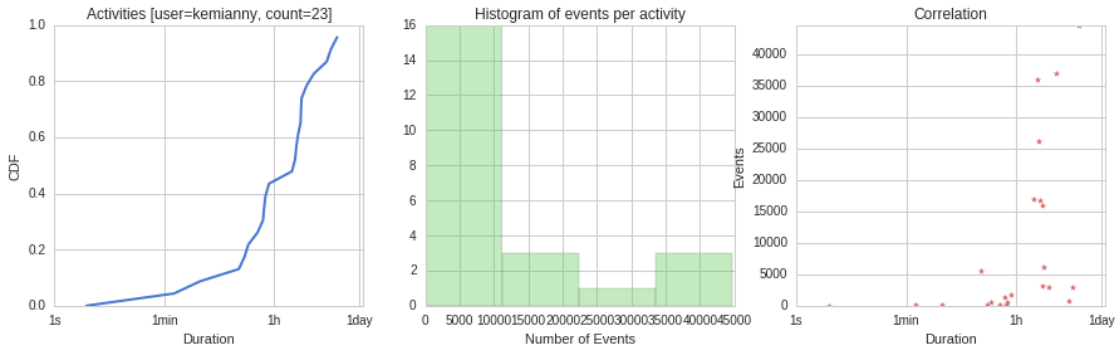

Activities [user=clifford.husband]
macbook
iphone
Time of Day
0
5
10
15
20
Oct 29 2015
Nov 12 2015
Nov 26 2015
Dec 10 2015
Dec 24 2015
Jan 07 2016
Jan 21 2016

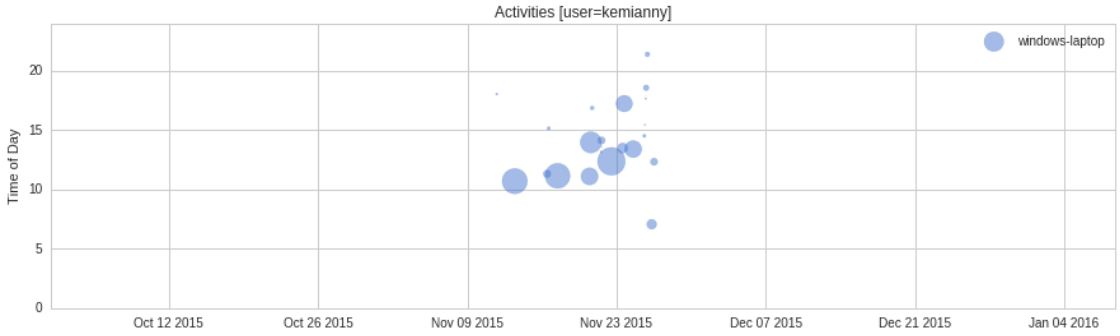

Activities [user=bowen.wife, count=70]
CDF
0.0
0.2
0.4
0.6
0.8
1.0
1s
1min
1h
1day
Duration


Histogram of events per activity
0
10
20
30
40
50
60
0
1000
2000
3000
4000
5000
6000
Number of Events


Correlation
Events
0
1000
2000
3000
4000
5000
1s
1min
1h
1day
Duration







1.5 Dissecting QoE Factors

Characterize the activities as a function of the QoE factors. How varying is the (QoE) context in the end ?

1.5.1 User

Demographics

Interests

Mood => Do the characterization per user, do not have enough data for breaking down per demographics and we do not know so much about their mood or interests either (could get something from the interviews ?)

1.5.2 System Factors

Device

- device type: phone, tablet, laptop, PC (proxy for screen size, capacity etc.)
- usage: shared or personal

=> Are some activites device specific ? Some others independent ? Span multiple devices ?

Network and QoS

- mobile, home (adsl, other), work | wifi or fixed

=> Are some activities network specific ?

- RTT: device - VPN - internet (access delay depends on above, former could proxy congestion)
- Losses: up/down retransmissions, dupl ACKs,
- bulk vs app limited transfer periods (mean pkt size vs interarrival)

=> does the network QoS impact activity (shorter than usual ?)

Application, Service, Content => maybe not so relevant, as we look at activities (not multimedia consumption in particular for example)

1.5.3 Context

Physical environment location, movement

Temporal time-of-day, duration, frequency

Economic cost of service, subscription type etc

Social situation presence of other people

Task context multitasking or not

```
In [112]: from sqlalchemy import or_, and_

          ses = Session()

          uname = 'neenagupta'
          u = ses.query(User).filter(User.username==uname).one()
          devs = {}
          for d in u.devices:
              if (d.shared):
                  continue
              devs[d.id] = d.platform

          for t in activities[uname]:
              print str(t[0]),str(t[1]),'duration (min)',t[2]/60.0,'events',t[3]

              # devices that sent http reqs during this activity
              q1 = ses.query(HttpReq.devid).filter(HttpReq.devid.in_(devs.keys()),
                                                   HttpReq.user_url==True,
                                                   HttpReq.ts >= t[0],
                                                   HttpReq.ts < t[1])
              # devices that sent dns reqs during this activity
              q2 = ses.query(DnsReq.devid).filter(DnsReq.devid.in_(devs.keys()),
                                                  DnsReq.ts >= t[0],
                                                  DnsReq.ts < t[1])


              # devices related to the event
              fdevs = []
              for d in q1.union(q2).all():
                  fdevs.append(d.devid)
                  print devs[d.devid],
              print ''

              # for locating the user, assume that he always carries his phone :)
              for d in u.devices:
                  if (d.platform == 'iphone' or d.platform == 'android-phone'):
                      fdevs.append(d.id)

              # location(s)
              ql = ses.query(Location).filter(Location.devid.in_(fdevs),
                                              or_(and_(Location.entertime <= t[0], Location.exit
                                                  and_(Location.entertime < t[1], Location.exitt
              for l in ql.all():
                  print l.name,l.loc_name,l.net_asname,l.source,l.entertime,l.exittime

              # domains
```

```
            q1 = ses.query(HttpReq.req_url_host).filter(HttpReq.devid.in_(devs.keys()),
                                                        HttpReq.user_url==True,
                                                        HttpReq.ts >= t[0],
                                                        HttpReq.ts < t[1])
            # devices that sent dns reqs during this activity
            q2 = ses.query(DnsReq.query).filter(DnsReq.devid.in_(devs.keys()),
                                                DnsReq.ts >= t[0],
                                                DnsReq.ts < t[1])


        #    # devices related to the event
        #    for d in q1.union(q2).all():
        #        print d,


            print '---------'

        ses.close()
```

```
2015-11-10 10:12:38.772903 2015-11-10 14:56:30.794398 duration (min) 283.867024917 events 4312
windows-pc
Long Row West, Nottingham None  JANET - Jisc Services Limited hostview 2015-11-10 10:10:18.90900
Triumph Road, Nottingham  None moves 2015-11-10 10:43:56 2015-11-10 17:03:52
---------
2015-11-10 18:29:20.782751 2015-11-10 19:25:35.375852 duration (min) 56.24321835 events 1980
macbook
Faraday Road, Nottingham  None moves 2015-11-10 18:20:27 2015-11-11 06:56:38
---------
2015-11-10 19:46:25.338380 2015-11-10 20:15:49.651009 duration (min) 29.4052104833 events 239
macbook
Faraday Road, Nottingham  None moves 2015-11-10 18:20:27 2015-11-11 06:56:38
---------
2015-11-10 20:26:29.373990 2015-11-10 21:46:23.854295 duration (min) 79.9080050833 events 1555
macbook iphone
Faraday Road, Nottingham  None moves 2015-11-10 18:20:27 2015-11-11 06:56:38
---------
2015-11-11 06:03:05.403336 2015-11-11 06:19:17.234604 duration (min) 16.1971878 events 505
macbook
Faraday Road, Nottingham  None moves 2015-11-10 18:20:27 2015-11-11 06:56:38
---------
2015-11-11 08:53:00.366642 2015-11-11 09:21:25.281731 duration (min) 28.4152514833 events 1068
macbook
Faraday Road, Nottingham  None moves 2015-11-11 08:17:51 2015-11-11 09:53:53
---------
2015-11-11 10:01:01.557000 2015-11-11 10:28:38.563000 duration (min) 27.6167666667 events 1464
windows-pc
Long Row West, Nottingham None  JANET - Jisc Services Limited hostview 2015-11-11 10:00:54.44000
Triumph Road, Nottingham  None moves 2015-11-11 10:00:25 2015-11-11 13:51:11
```

```
---------
2015-11-11 18:07:10.295186 2015-11-11 18:48:20.179845 duration (min) 41.1647443167 events 1402
macbook
Faraday Road, Nottingham  None moves 2015-11-11 17:43:47 2015-11-12 06:59:56
---------
2015-11-11 19:15:33.943525 2015-11-11 19:24:31.891899 duration (min) 8.96580623333 events 245
macbook
Faraday Road, Nottingham  None moves 2015-11-11 17:43:47 2015-11-12 06:59:56
---------
2015-11-12 08:53:54.406705 2015-11-12 09:04:38.258904 duration (min) 10.7308699833 events 173
macbook
Faraday Road, Nottingham  None moves 2015-11-12 08:17:22 2015-11-12 09:40:12
---------
2015-11-12 09:50:26.335000 2015-11-12 09:57:27.423000 duration (min) 7.01813333333 events 711
windows-pc
Nottingham, United Kingdom  None moves 2015-11-12 09:50:29 2015-11-12 16:54:50
Long Row West, Nottingham None  JANET - Jisc Services Limited hostview 2015-11-12 09:50:16.83700
---------
2015-11-12 20:55:18.990538 2015-11-12 21:44:42.560997 duration (min) 49.3928409833 events 861
macbook
Faraday Road, Nottingham  None moves 2015-11-12 20:42:37 2015-11-13 06:56:50
---------
2015-11-13 04:51:01.958078 2015-11-13 05:38:24.326835 duration (min) 47.3728126167 events 4389
macbook
Faraday Road, Nottingham  None moves 2015-11-12 20:42:37 2015-11-13 06:56:50
---------
2015-11-13 08:35:49.758083 2015-11-13 09:19:58.214202 duration (min) 44.1409353167 events 2360
macbook
Faraday Road, Nottingham  None moves 2015-11-13 08:20:29 2015-11-13 09:39:50
---------
2015-11-13 09:45:15.410000 2015-11-13 09:51:02.112000 duration (min) 5.77836666667 events 369
windows-pc
Long Row West, Nottingham None  JANET - Jisc Services Limited hostview 2015-11-13 09:45:12.37800
Triumph Road, Nottingham  None moves 2015-11-13 09:44:50 2015-11-13 16:09:53
---------
2015-11-13 16:21:26.870336 2015-11-13 16:55:01.143408 duration (min) 33.5712178667 events 557
macbook
Faraday Road, Nottingham  None moves 2015-11-13 16:18:48 2015-11-14 08:54:07
---------
2015-11-13 17:34:20.187000 2015-11-13 18:02:21.432000 duration (min) 28.02075 events 26
macbook
Faraday Road, Nottingham  None moves 2015-11-13 16:18:48 2015-11-14 08:54:07
---------
2015-11-13 18:17:46.093000 2015-11-13 18:18:16.340000 duration (min) 0.504116666667 events 4
macbook
Faraday Road, Nottingham  None moves 2015-11-13 16:18:48 2015-11-14 08:54:07
---------
2015-11-13 19:00:42.547000 2015-11-13 19:00:58.513000 duration (min) 0.2661 events 3
```

```
macbook
Faraday Road, Nottingham  None moves 2015-11-13 16:18:48 2015-11-14 08:54:07
---------
2015-11-13 19:11:54.602962 2015-11-13 19:55:52.419792 duration (min) 43.9636138333 events 727
macbook
Faraday Road, Nottingham  None moves 2015-11-13 16:18:48 2015-11-14 08:54:07
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2015-11-13 21:07:41.854556 2015-11-13 21:34:40.195802 duration (min) 26.9723541 events 700
macbook
Faraday Road, Nottingham  None moves 2015-11-13 16:18:48 2015-11-14 08:54:07
---------
2015-11-14 06:20:06.799109 2015-11-14 06:44:46.588896 duration (min) 24.6631631167 events 260
macbook
Faraday Road, Nottingham  None moves 2015-11-13 16:18:48 2015-11-14 08:54:07
---------
2015-11-14 06:55:10.596449 2015-11-14 08:54:14.586000 duration (min) 119.066492517 events 738
iphone
Faraday Road, Nottingham  None moves 2015-11-13 16:18:48 2015-11-14 08:54:07
---------
2015-11-14 10:54:22.862707 2015-11-14 11:19:38.099705 duration (min) 25.2539499667 events 1296
macbook
Faraday Road, Nottingham  None moves 2015-11-14 10:21:35 2015-11-14 11:22:11
---------
2015-11-14 11:34:13.182000 2015-11-14 12:20:23.658000 duration (min) 46.1746 events 489
windows-pc
Long Row West, Nottingham None  JANET - Jisc Services Limited hostview 2015-11-14 11:33:46.51000
Triumph Road, Nottingham  None moves 2015-11-14 11:33:08 2015-11-14 16:01:51
---------
2015-11-14 12:35:07.406000 2015-11-14 13:38:20.838000 duration (min) 63.2238666667 events 703
windows-pc
Triumph Road, Nottingham  None moves 2015-11-14 11:33:08 2015-11-14 16:01:51
---------
2015-11-14 19:18:50.286278 2015-11-14 19:45:01.156056 duration (min) 26.1811629667 events 533
macbook
Faraday Road, Nottingham  None moves 2015-11-14 19:00:57 2015-11-15 08:54:54
---------
2015-11-14 20:00:10.773000 2015-11-14 20:08:37.348000 duration (min) 8.44291666667 events 17
macbook
Faraday Road, Nottingham  None moves 2015-11-14 19:00:57 2015-11-15 08:54:54
---------
2015-11-14 20:26:27.663000 2015-11-14 20:32:08.029000 duration (min) 5.67276666667 events 18
macbook
Faraday Road, Nottingham  None moves 2015-11-14 19:00:57 2015-11-15 08:54:54
---------
2015-11-14 20:43:45.879000 2015-11-14 20:58:59.799000 duration (min) 15.232 events 12
macbook
Faraday Road, Nottingham  None moves 2015-11-14 19:00:57 2015-11-15 08:54:54
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2015-11-14 21:14:24.631000 2015-11-14 21:49:42.232000 duration (min) 35.29335 events 123
macbook
Faraday Road, Nottingham  None moves 2015-11-14 19:00:57 2015-11-15 08:54:54
---------
2015-11-14 22:00:26.839000 2015-11-14 22:09:17.720000 duration (min) 8.84801666667 events 32
macbook
Faraday Road, Nottingham  None moves 2015-11-14 19:00:57 2015-11-15 08:54:54
---------
2015-11-14 22:27:55.129000 2015-11-14 22:28:12.709000 duration (min) 0.293 events 5
macbook
Faraday Road, Nottingham  None moves 2015-11-14 19:00:57 2015-11-15 08:54:54
---------
2015-11-14 23:30:28.748405 2015-11-14 23:35:57.360157 duration (min) 5.47686253333 events 151
iphone
Faraday Road, Nottingham  None moves 2015-11-14 19:00:57 2015-11-15 08:54:54
---------
2015-11-14 23:51:00.711000 2015-11-14 23:53:00.343000 duration (min) 1.99386666667 events 3
iphone
Faraday Road, Nottingham  None moves 2015-11-14 19:00:57 2015-11-15 08:54:54
---------
2015-11-15 10:47:13.834092 2015-11-15 12:13:05.185910 duration (min) 85.8558636333 events 2641
macbook
Faraday Road, Nottingham  None moves 2015-11-15 10:21:31 2015-11-15 12:32:08
---------
2015-11-15 16:00:11.111075 2015-11-15 16:40:18.814221 duration (min) 40.1283857667 events 895
macbook
Faraday Road, Nottingham  None moves 2015-11-15 15:56:53 2015-11-15 16:45:09
---------
2015-11-15 18:30:51.254274 2015-11-15 18:56:58.272552 duration (min) 26.1169713 events 270
macbook
Faraday Road, Nottingham  None moves 2015-11-15 18:26:51 2015-11-16 06:56:25
---------
2015-11-15 19:14:43.897928 2015-11-15 19:19:43.640074 duration (min) 4.99570243333 events 154
macbook
Faraday Road, Nottingham  None moves 2015-11-15 18:26:51 2015-11-16 06:56:25
---------
2015-11-15 19:36:10.918324 2015-11-15 20:58:21.843000 duration (min) 82.1820779333 events 3598
macbook
Faraday Road, Nottingham  None moves 2015-11-15 18:26:51 2015-11-16 06:56:25
---------
2015-11-16 09:06:26.018236 2015-11-16 09:27:37.320000 duration (min) 21.1883627333 events 2066
macbook
Faraday Road, Nottingham  None moves 2015-11-16 08:16:24 2015-11-16 09:38:11
---------
2015-11-16 09:47:37.935000 2015-11-16 09:54:37.801000 duration (min) 6.99776666667 events 434
windows-pc
Long Row West, Nottingham None  JANET - Jisc Services Limited hostview 2015-11-16 09:47:12.60000
Triumph Road, Nottingham  None moves 2015-11-16 09:46:34 2015-11-16 16:56:16
```

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2015-11-16 17:11:47.678770 2015-11-16 17:52:10.407173 duration (min) 40.3788067167 events 581
macbook
Faraday Road, Nottingham  None moves 2015-11-16 17:08:00 2015-11-17 09:24:17
---------
2015-11-16 18:05:40.432396 2015-11-16 19:35:15.476031 duration (min) 89.5840605833 events 888
macbook
Faraday Road, Nottingham  None moves 2015-11-16 17:08:00 2015-11-17 09:24:17
---------
2015-11-17 08:37:59.894382 2015-11-17 09:16:23.642580 duration (min) 38.3958033 events 1984
macbook
Faraday Road, Nottingham  None moves 2015-11-16 17:08:00 2015-11-17 09:24:17
---------
2015-11-17 20:18:54.234455 2015-11-17 20:36:01.280144 duration (min) 17.11742815 events 433
macbook
Faraday Road, Nottingham  None moves 2015-11-17 19:48:22 2015-11-18 06:57:12
---------
2015-11-17 21:23:06.776147 2015-11-17 21:51:04.503961 duration (min) 27.9621302333 events 832
macbook
Faraday Road, Nottingham  None moves 2015-11-17 19:48:22 2015-11-18 06:57:12
---------
2015-11-18 05:22:36.432497 2015-11-18 06:02:33.240381 duration (min) 39.9467980667 events 3154
macbook
Faraday Road, Nottingham  None moves 2015-11-17 19:48:22 2015-11-18 06:57:12
---------
2015-11-18 08:27:00.017290 2015-11-18 09:25:38.466243 duration (min) 58.6408158833 events 4569
macbook
Faraday Road, Nottingham  None moves 2015-11-18 08:11:28 2015-11-18 09:28:30
---------
2015-11-18 09:41:03.057631 2015-11-18 10:40:06.513000 duration (min) 59.0575894833 events 1537
windows-pc
Long Row West, Nottingham None  JANET - Jisc Services Limited hostview 2015-11-18 09:40:50.32500
Triumph Road, Nottingham  None moves 2015-11-18 09:40:24 2015-11-18 13:56:55
---------
2015-11-18 19:35:08.034361 2015-11-18 20:00:04.275791 duration (min) 24.9373571667 events 589
macbook
Faraday Road, Nottingham  None moves 2015-11-18 18:26:44 2015-11-19 06:56:38
---------
2015-11-18 20:37:19.550958 2015-11-18 20:58:18.283000 duration (min) 20.9788673667 events 1299
macbook
Faraday Road, Nottingham  None moves 2015-11-18 18:26:44 2015-11-19 06:56:38
---------
2015-11-19 08:35:17.730509 2015-11-19 09:08:16.431688 duration (min) 32.9783529833 events 2380
macbook
Faraday Road, Nottingham  None moves 2015-11-19 08:19:22 2015-11-19 09:29:46
---------
2015-11-19 09:41:42.464000 2015-11-19 09:53:06.582000 duration (min) 11.4019666667 events 2030
windows-pc
```

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Long Row West, Nottingham None  JANET - Jisc Services Limited hostview 2015-11-19 09:41:12.53800
Triumph Road, Nottingham  None moves 2015-11-19 09:40:40 2015-11-19 12:16:17
---------
2015-11-19 18:39:59.178311 2015-11-19 19:29:38.312070 duration (min) 49.6522293167 events 1592
macbook iphone
Faraday Road, Nottingham  None moves 2015-11-19 17:21:07 2015-11-20 06:56:43
---------
2015-11-19 19:57:29.513663 2015-11-19 20:54:35.051742 duration (min) 57.0923013167 events 1968
macbook iphone
Faraday Road, Nottingham  None moves 2015-11-19 17:21:07 2015-11-20 06:56:43
---------
2015-11-20 01:16:16.697237 2015-11-20 01:52:56.531024 duration (min) 36.66389645 events 2341
macbook iphone
Faraday Road, Nottingham  None moves 2015-11-19 17:21:07 2015-11-20 06:56:43
---------
2015-11-20 09:44:29.284000 2015-11-20 09:48:06.637000 duration (min) 3.62255 events 888
windows-pc
Long Row West, Nottingham None  JANET - Jisc Services Limited hostview 2015-11-20 09:44:19.66600
Triumph Road, Nottingham  None moves 2015-11-20 09:43:53 2015-11-20 17:32:22
---------
2015-11-20 18:09:37.049217 2015-11-20 23:05:40.196018 duration (min) 296.052446683 events 6343
iphone macbook
Faraday Road, Nottingham  None moves 2015-11-20 17:39:44 2015-11-21 08:53:00
---------
2015-11-21 10:49:21.030159 2015-11-21 11:23:35.352014 duration (min) 34.2386975833 events 360
macbook
Faraday Road, Nottingham  None moves 2015-11-21 10:24:48 2015-11-21 11:39:45
---------
2015-11-21 11:51:04.235000 2015-11-21 12:55:07.447000 duration (min) 64.0535333333 events 688
windows-pc
Long Row West, Nottingham None  JANET - Jisc Services Limited hostview 2015-11-21 11:50:55.90200
Triumph Road, Nottingham  None moves 2015-11-21 11:49:33 2015-11-21 13:53:43
---------
2015-11-21 13:09:52.341000 2015-11-21 13:21:46.276000 duration (min) 11.8989166667 events 277
windows-pc
Triumph Road, Nottingham  None moves 2015-11-21 11:49:33 2015-11-21 13:53:43
---------
2015-11-21 13:36:27.352000 2015-11-21 13:38:40.200000 duration (min) 2.21413333333 events 174
windows-pc
Triumph Road, Nottingham  None moves 2015-11-21 11:49:33 2015-11-21 13:53:43
---------
2015-11-21 20:32:13.715153 2015-11-21 21:42:00.866683 duration (min) 69.7858588333 events 980
macbook
Faraday Road, Nottingham  None moves 2015-11-21 21:16:37 2015-11-22 08:53:03
---------
2015-11-21 22:20:58.886723 2015-11-21 23:44:15.598541 duration (min) 83.2785303 events 981
iphone macbook
Faraday Road, Nottingham  None moves 2015-11-21 21:16:37 2015-11-22 08:53:03
```

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2015-11-22 10:42:19.174400 2015-11-22 11:38:23.883773 duration (min) 56.07848955 events 1330
macbook
Faraday Road, Nottingham  None moves 2015-11-22 10:16:58 2015-11-22 11:57:58
---------
2015-11-22 16:36:05.401377 2015-11-22 16:38:44.871332 duration (min) 2.65783258333 events 379
windows-pc
Long Row West, Nottingham None  JANET - Jisc Services Limited hostview 2015-11-22 16:35:59.63600
Nottingham, United Kingdom  None moves 2015-11-22 16:35:36 2015-11-22 16:40:22
---------
2015-11-22 18:38:18.005552 2015-11-22 19:21:21.159646 duration (min) 43.0525682333 events 1390
iphone macbook
Faraday Road, Nottingham  None moves 2015-11-22 18:01:25 2015-11-23 06:56:27
---------
2015-11-22 19:58:06.514608 2015-11-22 20:21:32.575725 duration (min) 23.43435195 events 474
macbook
Faraday Road, Nottingham  None moves 2015-11-22 18:01:25 2015-11-23 06:56:27
---------
2015-11-23 09:48:57.943000 2015-11-23 09:52:36.553000 duration (min) 3.6435 events 870
windows-pc
Long Row West, Nottingham None  JANET - Jisc Services Limited hostview 2015-11-23 09:48:54.91700
Triumph Road, Nottingham  None moves 2015-11-23 09:48:17 2015-11-23 17:35:35
---------
2015-11-23 17:54:17.470353 2015-11-23 19:02:02.709907 duration (min) 67.7539925667 events 893
iphone macbook
Faraday Road, Nottingham  None moves 2015-11-23 17:44:54 2015-11-24 06:57:12
---------
2015-11-23 19:16:32.203677 2015-11-23 19:34:17.831661 duration (min) 17.7604664 events 126
iphone macbook
Faraday Road, Nottingham  None moves 2015-11-23 17:44:54 2015-11-24 06:57:12
---------
2015-11-23 19:45:06.599861 2015-11-23 20:06:29.151970 duration (min) 21.3758684833 events 198
macbook
Faraday Road, Nottingham  None moves 2015-11-23 17:44:54 2015-11-24 06:57:12
---------
2015-11-24 08:38:13.505983 2015-11-24 09:35:11.334000 duration (min) 56.9638002833 events 4819
macbook
Faraday Road, Nottingham  None moves 2015-11-24 08:19:12 2015-11-24 09:46:00
---------
2015-11-24 20:57:34.090453 2015-11-24 21:15:56.801575 duration (min) 18.3785187 events 140
macbook iphone
Faraday Road, Nottingham  None moves 2015-11-24 20:49:08 2015-11-25 06:55:58
---------
2015-11-25 08:33:14.254935 2015-11-25 11:25:51.133000 duration (min) 172.614634417 events 3224
iphone windows-pc macbook
Faraday Road, Nottingham  None moves 2015-11-25 08:17:20 2015-11-25 09:35:17
Triumph Road, Nottingham  None moves 2015-11-25 09:44:03 2015-11-25 15:13:05
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2015-11-25 13:03:38.790582 2015-11-25 13:57:09.116000 duration (min) 53.5054236333 events 4457
windows-pc
Long Row West, Nottingham None  JANET - Jisc Services Limited hostview 2015-11-25 13:03:36.53400
Triumph Road, Nottingham  None moves 2015-11-25 09:44:03 2015-11-25 15:13:05
---------
2015-11-25 18:41:30.146754 2015-11-25 18:52:41.586717 duration (min) 11.19066605 events 462
macbook
Faraday Road, Nottingham  None moves 2015-11-25 18:30:07 2015-11-26 09:32:38
---------
2015-11-25 19:13:12.996474 2015-11-25 21:02:39.597205 duration (min) 109.443345517 events 4222
iphone macbook
Faraday Road, Nottingham  None moves 2015-11-25 18:30:07 2015-11-26 09:32:38
---------
2015-11-26 08:34:33.958061 2015-11-26 09:15:42.695733 duration (min) 41.1456278667 events 1032
macbook
Faraday Road, Nottingham  None moves 2015-11-25 18:30:07 2015-11-26 09:32:38
---------
2015-11-26 20:37:52.648352 2015-11-26 20:54:19.325695 duration (min) 16.4446223833 events 299
macbook iphone
Faraday Road, Nottingham  None moves 2015-11-26 19:50:16 2015-11-27 06:58:21
---------
2015-11-27 05:07:17.423160 2015-11-27 05:27:29.095000 duration (min) 20.1945306667 events 3179
macbook
Faraday Road, Nottingham  None moves 2015-11-26 19:50:16 2015-11-27 06:58:21
---------
2015-11-27 08:39:39.210194 2015-11-27 08:56:00.170630 duration (min) 16.3493406 events 1860
macbook iphone
Faraday Road, Nottingham  None moves 2015-11-27 08:14:18 2015-11-27 09:42:09
---------
2015-11-27 09:12:43.706112 2015-11-27 09:41:12.678364 duration (min) 28.4828708667 events 14
iphone
Faraday Road, Nottingham  None moves 2015-11-27 08:14:18 2015-11-27 09:42:09
---------
2015-11-27 20:19:20.938285 2015-11-27 20:43:17.767727 duration (min) 23.9471573667 events 2811
macbook
Faraday Road, Nottingham  None moves 2015-11-27 19:47:29 2015-11-28 08:56:33
---------
2015-11-28 17:43:00.177344 2015-11-28 18:42:18.021797 duration (min) 59.29740755 events 2700
macbook iphone
Faraday Road, Nottingham  None moves 2015-11-28 17:22:20 2015-11-29 08:56:31
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2015-11-28 19:22:21.240003 2015-11-28 19:23:58.738684 duration (min) 1.62497801667 events 17
iphone
Faraday Road, Nottingham  None moves 2015-11-28 17:22:20 2015-11-29 08:56:31
---------
2015-11-28 20:36:40.410850 2015-11-28 21:12:29.723895 duration (min) 35.8218840833 events 253
macbook iphone
Faraday Road, Nottingham  None moves 2015-11-28 17:22:20 2015-11-29 08:56:31
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2015-11-29 11:22:09.694764 2015-11-29 11:55:20.754225 duration (min) 33.18432435 events 1066
macbook
Faraday Road, Nottingham  None moves 2015-11-29 10:23:18 2015-11-29 12:02:55
---------
2015-11-29 17:02:47.262669 2015-11-29 17:22:44.395808 duration (min) 19.9522189833 events 755
macbook
Faraday Road, Nottingham  None moves 2015-11-29 14:33:42 2015-11-30 06:57:03
---------
2015-11-29 18:36:48.874690 2015-11-29 19:11:18.028060 duration (min) 34.4858895 events 1048
macbook
Faraday Road, Nottingham  None moves 2015-11-29 14:33:42 2015-11-30 06:57:03
---------
2015-11-30 08:51:01.862297 2015-11-30 09:25:06.265681 duration (min) 34.0733897333 events 1139
macbook
Faraday Road, Nottingham  None moves 2015-11-30 08:17:56 2015-11-30 09:49:06
---------
2015-12-01 20:10:30.892533 2015-12-01 20:19:50.401138 duration (min) 9.32514341667 events 319
macbook
Faraday Road, Nottingham  None moves 2015-12-01 19:41:09 2015-12-02 06:54:10
---------
2015-12-01 21:17:08.994416 2015-12-01 21:41:49.840438 duration (min) 24.6807670333 events 425
macbook iphone
Faraday Road, Nottingham  None moves 2015-12-01 19:41:09 2015-12-02 06:54:10
---------
2015-12-03 05:20:55.526913 2015-12-03 05:31:20.337000 duration (min) 10.41350145 events 740
macbook
Faraday Road, Nottingham  None moves 2015-12-02 20:12:07 2015-12-03 06:57:33
---------
2015-12-03 08:37:03.530794 2015-12-03 09:13:30.365000 duration (min) 36.4472367667 events 2694
macbook
Faraday Road, Nottingham  None moves 2015-12-03 08:17:20 2015-12-03 09:41:25
---------
2015-12-03 23:03:10.187561 2015-12-03 23:15:10.234000 duration (min) 12.0007739833 events 600
macbook
Faraday Road, Nottingham  None moves 2015-12-03 18:59:08 2015-12-04 09:51:21
---------
2015-12-04 09:13:42.562650 2015-12-04 09:17:46.924000 duration (min) 4.07268916667 events 240
macbook
Faraday Road, Nottingham  None moves 2015-12-03 18:59:08 2015-12-04 09:51:21
---------
2015-12-05 18:24:17.898587 2015-12-05 19:23:25.759749 duration (min) 59.1310193667 events 2854
macbook
Faraday Road, Nottingham  None moves 2015-12-05 18:18:43 2015-12-06 08:54:15
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2015-12-06 10:57:42.168737 2015-12-06 11:02:34.407671 duration (min) 4.8706489 events 124
macbook
Faraday Road, Nottingham  None moves 2015-12-06 10:33:51 2015-12-06 13:15:53
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2015-12-06 16:41:38.563159 2015-12-06 17:03:05.085965 duration (min) 21.4420467667 events 799
macbook
Faraday Road, Nottingham  None moves 2015-12-06 16:27:11 2015-12-07 06:58:47
---------
2015-12-06 18:51:59.600506 2015-12-06 19:04:03.932000 duration (min) 12.0721915667 events 634
macbook
Faraday Road, Nottingham  None moves 2015-12-06 16:27:11 2015-12-07 06:58:47
---------
2015-12-08 18:49:30.822935 2015-12-08 19:42:46.718590 duration (min) 53.2649275833 events 640
macbook iphone
Faraday Road, Nottingham  None moves 2015-12-08 18:29:38 2015-12-09 06:56:12
---------
2015-12-08 19:54:18.796583 2015-12-08 20:18:56.702781 duration (min) 24.6317699667 events 25
iphone
Faraday Road, Nottingham  None moves 2015-12-08 18:29:38 2015-12-09 06:56:12
---------
2015-12-09 09:05:16.536320 2015-12-09 09:24:46.182315 duration (min) 19.4940999167 events 260
macbook
Faraday Road, Nottingham  None moves 2015-12-09 08:23:03 2015-12-09 09:38:40
---------
2015-12-09 19:47:35.122458 2015-12-09 19:59:06.836339 duration (min) 11.5285646833 events 599
macbook
Faraday Road, Nottingham  None moves 2015-12-09 18:06:39 2015-12-10 06:58:53
---------
2015-12-10 08:52:47.138841 2015-12-10 09:24:50.281800 duration (min) 32.05238265 events 3407
macbook
Faraday Road, Nottingham  None moves 2015-12-10 08:19:00 2015-12-10 09:41:38
---------
2015-12-10 18:40:22.546270 2015-12-10 18:47:16.302000 duration (min) 6.89592883333 events 314
macbook
Faraday Road, Nottingham  None moves 2015-12-10 18:18:59 2015-12-11 06:57:31
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```

```
In [109]: from sqlalchemy import or_, and_

          ses = Session()

          uname = 'sormain'
          u = ses.query(User).filter(User.username==uname).one()
          devs = {}
          for d in u.devices:
              if (d.shared):
                  continue
              devs[d.id] = d.platform

          for t in activities[uname]:
```