0. Exploring enron email dataset

June 25, 2020

> Enron Corporation was an American energy, commodities, and services company based in Houston, Texas. It was founded in 1985 as a merger between Houston Natural Gas and InterNorth, both relatively small regional companies. Before its bankruptcy on December 3, 2001, Enron employed approximately 29,000 staff and was a major electricity, natural gas, communications and pulp and paper company, with claimed revenues of nearly $101 billion during 2000. Fortune named Enron ”America’s Most Innovative Company” for six consecutive years.
>
> — Wikipedia

Let’s watch enron email dataset which became public domain after Enron bankruptcy.

You can download the dataset from this place.

0.1 Loading data and draft data preparing

[1]:
```
import warnings
import pandas as pd
from utils import make_dataset
warnings.filterwarnings("ignore")

data = make_dataset()
```

```
100%|      | 30109/30109 [00:02<00:00, 12782.82it/s]
```

[2]:
```
data.head()
```

[2]:
```
                         date              subject                      from  \
11433 1999-12-10 05:05:00           Tetco 7c's   chris.germany@enron.com
11432 1999-12-10 05:05:00           Tetco 7c's   chris.germany@enron.com
18894 1999-12-10 05:12:00     New EPRM Speakers  vince.kaminski@enron.com
18893 1999-12-10 05:13:00  Re: New EPRM Speakers  vince.kaminski@enron.com
304   1999-12-10 07:00:00                          phillip.allen@enron.com

                              to  \
11433    judy.townsend@enron.com
11432  brenda.fletcher@enron.com
18894   stinson.gibner@enron.com
18893          helen@risk.co.uk
```

```
304     naomi.johnston@enron.com


                                                     text
11433  I have updated the Tetco 7c usage tickets to i…
11432  I have updated the Tetco 7c usage tickets to i…
18894  Stinson,\n\nThis is the request I got from RIS…
18893  Helen,\n\nI forwarded your message to my assoc…
304    Naomi,\n\nThe two analysts that I have had con…
```

We should tokenize and lemmatize(or stem) text data for unification and better feature engineering.

[3]:

```
%%time
import nltk
from bs4 import BeautifulSoup
from nltk.stem import WordNetLemmatizer
from nltk.tokenize import TweetTokenizer

tknzr = TweetTokenizer()
lm = WordNetLemmatizer()

data['text'] = data['text'].apply(lambda x: tknzr.tokenize(x))
data['subject'] = data['subject'].apply(lambda x: tknzr.tokenize(x))

data['text'] = data['text'].apply(lambda x:
    BeautifulSoup(
        ' '.join([lm.lemmatize(token).lower() for token in x])
    ).text
)
data['subject'] = data['subject'].apply(lambda x:
    BeautifulSoup(
        ' '.join([lm.lemmatize(token).lower() for token in x])
    ).text
)
```

```
CPU times: user 1min 12s, sys: 1.07 s, total: 1min 13s
Wall time: 1min 12s
```

[4]:

```
data.head()
```

[4]:

```
                      date                subject                     from  \
11433 1999-12-10 05:05:00           tetco 7c ' s   chris.germany@enron.com
11432 1999-12-10 05:05:00           tetco 7c ' s   chris.germany@enron.com
18894 1999-12-10 05:12:00      new eprm speakers  vince.kaminski@enron.com
18893 1999-12-10 05:13:00 re : new eprm speakers  vince.kaminski@enron.com
304   1999-12-10 07:00:00                          phillip.allen@enron.com

                           to  \
11433    judy.townsend@enron.com
11432  brenda.fletcher@enron.com
18894   stinson.gibner@enron.com
18893           helen@risk.co.uk
304     naomi.johnston@enron.com

                                                    text
11433  i have updated the tetco 7c usage ticket to in…
11432  i have updated the tetco 7c usage ticket to in…
18894  stinson , this is the request i got from risk …
18893  helen , i forwarded your message to my associa…
304    naomi , the two analyst that i have had contac…
```

0.2 Sentiments in dataset

Of course, as we know story of this company is accounting fraud story.

Therefore, look on sentiments on email subjects and message bodies.

0.2.1 Sentiment in subjects

[5]:

```
%%time
from vaderSentiment.vaderSentiment import SentimentIntensityAnalyzer
analyzer = SentimentIntensityAnalyzer()

text_sentiment = pd.DataFrame(data['text'].apply(lambda x: analyzer.
 ↪polarity_scores(x)).tolist())
subject_sentiment = pd.DataFrame(data['subject'].apply(lambda x: analyzer.
 ↪polarity_scores(x)).tolist())
subject_sentiment.head()
```

```
CPU times: user 5min 44s, sys: 79.9 ms, total: 5min 44s
Wall time: 5min 44s
```

[5]:

```
   neg  neu  pos  compound
0  0.0  1.0  0.0       0.0
1  0.0  1.0  0.0       0.0
2  0.0  1.0  0.0       0.0
3  0.0  1.0  0.0       0.0
4  0.0  0.0  0.0       0.0
```

[6]:

```
subject_sentiment['neg'].max(), subject_sentiment['pos'].max()
```

[6]:

```
(1.0, 1.0)
```

```
[7]: data[subject_sentiment['neg'] == subject_sentiment['neg'].max()][['date',␣
     ↪'subject', 'text']]
```

```
[7]:                      date                                            subject  \
18619 2000-01-31 00:20:00  re : additional bloomberg terminal for weather…
7730  2000-04-06 01:40:00                               re : sitara training
2494  2000-09-28 01:09:00  jackson.logan@enron.com , ami.chokshi@enron.com ,
6037  2000-10-02 05:55:00                                          re : lipa
14270 2000-10-11 01:56:00                                        re : thanks
33803 2000-11-28 07:37:00                             re : ken lay interview
23757 2000-12-07 14:20:00                  speak now … turbopark consent
23727 2000-12-08 04:25:00                               re : override letter
27097 2000-12-29 03:52:00                        re : mhi - 2162 / launching
34763 2001-02-13 04:29:00                                       re : #517891
21146 2001-03-26 00:09:00  andres.balmaceda@enron.com , sladana-anna.kuli…

                                                    text
18619  jason , there wa a problem with the request . …
7730                               no , i don't want to .
2494   - - - forwarded by eric bass / hou / ect on 09…
6037   guys , assuming that we receive $ 7m for the 6…
14270                                                no
33803  thanks for the in-depth information on our man…
23757  here's the turbopark consent . please call me …
23727  " taylor , rob "  on 12/08 / 2000 12:21 : 28 p…
27097    thanks , i had not seen it . happy new year . m
34763  no , thank you ! i've changed it to caiso ener…
21146  fyi , it may be wise to run a few of your macr…
```

```
[8]: data[subject_sentiment['pos'] == subject_sentiment['pos'].max()][['date',␣
     ↪'subject', 'text']]
```

```
[8]:                      date                                            subject  \
1747  1999-12-14 02:59:00                                   re : deal 117413
19582 1999-12-14 07:11:00                                           re : eol
9063  2000-01-11 00:42:00                                           the memo
15191 2000-02-09 08:18:00  michelle.neville@enron.com , angela.barnett@en…
10760 2000-03-08 23:54:00                                  re : cng-kriscott
…                     …                                                 …
25364 2001-05-14 06:58:00                     re : confidentiality agreement
22228 2001-05-31 03:55:00                     re : mdea agreement scheduling
4738  2001-06-17 20:41:00        re : question about tw operational capacity
4737  2001-06-17 20:41:00        re : question about tw operational capacity
4739  2001-06-26 10:55:00  re : wednesday's meeting on tropical storm all…

                                                    text
1747   done ! anything else entex man ? - e enron nor…
```

```
19582  sorry , he ha told me that at least 10 time . …
9063   congratulations to you both ! your designation…
15191  - - - forwarded by judy hernandez / hou / ect …
10760  angie , this is not anything to worry about ri…
…                                                 …
25364  three glitch he probably just changed over to …
22228  please fill in the blank : = 01 & first contin…
4738   brian , just wanted to follow up to be sure yo…
4737   brian , just wanted to follow up to be sure yo…
4739   mary , we would love to have you come . thanks…

[107 rows x 3 columns]
```

Yes, as we can see, there were messages with negative subjects about financial troubles.

0.2.2 Sentiment in messages

Also there are similar picture with message body sentiments.

```
[9]: text_sentiment.head()
```

```
[9]:    neg    neu    pos  compound
     0  0.000  1.000  0.000    0.0000
     1  0.000  1.000  0.000    0.0000
     2  0.013  0.868  0.119    0.9388
     3  0.000  0.851  0.149    0.9593
     4  0.013  0.926  0.061    0.6786
```

```
[10]: text_sentiment['neg'].max(), text_sentiment['pos'].max()
```

```
[10]: (1.0, 1.0)
```

```
[11]: data[text_sentiment['neg'] == text_sentiment['neg'].max()][['date', 'subject',␣
       ↪'text']]
```

```
[11]:                      date                                           subject  \
      18866 1999-12-17 07:15:00                             re : emission trading
      9986  2000-06-19 09:49:00                                          re : map
      14546 2001-02-01 01:03:00  shelia.benke@enron.com , donald.black@enron.com ,
      9363  2001-02-06 09:41:00                   re : gallup station - demand rebate
      6813  2001-02-14 00:59:00               re : ees europe - outsourcing reorganisation
      21175 2001-03-21 00:05:00  re : november 2000 emw variances v financial l…
      26767 2001-04-04 08:15:00                                              pseg
      26598 2001-04-11 07:16:00                                 breakout contract
      35367 2001-05-07 15:57:00          west gas customer offisite - proposed

                                                    text
```

```
18866  - - - forwarded by vince j kaminski / hou / ec…
9986   you de man . could you change the spelling fro…
14546  christian asked me to work with dan watkiss to…
9363   i haven't had a chance to study this yet , but…
6813   matthew , sound fine - i will have kay start m…
21175  where are these being transferred from ? i onl…
26767     i hear your deal blew up . what happened ? ckm
26598  fyi - - - forwarded by kay mann / corp / enron…
35367  dorie , laura … can i get together with you …
```

[12]:
```
data[text_sentiment['pos'] == text_sentiment['pos'].max()][['date', 'subject',␣
 ↪'text']]
```

[12]:
```
                     date                                             subject  \
18870 1999-12-17 07:05:00                                     a paper of mine
18727 2000-01-11 01:56:00                                     congratulations
10770 2000-03-08 05:51:00                                 re : demand charges
30861 2000-03-16 04:51:00  re : the texas graduate school of business - r…
5439  2000-04-26 03:28:00
…                     …                                               …
26082 2001-05-01 05:08:00                                                re :
14977 2001-05-01 15:30:00                                    re : price quote
12486 2001-05-14 19:01:00                                                re :
31361 2001-06-06 13:02:00  richard.barry@enron.com , keith.braswell@enron…
31362 2001-06-06 13:02:00  richard.barry@enron.com , keith.braswell@enron…

                                                    text
18870  - - - forwarded by vince j kaminski / hou / ec…
18727   george , congratulations . well deserved . vince
10770  - - - forwarded by chris germany / hou / ect o…
30861  dr . harris : sorry for the delay , i have bee…
5439   did you guy need me to make a hotel reservatio…
…                                                  …
26082  one comment which wa taken related to the appl…
14977                        you are correct sir ! scott
12486  - - - forwarded by chris germany / hou / ect o…
31361  this is a new interconnect into the suction si…
31362  this is a new interconnect into the suction si…

[68 rows x 3 columns]
```

0.3 More general text features

The longest letters were made by:

[80]:

```
%%time
message_len = data['text'].apply(lambda x: len(tknzr.tokenize(x)))
```

```
CPU times: user 28.9 s, sys: 72 ms, total: 29 s
Wall time: 29 s
```

[81]:

```
set(data.loc[message_len.sort_values(ascending=False)[:30].index]['from'].
 ↪tolist())
```

[81]:

```
{'chris.germany@enron.com',
 'cooper.richey@enron.com',
 'darron.giron@enron.com',
 'eric.bass@enron.com',
 'errol.mclaughlin@enron.com',
 'john.arnold@enron.com',
 'judy.hernandez@enron.com',
 'kay.chapman@enron.com',
 'kim.ward@enron.com',
 'lysa.akin@enron.com',
 'mary.hain@enron.com',
 'susan.scott@enron.com',
 'tracy.geaccone@enron.com',
 'vince.kaminski@enron.com'}
```

The biggest mean length of letters:

[82]:

```
means = pd.DataFrame()
means['from'] = data['from']
means['length'] = message_len

means = means.groupby('from').agg({'length': ['max', 'mean']})
means.sort_values(by=[('length', 'max')], ascending=False, inplace=True)
means.head(30)
```

[82]:

```
                           length
                              max         mean
from
lysa.akin@enron.com         38123  1157.769231
cooper.richey@enron.com     36550   582.212963
judy.hernandez@enron.com    17888   843.993392
mary.hain@enron.com          8064   416.182731
eric.bass@enron.com          7570   241.483032
errol.mclaughlin@enron.com   6316   161.000000
darron.giron@enron.com       6260   292.718269
john.arnold@enron.com        5956   196.604734
kay.chapman@enron.com        5216   205.948598
chris.germany@enron.com      5061   195.191530
vince.kaminski@enron.com     4891   297.886395
```

```
kim.ward@enron.com            4802   274.415686
susan.scott@enron.com         4724   300.592935
tracy.geaccone@enron.com      4619   298.377193
sandra.brawner@enron.com      4476   209.020979
larry.campbell@enron.com      4022   263.316406
tori.kuykendall@enron.com     3841   196.128079
kevin.ruscitti@enron.com      3811   151.462428
geoff.storey@enron.com        3809   439.307692
hunter.shively@enron.com      3806   219.180000
daren.farmer@enron.com        3766   262.104238
randall.gay@enron.com         3761   252.532407
matt.smith@enron.com          3683   131.588652
david.delainey@enron.com      3547   320.133268
kay.mann@enron.com            3522   243.873231
phillip.allen@enron.com       3508   195.857784
tamara.black@enron.com        3507  3507.000000
mike.mcconnell@enron.com      3506   277.439252
susan.pereira@enron.com       3503   213.354839
kate.symes@enron.com          3188   171.708751
```

[83]:
```
means.sort_values(by=[('length', 'mean')], ascending=False, inplace=True)
means.head(30)
```

[83]:
```
                             length
                                max         mean
from
tamara.black@enron.com         3507  3507.000000
lysa.akin@enron.com           38123  1157.769231
judy.hernandez@enron.com      17888   843.993392
jeff.king@enron.com            1045   789.750000
clint.dean@enron.com           2036   665.166667
cooper.richey@enron.com       36550   582.212963
j.harris@enron.com              471   471.000000
geoff.storey@enron.com         3809   439.307692
mary.hain@enron.com            8064   416.182731
james.derrick@enron.com        2364   412.339286
lynn.blair@enron.com           1062   401.137931
drew.fossum@enron.com          2854   365.605048
cathy.phillips@enron.com       1343   360.862745
rod.hayslett@enron.com         1105   360.232558
joannie.williamson@enron.com   1571   358.760870
katherine.brown@enron.com       680   347.214286
david.delainey@enron.com       3547   320.133268
sally.beck@enron.com           2393   307.648495
susan.scott@enron.com          4724   300.592935
tracy.geaccone@enron.com       4619   298.377193
vince.kaminski@enron.com       4891   297.886395
```

```
darron.giron@enron.com          6260   292.718269
mike.mcconnell@enron.com        3506   277.439252
sherri.reinartz@enron.com        563   275.266667
kim.ward@enron.com              4802   274.415686
andrea.ring@enron.com           2257   272.271318
michelle.lokay@enron.com        2811   270.826087
scott.neal@enron.com            2735   268.931818
larry.campbell@enron.com        4022   263.316406
daren.farmer@enron.com          3766   262.104238
```

And let's clean text from puncts.

[84]:

```
%%time
message_len = data['text'].apply(lambda x: len([xx for xx in tknzr.tokenize(x)␣
 ↪if xx.isalpha()]))
```

```
CPU times: user 29.6 s, sys: 48 ms, total: 29.7 s
Wall time: 29.7 s
```

[85]:

```
set(data.loc[message_len.sort_values(ascending=False)[:30].index]['from'].
 ↪tolist())
```

[85]:

```
{'chris.germany@enron.com',
 'cooper.richey@enron.com',
 'darron.giron@enron.com',
 'eric.bass@enron.com',
 'errol.mclaughlin@enron.com',
 'john.arnold@enron.com',
 'judy.hernandez@enron.com',
 'lysa.akin@enron.com',
 'mike.mcconnell@enron.com',
 'vince.kaminski@enron.com'}
```

[86]:

```
means = pd.DataFrame()
means['from'] = data['from']
means['length'] = message_len

means = means.groupby('from').agg({'length': ['max', 'mean']})
means.sort_values(by=[('length', 'max')], ascending=False, inplace=True)
means.head(30)
```

[86]:

```
                           length
                              max        mean
from
lysa.akin@enron.com         25503  703.676923
eric.bass@enron.com          4840  154.313914
john.arnold@enron.com        4762  137.986982
```

```
judy.hernandez@enron.com     4079   399.610132
errol.mclaughlin@enron.com   3941   104.941176
darron.giron@enron.com       3920   174.301923
vince.kaminski@enron.com     3907   207.510114
chris.germany@enron.com      3370   132.406333
cooper.richey@enron.com      3037   203.009259
mike.mcconnell@enron.com     3015   209.823598
tracy.geaccone@enron.com     2865   191.750000
kay.chapman@enron.com        2815   133.747664
david.delainey@enron.com     2758   236.108949
kay.mann@enron.com           2739   169.642689
susan.scott@enron.com        2734   215.577796
sandra.brawner@enron.com     2715   120.398601
kate.symes@enron.com         2545   123.470942
matt.smith@enron.com         2301    93.578014
tori.kuykendall@enron.com    2278   117.729064
mary.hain@enron.com          2263   280.028112
drew.fossum@enron.com        2261   263.369710
randall.gay@enron.com        2238   162.861111
kim.ward@enron.com           2094   153.309804
hunter.shively@enron.com     2070   140.713333
larry.campbell@enron.com     2057   167.281250
geoff.storey@enron.com       2035   263.307692
kevin.ruscitti@enron.com     2033   103.040462
tamara.black@enron.com       1925  1925.000000
daren.farmer@enron.com       1922   175.538373
susan.pereira@enron.com      1920   142.612903
```

[87]:
```
means.sort_values(by=[('length', 'mean')], ascending=False, inplace=True)
means.head(30)
```

[87]:
```
                             length
                                max         mean
from
tamara.black@enron.com         1925  1925.000000
lysa.akin@enron.com           25503   703.676923
jeff.king@enron.com             847   640.250000
judy.hernandez@enron.com       4079   399.610132
j.harris@enron.com              326   326.000000
clint.dean@enron.com            860   314.166667
james.derrick@enron.com        1688   308.785714
mary.hain@enron.com            2263   280.028112
lynn.blair@enron.com            668   264.327586
drew.fossum@enron.com          2261   263.369710
geoff.storey@enron.com         2035   263.307692
cathy.phillips@enron.com        924   262.333333
joannie.williamson@enron.com   1215   260.304348
```

```
katherine.brown@enron.com       536   253.857143
rod.hayslett@enron.com          744   240.906977
david.delainey@enron.com       2758   236.108949
sally.beck@enron.com           1733   230.587469
susan.scott@enron.com          2734   215.577796
mike.mcconnell@enron.com       3015   209.823598
vince.kaminski@enron.com       3907   207.510114
cooper.richey@enron.com        3037   203.009259
sherri.reinartz@enron.com       445   197.733333
tracy.geaccone@enron.com       2865   191.750000
andrea.ring@enron.com          1458   185.961240
scott.neal@enron.com           1861   178.971591
sherri.sera@enron.com           753   175.647059
daren.farmer@enron.com         1922   175.538373
darron.giron@enron.com         3920   174.301923
kay.mann@enron.com             2739   169.642689
larry.campbell@enron.com       2057   167.281250
```

There we can see some important persons of this story: Vince Kaminski, Kay Mann and John Arnold

0.4 Graph features

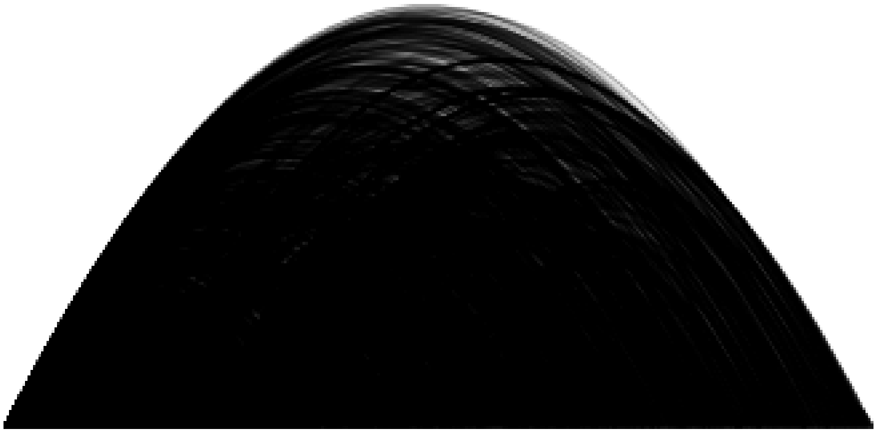
This data is about emails and therefore it can be considered as complex network data.

[18]:

```
import numpy as np
import nxviz as nv
import networkx as nx
import matplotlib.pyplot as plt
%matplotlib inline

np.random.seed(999)
```

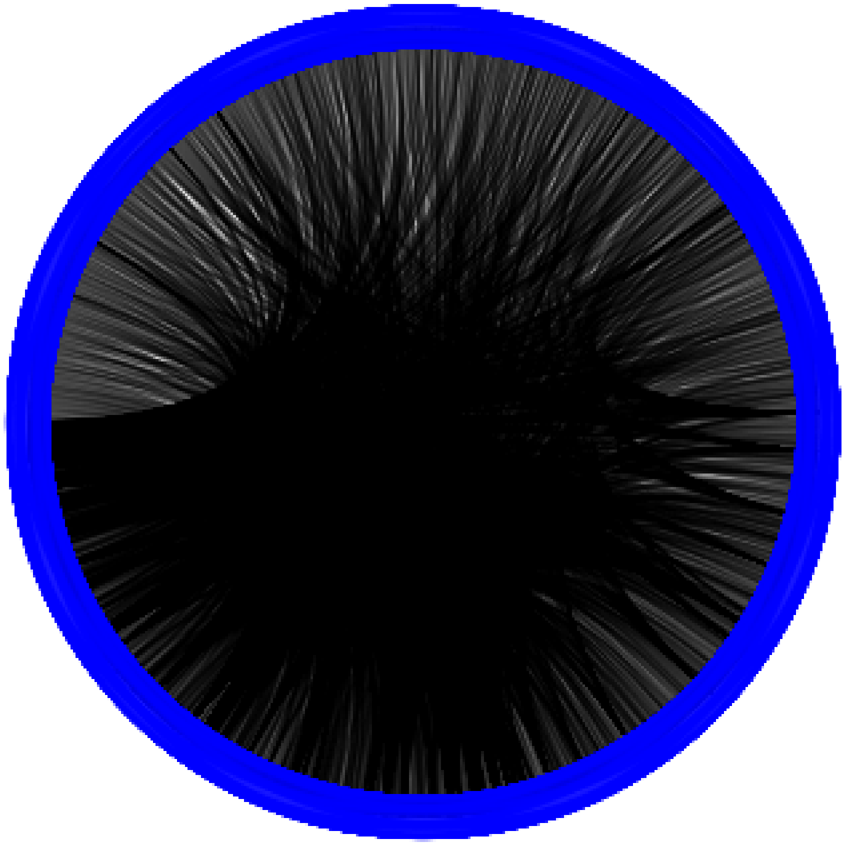
[19]:

```
G = nx.from_pandas_edgelist(
    data,
    'from',
    'to',
    edge_attr=['date', 'subject']
)
plot = nv.ArcPlot(G)
plot.draw();
```



[20]:

```
plot = nv.CircosPlot(G)
plot.draw();
```

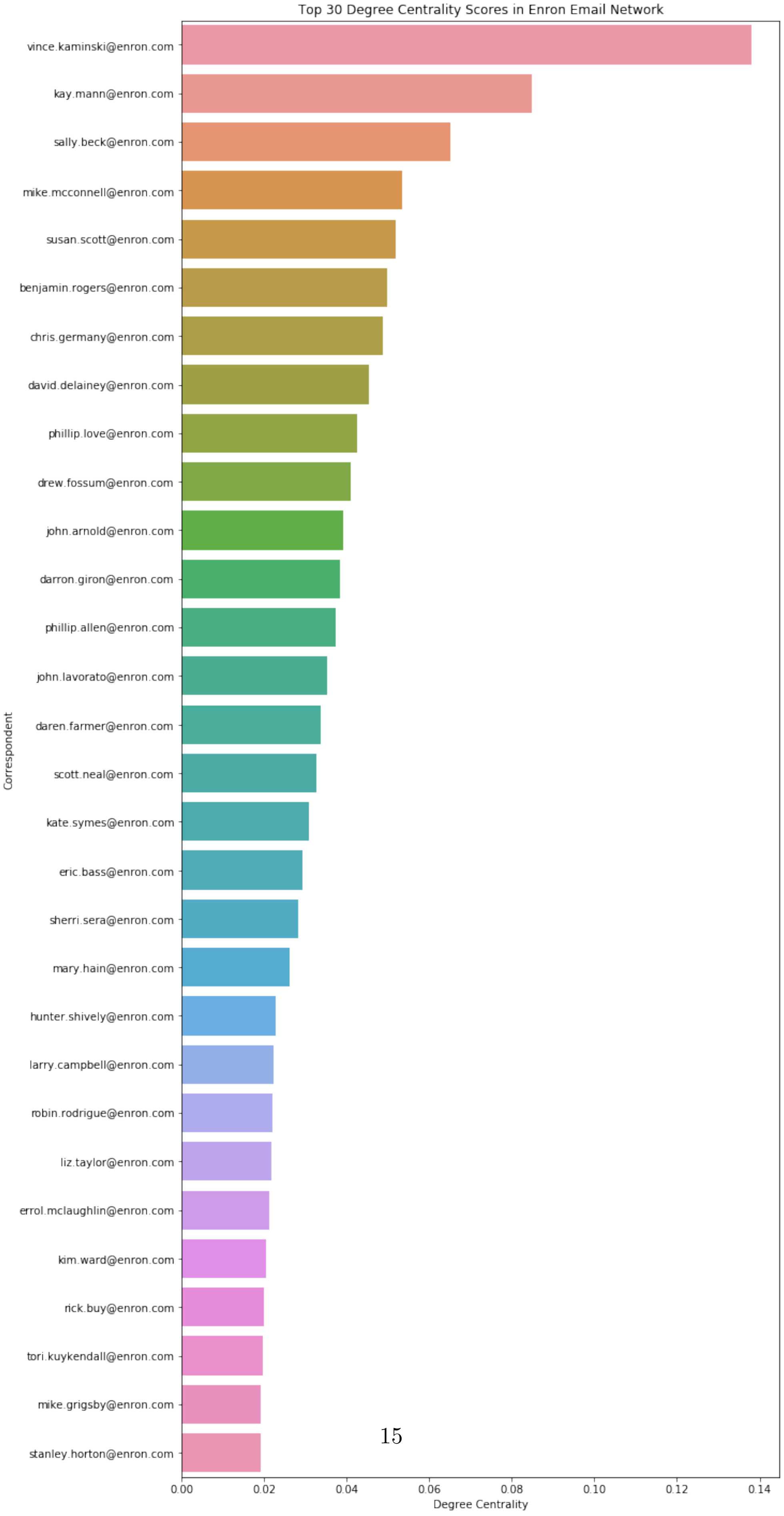


Our complex network looks like ”hairy ball” that is why we try to see on data just by centrality measures.

[29]:
```
import seaborn as sns

def plot_top(cent, centrality_s="Closeness"):
    plt.figure(figsize=(10, 25))
    _ = sns.barplot(x='centrality', y='name', data=cent[:30], orient='h')
    _ = plt.xlabel(f'{centrality_s} Centrality')
    _ = plt.ylabel('Correspondent')
    _ = plt.title(f'Top 30 {centrality_s} Centrality Scores in Enron Email␣
 ↪Network')
    plt.show()
```

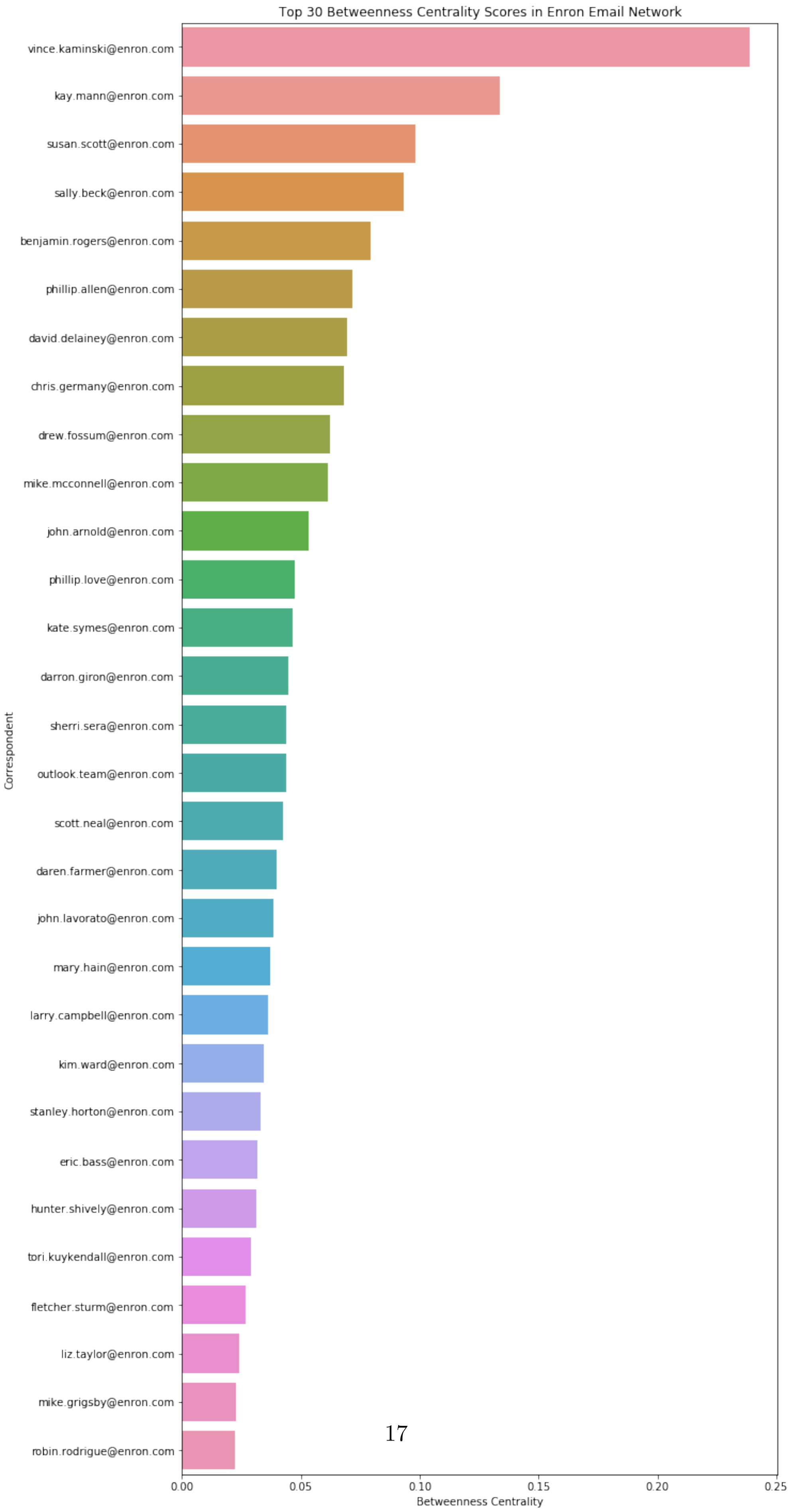
[30]:
```
cent = nx.degree_centrality(G)
cent = pd.DataFrame(cent.items())
cent.columns = ['name', 'centrality']
cent = cent.sort_values(by='centrality', ascending=False)
```

```
plot_top(cent, 'Degree')
```


Top 30 Degree Centrality Scores in Enron Email Network
Correspondent
vince.kaminski@enron.com
kay.mann@enron.com
sally.beck@enron.com
mike.mcconnell@enron.com
susan.scott@enron.com
benjamin.rogers@enron.com
chris.germany@enron.com
david.delainey@enron.com
phillip.love@enron.com
drew.fossum@enron.com
john.arnold@enron.com
darron.giron@enron.com
phillip.allen@enron.com
john.lavorato@enron.com
daren.farmer@enron.com
scott.neal@enron.com
kate.symes@enron.com
eric.bass@enron.com
sherri.sera@enron.com
mary.hain@enron.com
hunter.shively@enron.com
larry.campbell@enron.com
robin.rodrigue@enron.com
liz.taylor@enron.com
errol.mclaughlin@enron.com
kim.ward@enron.com
rick.buy@enron.com
tori.kuykendall@enron.com
mike.grigsby@enron.com
stanley.horton@enron.com
0.00
0.02
0.04
0.06
0.08
0.10
0.12
0.14
Degree Centrality

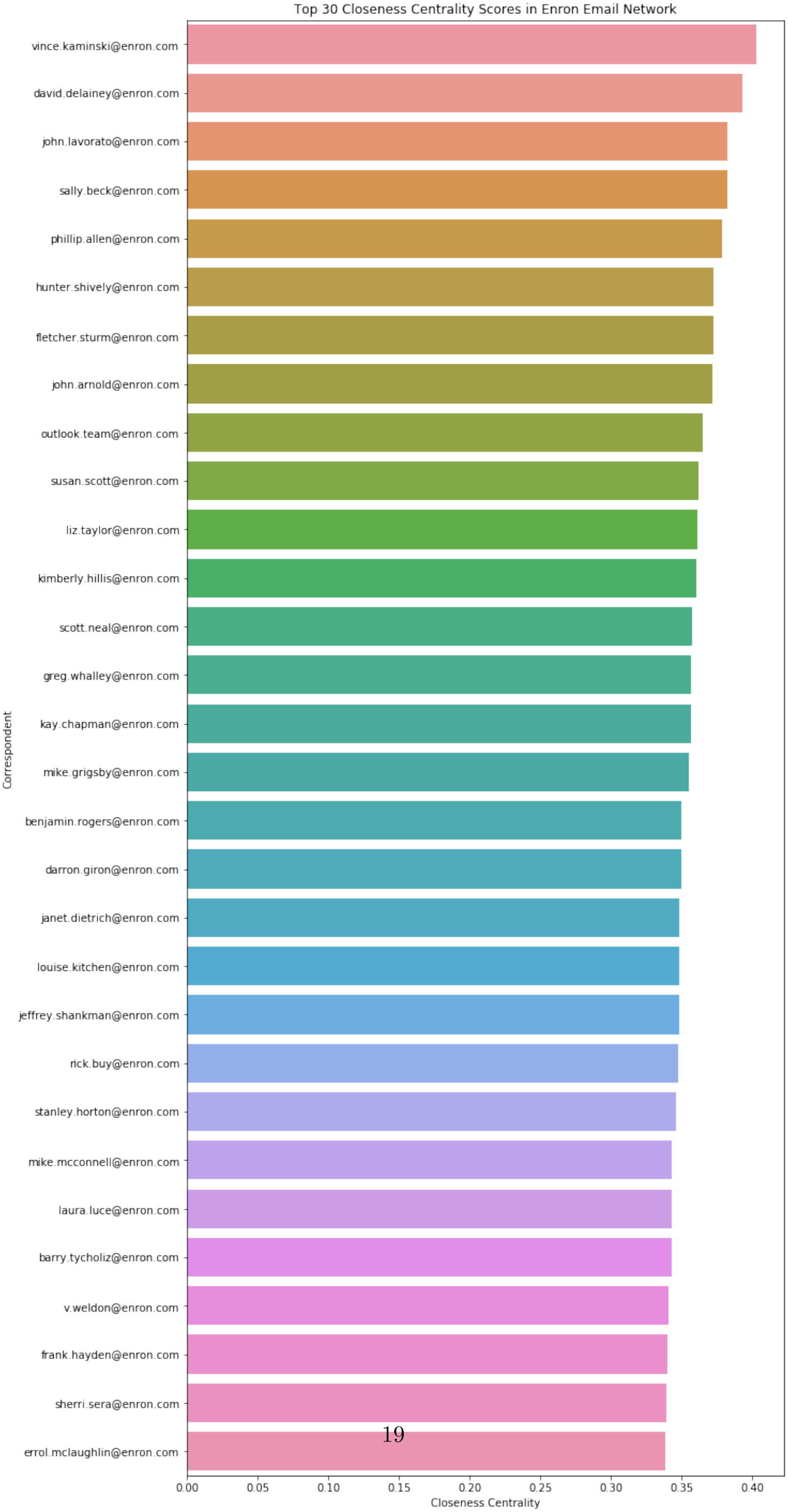
[31]:

```
cent = nx.betweenness_centrality(G)
cent = pd.DataFrame(cent.items())
cent.columns = ['name', 'centrality']
cent = cent.sort_values(by='centrality', ascending=False)

plot_top(cent, 'Betweenness')
```


Top 30 Betweenness Centrality Scores in Enron Email Network
vince.kaminski@enron.com
kay.mann@enron.com
susan.scott@enron.com
sally.beck@enron.com
benjamin.rogers@enron.com
phillip.allen@enron.com
david.delainey@enron.com
chris.germany@enron.com
drew.fossum@enron.com
mike.mcconnell@enron.com
john.arnold@enron.com
phillip.love@enron.com
kate.symes@enron.com
darron.giron@enron.com
sherri.sera@enron.com
outlook.team@enron.com
scott.neal@enron.com
daren.farmer@enron.com
john.lavorato@enron.com
mary.hain@enron.com
larry.campbell@enron.com
kim.ward@enron.com
stanley.horton@enron.com
eric.bass@enron.com
hunter.shively@enron.com
tori.kuykendall@enron.com
fletcher.sturm@enron.com
liz.taylor@enron.com
mike.grigsby@enron.com
robin.rodrigue@enron.com
Correspondent
0.00
0.05
0.10
0.15
0.20
0.25
Betweenness Centrality

[32]:

```
cent = nx.closeness_centrality(G)
cent = pd.DataFrame(cent.items())
cent.columns = ['name', 'centrality']
cent = cent.sort_values(by='centrality', ascending=False)

plot_top(cent, 'Closeness')
```


Top 30 Closeness Centrality Scores in Enron Email Network
Correspondent
vince.kaminski@enron.com
david.delainey@enron.com
john.lavorato@enron.com
sally.beck@enron.com
phillip.allen@enron.com
hunter.shively@enron.com
fletcher.sturm@enron.com
john.arnold@enron.com
outlook.team@enron.com
susan.scott@enron.com
liz.taylor@enron.com
kimberly.hillis@enron.com
scott.neal@enron.com
greg.whalley@enron.com
kay.chapman@enron.com
mike.grigsby@enron.com
benjamin.rogers@enron.com
darron.giron@enron.com
janet.dietrich@enron.com
louise.kitchen@enron.com
jeffrey.shankman@enron.com
rick.buy@enron.com
stanley.horton@enron.com
mike.mcconnell@enron.com
laura.luce@enron.com
barry.tycholiz@enron.com
v.weldon@enron.com
frank.hayden@enron.com
sherri.sera@enron.com
errol.mclaughlin@enron.com
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
0.40
Closeness Centrality

[33]:

```
from collections import Counter
sorted(Counter(data['from']).items(), key=lambda x: -x[1])[:30]
```

[33]:

```
[('kay.mann@enron.com', 5088),
 ('vince.kaminski@enron.com', 3609),
 ('chris.germany@enron.com', 2621),
 ('eric.bass@enron.com', 1768),
 ('kate.symes@enron.com', 1497),
 ('drew.fossum@enron.com', 1347),
 ('sally.beck@enron.com', 1229),
 ('susan.scott@enron.com', 1189),
 ('phillip.love@enron.com', 1140),
 ('darron.giron@enron.com', 1040),
 ('david.delainey@enron.com', 1028),
 ('benjamin.rogers@enron.com', 996),
 ('daren.farmer@enron.com', 873),
 ('mike.mcconnell@enron.com', 856),
 ('john.arnold@enron.com', 845),
 ('robin.rodrigue@enron.com', 815),
 ('phillip.allen@enron.com', 668),
 ('john.lavorato@enron.com', 550),
 ('scott.neal@enron.com', 528),
 ('mary.hain@enron.com', 498),
 ('judy.hernandez@enron.com', 454),
 ('mark.guzman@enron.com', 358),
 ('mike.grigsby@enron.com', 348),
 ('errol.mclaughlin@enron.com', 306),
 ('hunter.shively@enron.com', 300),
 ('matt.smith@enron.com', 282),
 ('larry.campbell@enron.com', 256),
 ('kim.ward@enron.com', 255),
 ('patrice.mims@enron.com', 243),
 ('jane.tholt@enron.com', 239)]
```

[34]:

```
sorted(Counter(data['to']).items(), key=lambda x: -x[1])[:30]
```

[34]:

```
[('vkaminski@aol.com', 1061),
 ('suzanne.adams@enron.com', 427),
 ('shirley.crenshaw@enron.com', 301),
 ('nmann@erac.com', 285),
 ('gabriel.monroy@enron.com', 242),
 ('ben.jacoby@enron.com', 239),
 ('evelyn.metoyer@enron.com', 236),
 ('kathleen.carnahan@enron.com', 229),
 ('kerri.thompson@enron.com', 226),
 ('carlos.sole@enron.com', 210),
 ('john.lavorato@enron.com', 200),
 ('bryan.hull@enron.com', 194),
 ('martha.benner@enron.com', 178),
 ('sheila.tweed@enron.com', 175),
 ('jkeffer@kslaw.com', 171),
 ('jason.bass2@compaq.com', 162),
 ('shanna.husser@enron.com', 162),
 ('ccampbell@kslaw.com', 154),
 ('timothy.blanchard@enron.com', 144),
 ('susan.scott@enron.com', 134),
 ('jeffrey.shankman@enron.com', 132),
 ('ina.rangel@enron.com', 132),
 ('roseann.engeldorf@enron.com', 128),
 ('tim.belden@enron.com', 127),
 ('matthew.lenhart@enron.com', 126),
 ('phillip.love@enron.com', 123),
 ('stinson.gibner@enron.com', 121),
 ('david.baumbach@enron.com', 120),
 ('victor.lamadrid@enron.com', 117),
 ('katie.trullinger@wfsg.com', 116)]
```

Vince Kaminski was the Managing Director for Research at Enron. Kaminski repeatedly raised strong objections to the financial practices of Enron's Chief Financial Officer, Andrew Fastow, designed to fraudulently conceal the company's burgeoning debt.

David Delainey, John Lavorato were top Executives, John D. Arnold was a gas trader. Sally Beck was Chief Operating Officer at Enron Networks LLC.

Kay Mann was a head of Legal of Enron company and its node has the biggest number of ”from”.

0.5 Time distribution

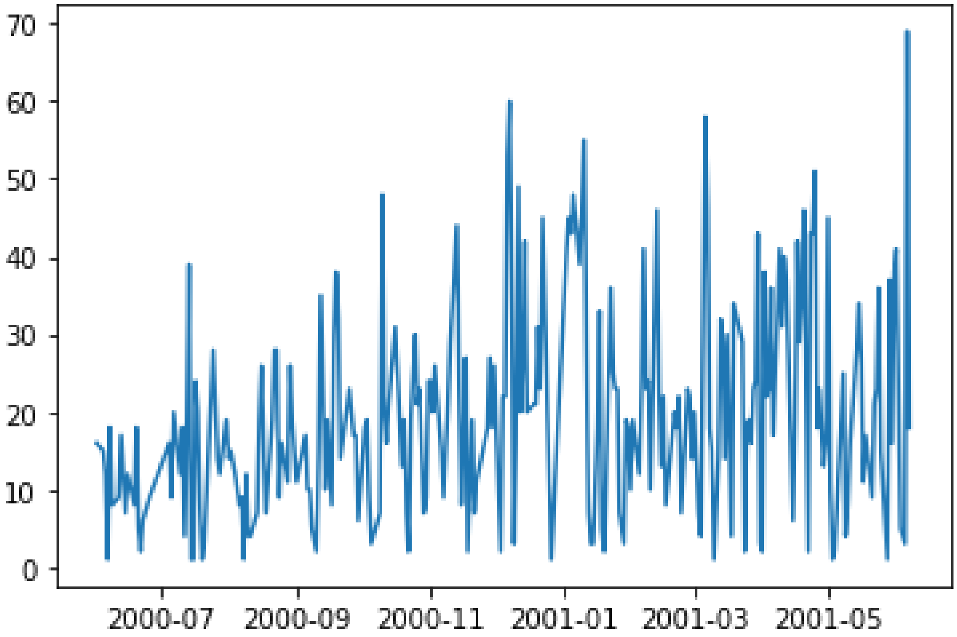
[100]:

```
data['only_date'] = data['date'].dt.date
df = data[['from', 'only_date', 'date']].groupby(by=['from', 'only_date']).
 ↪agg('count')
df.head()
```

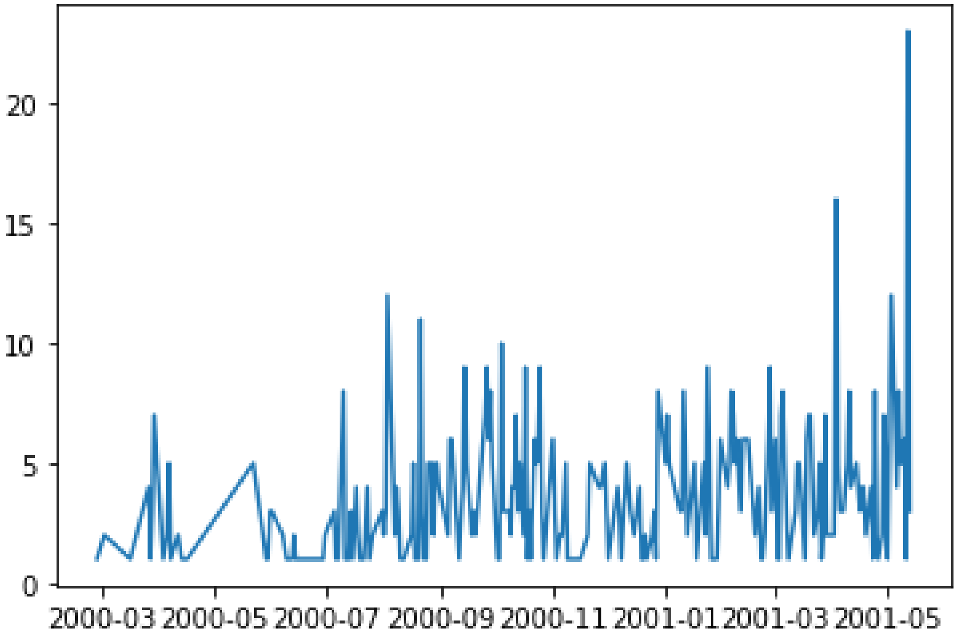
[100]:

```
                                      date
from                    only_date
amelia.alder@enron.com  2001-03-29       1
andrea.ring@enron.com   2000-06-06       1
                        2000-07-11       2
                        2000-07-25       1
                        2000-08-09       1
```

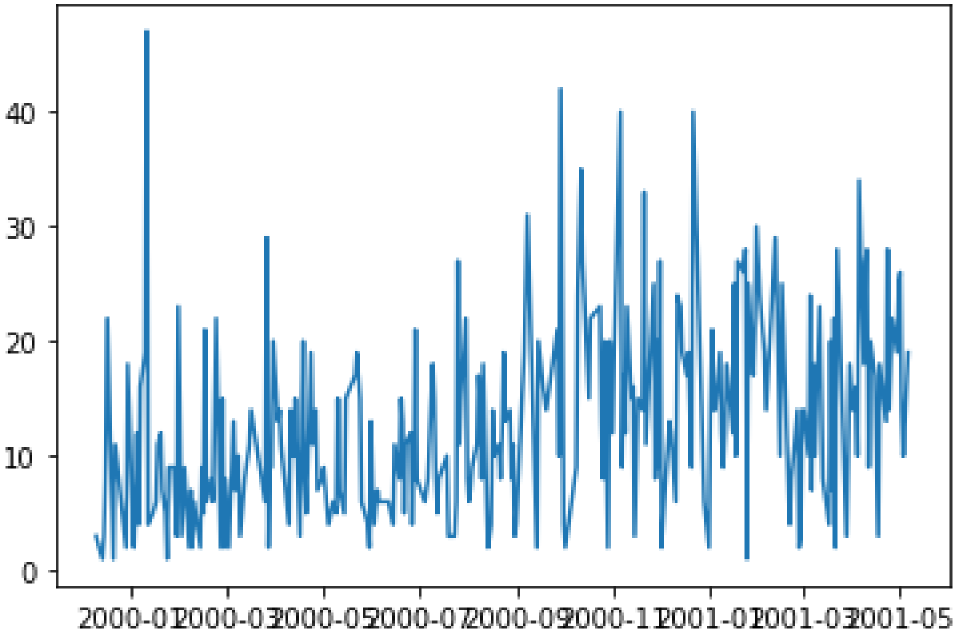
```
[113]: kay_mann = df.T['kay.mann@enron.com'].T.sort_index()
       plt.plot(kay_mann);
```



```
[115]: john_arnold = df.T['john.arnold@enron.com'].T.sort_index()
       plt.plot(john_arnold);
```



```
[114]: vince_kaminski = df.T['vince.kaminski@enron.com'].T.sort_index()
       plt.plot(vince_kaminski);
```



Head of Legal and gas trader numbers of letters were increased from 2000 to 2001.

It is looks organically.