

Natural Language Processing

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Enron was an American energy company and was one of the largest electricity and natural gas companies in the world. However, at the end of 2001, its financial condition was revealed to be an accounting fraud. The Federal Energy Regulatory Commission (FERC) has generated many Enron emails during the investigation.

We are using 1980 Enron emails of Enron's top executives to provide an overview of Enron Scandal and recommendations for who to investigate at what times on what general topics by using Natural Language Processing.

And we have explored the data, brainstormed what factors could help improve the investigation recommendation, proposed several models, and implemented the variants below.

Add-on Value of the Data

- Find evidence of fraud.
- Extract frequent keywords to determine what are the important topics in these emails.
- Cover frequently asked questions in training Detect people who make fraud and block them to ensure safety in working environment.
- Analyze employees' social networks to see which group of people work closely.
- Filter out junk emails.

Key Metrics to Measure Success

- Accuracy of correctly detecting fraud
- Less pecuniary loss due to fraud
- Quicker response to fraud which benefits internal management of the company
- For the topic model, we want to see if the actual emails match the results. (i.e. When the topic model suggests the topic of the email, we want to see if it correctly categorize the topic.)

Data Exploration

Problem with the data

First, we have discovered some problems with the data. One is that some dates are not correctly recorded. The other one is that there are many duplicate emails in the dataset.

	file	message	text	
184	kean-s/all_documents/121.	Message-ID: <7230661.1075846142733.JavaMail.ev...>	Xbcc XFolder StevenKeanDecNotes FoldersAll do...	197 16:0
290	kean-s/discussion_threads/120.	Message-ID: <2828867.1075848072222.JavaMail.ev...>	Xbcc XFolder StevenKeanJuneNotes FoldersDiscu...	197 16:0
256	kean-s/calendar/untitled/121.	Message-ID: <4764867.1075846273865.JavaMail.ev...>	Xbcc XFolder StevenKeanDecNotes FoldersCalend...	197 16:0
216	kean-s/archiving/untitled/2205.	Message-ID: <33244591.1075846267388.JavaMail.e...>	Xbcc XFolder StevenKeanDecNotes FoldersArchiv...	197 16:0
1951	taylor-m/stored_messages/31.	Message-ID: <22235925.1075860085251.JavaMail.e...>	XOrigin TaylorM XFileName mtaylornsf Here is ...	199 09:2
1950	taylor-m/all_documents/457.	Message-ID: <24585790.1075859888383.JavaMail.e...>	XOrigin TaylorM XFileName mtaylornsf Here is ...	199 09:2
884	lay-k/elizabeth/1.	Message-ID: <6458946.1075840255272.JavaMail.ev...>	Try you may need the second one Let me know ...	199 10:2
442	lay-k/all_documents/3.	Message-ID: <10250203.1075840200733.JavaMail.e...>	Try you may need the second one Let me know ...	199 10:2
634	lay-k/discussion_threads/1.	Message-ID: <4373267.1075840230368.JavaMail.ev...>	Ken I finally found Franco Bernabes work numb...	199 08:3
633	lay-k/business/1.	Message-ID: <29020904.1075840230207.JavaMail.e...>	Ken I finally found Franco Bernabes work numb...	199 08:3

Table I: Emails sorted by time from the earliest to the most recent.

If the emails are sorted by time, the first four emails were sent in 1979, and the fifth email was sent in 1999. There is a large gap from 1979 to 1999, and Enron was founded in 1985, which is later than 1979. In addition, the first four emails have the same content, so it is very likely that the date of the first 4 emails was not correctly recorded.

Among the 1980 emails, 1079 of them are duplicated emails. So we remove the duplicated emails from our dataset.

Interaction between people

Then we take a look at the senders and recipients, and their communication.

	senders	sent
0	steven.kean@enron.com	37
1	terrie.james@enron.com	22
2	svarga@kudlow.com	20
3	karen.denne@enron.com	19
4	kenneth.lay@enron.com	17
...
661	michael.harris@enron.com	1
662	michael.horning@enron.com	1
663	michael.krautz@enron.com	1
664	michael.norris@enron.com	1
665	15126-1267@m2.innovyx.com	1

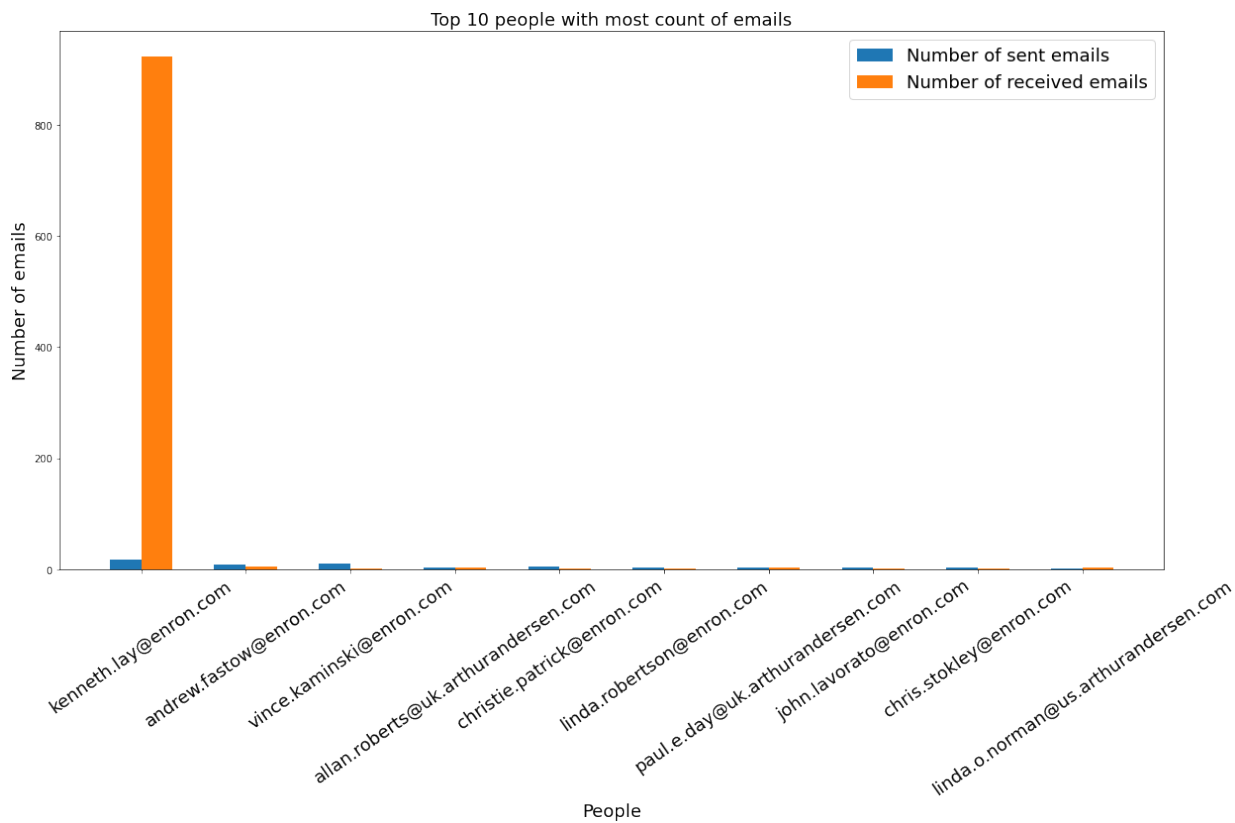
666 rows × 2 columns

Table II: People with most counts of emails sent.

	recipients	received
0	kenneth.lay@enron.com	922
1	kenneth.lay@enron.com, jeff.skilling@enron.com	31
2	kenneth_lay@enron.com	19
3	kenneth.lay@enron.com, rosalee.fleming@enron.com	13
4	jeff.skilling@enron.com, kenneth.lay@enron.com	11
...
138	kenneth.lay@enron.com, l..wells@enron.com	1
139	kenneth.lay@enron.com, lay.linda@enron.com	1
140	kenneth.lay@enron.com, linda.lay@enron.com	1
141	kenneth.lay@enron.com, mark.frevert@enron.com	1
142	wired@condenast.flonetwork.com	1

143 rows × 2 columns

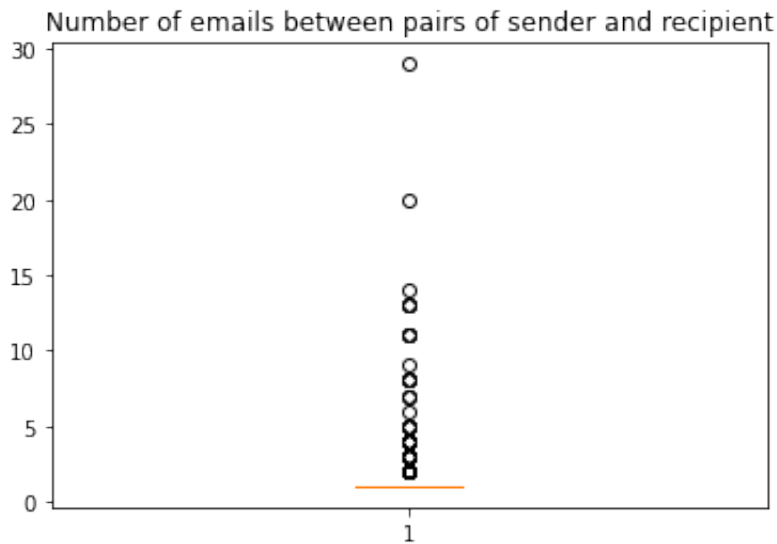
Table III: People with most counts of emails sent.



	senders	recipients	count
0	steven.kean@enron.com	kenneth.lay@enron.com	29
1	svarga@kudlow.com	kenneth.lay@enron.com	20
2	karen.denne@enron.com	kenneth.lay@enron.com	14
3	terrie.james@enron.com	kenneth.lay@enron.com	13
4	enron_update@concureworkplace.com	kenneth.lay@enron.com	13
5	rob.bradley@enron.com	kenneth.lay@enron.com	13
6	greg.piper@enron.com	kenneth.lay@enron.com	13
7	michael.mann@enron.com	kenneth.lay@enron.com	11
8	j..kean@enron.com	kenneth.lay@enron.com	11
9	lynda.l.phinney@williams.com	kenneth.lay@enron.com	11

Table IV: People with most communication.

Kenneth Lay has received most emails, and Steven Kean has sent the most emails. Also they are the two people with the most communication. This is reasonable since Kenneth Lay is the CEO of Enron, and Steven Kean is the chief of staff.

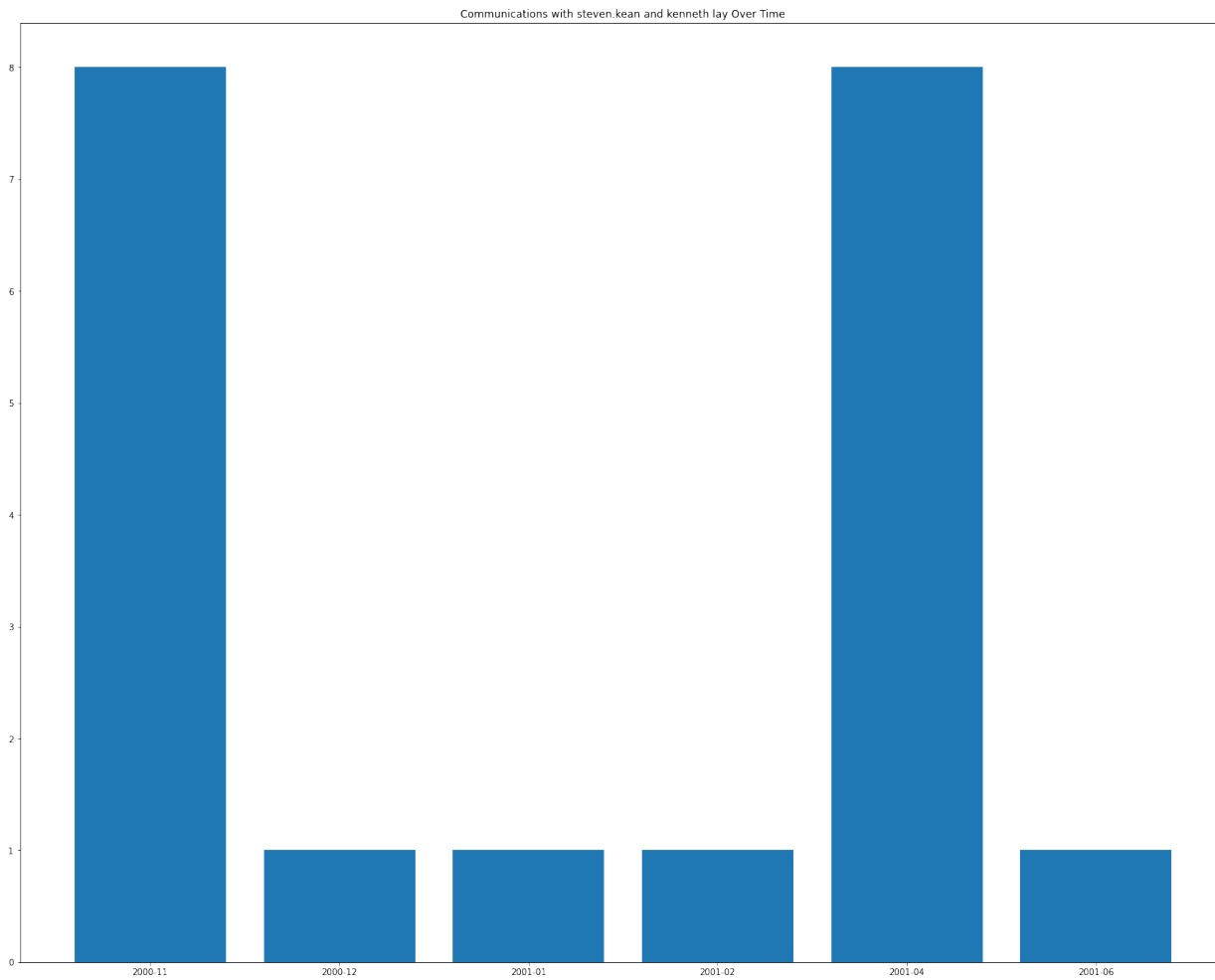


```
count      779.000000
mean        1.587933
std         1.938225
min         1.000000
25%         1.000000
50%         1.000000
75%         1.000000
max         29.000000
Name: text, dtype: float64
```

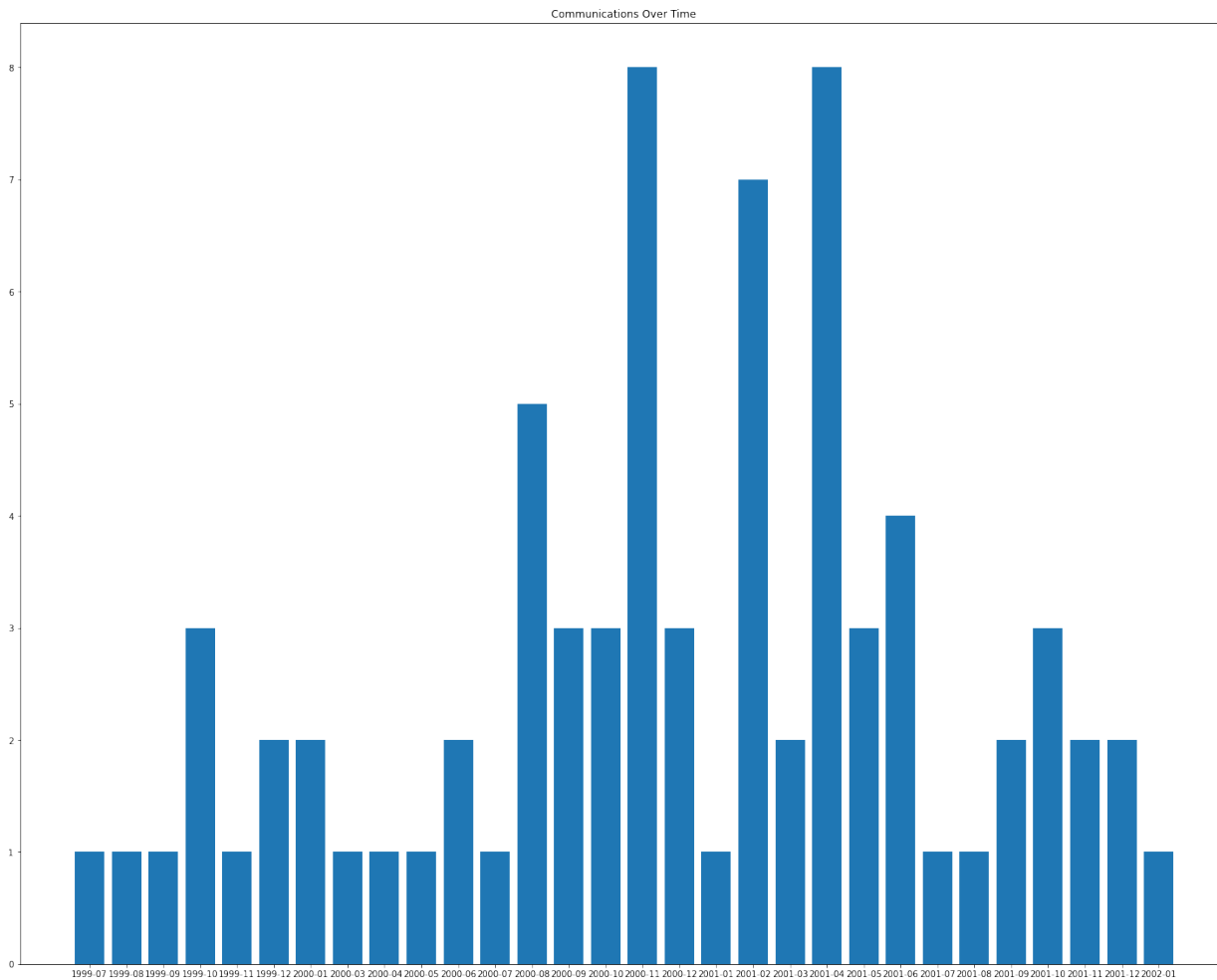
Table V: Number of emails between pairs of sender and recipient

We grouped all emails by the pair of sender and recipient and counted the total number of email between each pair. From the boxplot, we discovered that most pairs of sender and recipient only connect once and only a small proportion of sender and recipients communicate regularly.

After that, we take a deeper insight into the pairs with regular communications. We take the top pair as an instance to see whether they communicate regularly by email but suddenly stop.



The figure above demonstrate the number of emails sent between steven.kean and kenneth.lay, the pair who communicate with each other the most frequently, over time. We discover that they continue to communicate between 2000-11 to 2001-06. However, while the communications in 2000-11 and 2001-04 are frequent, the communications in the months between, from 2000-12 to 2001-03 is rare.



Because it is strange the kenneth.lay and steven.kean communicate less frequent in months around 2001-01, we also take a look at all communications overtime.

From the figure above, we discover that while the overall communications between 2000-08 and 2001-06 were frequent, there was only 1 email overall in 2001-01, which is very strange. Therefore, it is suspicious that emails in 2001-01 might be deleted for some unknown reasons, probably associated with the fraud.

Interaction between companies

	sender_company	count
0	enron	708
1	aol	37
2	kudlow	20
3	concureworkplace	13
4	us.arthurandersen	12
5	layfam	11
6	williams	11
7	yale.ed	11
8	lpipi	11
9	cnn	11

Table V: Companies with most communication with Enron

Enron has lots of interaction with companies like Arthur Andersen, and AOL. Arthur Andersen is Enron's accounting firm, and in 2002, it was found guilty of crimes in the firm's auditing of Enron. And for AOL, there is lots of news between AOL and Enron, for example, like "Enron signs with AOL to sell energy online", "Enron, IBM, AOL Form Retail Energy Dream Team". So these firms indeed have close interaction with Enron. And if we further want to have some investigation from other companies, we can focus on these companies.

Brainstorm a comprehensive list of factors that could affect the recorded data, or the trends your models will capture.

Before building up a model, it is important to notice that there are many factors that could conceivably influence the recorded emails' content and amount in our dataset accidentally or intentionally. Also, some factors may also influence the performance of our NLP model. Here are some of these factors:

- Emails being deleted.
- Emails being edited.
- Important and illegal activities are talked via phones, or face-to-face, not via emails.
- Email contents do not contain important information, instead, links and attached files contain important information.
- People being cced or bcced.
- Suspicion of future investigation, so they will convey wrong information.
- People use code words or abbreviation.
- Misspelling of words.
- Single person uses multiple email addresses.
- Email servers are down.
- Position of the sender and recipient.

Complementary Sources of Data

Emails can only show part of the information about investigation recommendation and evidence of fraud. So to better conduct an investigation, we also need some complementary sources of data.

- Data from other related companies such as Arthur Andersen.
- Enron's employee records.
- Enron's transactions with its partnerships.
- Enron's communication record from other platforms, like call history.
- Enron's financial report.
- Interviews of suspected employees.
- Internal documents of Enron.

Model Staircase

Here are some approaches we proposed.

- Topic modeling using LDA(Latent Dirichlet Allocation) (baseline model).
- Simple keyword search (Variant 1).
- Topic modeling on emails with negative sentiment scores (Variant 1).
- Run a topic model on the whole corpus using LDA, then see how topic use varies with time (Variant 2).
- Use Top2Vec (Angelov, D., 2020.) for topic modeling (Variant 3).
- Use Embedded Topic Model (Dieng, A. B., Ruiz, F. J., & Blei, D. M., 2020.) for topic modeling.
- Use BERTopic for topic modeling.
- Use dynamic topic model (Variant 4).
- Network analysis (Variant 5).

Baseline Model(LDA: Latent Dirichlet Allocation)

In the baseline model, Latent Dirichlet Allocation is used to do topic modeling. And it generates 25 topics that occur in the emails. However, there are some problems and limitations with this baseline model. For example, LDA uses bag-of-words and ignores syntactic and semantic word relationships. Also, in baseline model, we only look at the key words of the 25 topics without conducting any deeper and further investigation. So in the next few variants, we will provide a detailed overview of the situation and recommendations for who to investigate at what times on what topics. Also, we will use a different model to take syntactic and semantic word relationships into consideration.

Data Size 141767

```
WARNING:absl:No GPU/TPU found, falling back to CPU. (Set TF_CPP_MIN_LOG_LEVEL=0 and rerun for more info.)
```

TOPIC 0 ['enron', 'india', 'deal', 'would', 'first']
 TOPIC 1 ['enron', 'call', 'xfilename', 'xorigin', 'list']
 TOPIC 2 ['letter', 'please', 'call', 'arena', 'send']
 TOPIC 3 ['communications', 'communicationsenron', 'ken', 'business', 'mark']
 TOPIC 4 ['cable', 'vod', 'service', 'new', 'million']
 TOPIC 5 ['houston', 'us', 'business', 'international', 'time']
 TOPIC 6 ['business', 'contract', 'concerns', 'february', 'call']
 TOPIC 7 ['xorigin', 'xfilename', 'layk', 'fund', 'provide']
 TOPIC 8 ['xfilename', 'xorigin', 'layk', 'conference', 'please']
 TOPIC 9 ['email', 'message', 'please', 'information', 'october']
 TOPIC 10 ['ferc', 'immelt', 'ge', 'gas', 'said']
 TOPIC 11 ['meeting', 'best', 'ken', 'time', 'draft']
 TOPIC 12 ['us', 'know', 'god', 'lay', 'family']
 TOPIC 13 ['enron', 'would', 'know', 'ken', 'time']
 TOPIC 14 ['time', 'cost', 'price', 'must', 'real']
 TOPIC 15 ['energy', 'gas', 'power', 'government', 'vice']
 TOPIC 16 ['tt', 'j', 'pm', 'steven', 'jeff']
 TOPIC 17 ['see', 'back', 'get', 'think', 'one']
 TOPIC 18 ['enron', 'business', 'new', 'global', 'development']
 TOPIC 19 ['president', 'board', 'company', 'enron', 'mr']
 TOPIC 20 ['pm', 'subject', 'please', 'lay', 'message']
 TOPIC 21 ['would', 'interest', 'market', 'million', 'several']
 TOPIC 22 ['would', 'yahoo', 'new', 'th', 'people']
 TOPIC 23 ['enron', 'company', 'employees', 'know', 'many']
 TOPIC 24 ['time', 'management', 'would', 'enron', 'year']

Variant 1: Simple Keyword Search

Subvariant: Search by Keyword

Firstly, the easiest and the most straight-forward approach to find evidence of fraud is to search for phrases like "police", "fraud", and "investigation", followed by an expensive and time-consuming manual review process to determine which emails are responsive for the fraud.

In this part, we simply searched three keywords: police, fraud, and investigation, that might be associated with the fraud and print out related emails to demonstrate some examples of this approach.

Sender: j..kean@enron.com

Date: 2001-11-14 12:35:16-08:00

Subject: nan

Text: XOrigin KeanS XFileName SKEAN NonPrivilegedpst Some background information for the meeting with Mayor Brown Brown won of the vote to Sanchez and is now in a run off with Sanchez Sue Waldens perspective not surprisingly is that Brown will win and that campaign p

olls show him ahead among likely voters African American turnout in the election was lower than expected but an active getoutthevote campaign could turn that around Enron has supported the mayor with a contribution I would not recommend a further commitment under the current circumstances If you want to discuss some of the positive accomplishments of his administration you could Congratulate him on passage of his version of the light rail proposition Compliment him on how he has responded to security issues since Sept and his handling of flood relief You should know that the Houston police were extremely helpful and responsive when we asked for assistance in connection with the October threat to the Enron building We have responded to the Citys RFP for energy service EES made a presentation last week proposing a year transaction The city is opting for a year transaction That would require very detailed load data which is in Reliants possession We have expressed concern that we are merely a stalking horse in the citys effort to do a deal with Reliant We have said that we wont play on those terms Separately we are working with the city on a demand side deal

Sender: billy.lemmons@enron.com

Date: 2002-01-10 12:10:39-08:00

Subject: Accounting Article From Fortune Magazine

Text: Ken Beth suggested that I forward a copy of this article to you Ive highlighted some relevant points for your convenience Regards Billy ACCOUNTING IN CRISIS One Plus One Makes What The accounting profession had a credibility problem before Enron Now it has a crisis FORTUNE Monday January Where were the auditors People ask that question after every corporate collapse and lately theyve been asking it with disturbing frequency At Waste Management Sunbeam Rit e Aid Xerox and Lucent major accounting firms either missed or ignored serious problems The number of public companies that have corrected or restated earnings since has doubled to according to a study by Big Five accounting firm Arthur Andersen Now following the stunning bankruptcy of Andersens own client Enron that question where were the auditors has become a deafening refrain I believe that there is a crisis of confidence in my profession Andersen CEO Joseph Berardi no told a congressional committee investigating Enrons collapse in midDecember Real change will be required to regain the public trust The full story of the Enron debacle and what Andersen did or did not do in its audit will take months to emerge In the meantime no one disagrees with Berardinos diagnosis that theres a crisis in accounting even if his sudden emphasis on industrywide reform springs from a desire to deflect attention from Andersens own culpability But the kind of real change required is a matter of substantial debate The government gave the franchise of auditing public companies financial statements to the accounting industry after the stock market crash In the decades since the accountants have adroitly avoided significant government regulation by arguing that they can police themselves Now postEnron theyre doing it again The Big Five CEOs issued a rare joint statement outlining how they intend to strengthen fi

financial reporting and auditing standards Selfregulation is right for investors the profession and the financial markets the release concludes But is it Accountings main selfregulatory body the Public Oversight Board is a monument to the professions failures The POB was created in the late s when Congress held hearings on a string of audit failures at public companies that had much like the recent rash shaken confidence in the major auditing firms The POB which has no enforcement power investigates alleged audit failures and oversees a triennial review process in which the major accounting firms examine one anothers procedures And yet problems persist arguably they have grown more acute Is accounting selfregulation working On the face of it it is not says Representative John Dingell the powerful Michigan Democrat who has long sparred with the accounting profession In their defense the auditors note that current accounting methods many of which were designed years ago are difficult to apply to todays complex financial transactions And there is no way they insist to prevent sophisticated fraud The American Institute of Certified Public Accountants AICPA the industrys professional association points out that accountants examine the books of more than public companies every year they are accused of errors in just of those audits But oh the price of those few failures Lynn Turner former chief accountant of the Securities and Exchange Commission estimates that investors have lost more than billion because of financial fraud and the accompanying earnings restatements since Perhaps the most glaring example of selfregulations deficiency has been accountants unwillingness to deal with conflicts of interest Over the years the major auditing firms have transformed themselves into professional services companies that derive an increasing portion of revenues and profits from consulting selling computer systems advising clients on tax shelters and evaluating their business strategies In according to the SEC half of the Big Fives revenues came from consulting fees vs in Auditing meanwhile has become a commodity Firms have even been accused of using it as a loss leader a way of getting in the door at a company to sell more profitable consulting contracts Audit work is a marvelous marketing tool says Lou Lowenstein a professor emeritus of finance and law at Columbia University You are already there doing the audit You say their internal controls are no good Well who are they going to call to fix it But this requires a firm to work for the public auditing and management consulting You can not serve them both says former SEC commissioner Bevis Longstreth This conflict may have played a role at Enron Andersen received million in auditing fees from Enron last year Thats money Andersen was paid both as Enrons outside auditor certifying its financial statements and as its internal auditor making sure Enron had the right systems to keep its books and working to detect fraud and irregularities This double duty alone raised a serious potential for conflict Besides million in accounting fees Andersen was paid million for consulting services If you are auditing your own creations it is very difficult to criticize them says Robert Willens a Lehman Brothers tax expert who disapproves of the accounting professions recent m

ove into selling aggressive tax shelters Andersen has not revealed the details of its work on Enrons highly controversial off balancesheet transactions but the accounting firms have never believed consulting fees compromise their objectivity They have militantly refused to ever acknowledge the possibility of a problem Longstreth says

Sender: gargravi@hotmail.com

Date: 2001-10-13 09:37:18-07:00

Subject: Dabhol India - Illegal Action and Criminal Conduct / violation of

Text: XFileName KLAY NonPrivilegedpst Sir I am an Enron employee I tried to send this email using name of your high office as email ID however the same came back as undelivered with the fatal error message from server Since the matter is very serious I am respectfully marking it to your direct attention and consideration With Kind Regards Ravi Garg From RAVI GARG gargravihotmailcom To officeofthechairmanenroncom CC wadeclineenroncom Subject Illegal Action and Criminal Conduct violation of human rights Date Fri Oct Enron Compliance officer Re Illegal Action I was working with Enrons offshore Power Operation CV at Dabhol Power Plant India since May I was very honest sincere and hardworking There was no allegations on me My work was always appreciated including by visiting audit teams from Houston However I was very forthright when my work was coming and even more whenever the interest of firm Enron was at stake including adherence to law I also perused Enrons concept of Know Why I was always ensuring the high dignity and value that was attached to my job including of Respect Integrity Communication and Excellence However despite that the officer incharge at Dabhol Complex for reasons best known to him developed vengeance against me and on th August my services were illegally terminated by unilaterally and while acting out of the capacity imposing an alleged severance plan with effect from th August itself which was never disclosed to me or accepted by me Subsequently I was forced upon a cheque of severance amount on th August which I received under protest and the notice of such protest was served by me on firm in the interest of justice I submit such a termination is illegal bad in law and void abinitio and accordingly and when such an action was not corrected by firm I constrained to approach the Court of law I therefore request your attention to the illegality of such an action and suitable redressal correction of such an action in the form of my reinstatement in the job Re Criminal Conduct Violation to Human Rights On th August subsequent to my protest representation I was criminally man handled by officers of the firm Enron namely Kenneth D Lambert P R Krishna Murthy Capt Samuel Singh and Arvind Dabar Besides other criminal acts I was criminally insulted detained physically hurt by these persons inasmuch as security was ordered to place a guard on me and at my house I was not allowed to go back to my house and my access was blocked and I was thrown out of the colony premises in night without any aid or consideration and out of no fault of meI was constrained to approach state police for my protection Police also registered a criminal offence u

nder various sections of Indian Penal code at police station against these four persons for atrocities and violation of human rights on me Prayer tAs I have not even been given a hearing on the subject b y any officer of firm Enron I submit the case to your high office f or giving me an opportunity to place before you all the records and other relevant facts and information t I request the above complain t may be investigated by your high office including an opportunity t o me to plead my case as requested herein above following the concep t of natural justice tI request justice to me and deserving action against the culprits For this consideration of yours I pray always duty bound Sincerely yours Ravi Garg Get your FREE download o f MSN Explorer at <http://explorer.msn.com/intl.asp>

Sender: j..kean@enron.com

Date: 2001-11-14 12:35:16-08:00

Subject: nan

Text: XOrigin LayK XFileName KLAY NonPrivilegedpst Some background information for the meeting with Mayor Brown Brown won of the vote to Sanchez and is now in a run off with Sanchez Sue Waldens perspe ctive not surprisingly is that Brown will win and that campaign poll s show him ahead among likely voters African American turnout in th e election was lower than expected but an active getoutthevote campa ign could turn that around Enron has supported the mayor with a con tribution I would not recommend a further commitment under the curr ent circumstances If you want to discuss some of the positive accomp lishments of his administration you could Congratulate him on passag e of his version of the light rail proposition Compliment him on how he has responded to security issues since Sept and his handling of flood relief You should know that the Houston police were extremely helpful and responsive when we asked for assistance in connection wi th the October threat to the Enron building We have responded to th e Citys RFP for energy service EES made a presentation last week pro posing a year transaction The city is opting for a year transactio n That would require very detailed load data which is in Reliants po ssession We have expressed concern that we are merely a stalking hor se in the citys effort to do a deal with Reliant We have said that we wont play on those terms Separately we are working with the city on a demand side deal

Sender: nshaw@usenergyservices.com

Date: 2001-10-09 08:41:14-07:00

Subject: RE:

Text: XOrigin LayK XFileName KLAY NonPrivilegedpst Ken Thank you f or your response to my email Whether you actually took the time to respond or left it to one of your assistants I hope you read my comm entssuggestions and truly understood them I have a few more comment s and suggestions You are correct overall stock values have decline d and Enron has some additional unique issues related to its broadba nd and telecom business payments from California and large investmen ts in foreign power plants particularly India However I cannot agree

e with your comments or Jeffs about short sellers Short sellers like jackals and vultures exist for a reason and are an important part of the whole financial community in which we live Short sellers and Jackals are always looking for a dealmeal When they find an unhealthy company animal they investigate which oftens leads to greater opportunities Enron under Jeffs leadership was not healthy and the short sellers jackals found a wonderful opportunity Your current job as was Jeff Skillings is to not provide the short sellers jackals a reason or opportunity to focus on Enrons stock price I applaud your recent commitment to the financial community to provide better definition regarding Enrons profits Developing the necessary internal mechanism for a largely transparent financial reporting system will police itself and will ultimately reinforce confidence in Enrons true value As an economist you need to remember that the market value of any company in todays economy is largely based on the markets perception of its value As you and I have so recently seen the market very often reacts on preception and only looks at intrinsic value as an afterthought The financial community believes that if it quacks like a duck and walks like a duck thenjust maybe it is a duck and not really a racehorse Enron executives need to be more cognizant of the negative impact their excessive insider selling of shares has on market preception Using stock options in lieu of salary is a very powerful incentive but it can also backfire especially if the proper safeguards are not in place Excessive insider trades can and should be limited Doing good things for the right reasons works For some years now Northerns leadership has not done many good things for the right reasons They are highly political and have developed a nasty habit of not telling their upper management Stan Horton the truth but what Stan wants to hear They are doing many things not because they should but because they can get away with them This activity works only as long as their customers do not have a choice You want examples look at the nonEnron pipeline activity in Florida and the upper midwest A solid domestic asset with a reasonable return is much better than the possibility of much higher returns on assets in unstable foreign markets Enron is not smarter than the world and the world has certainly demonstrated that it will not allow Enron to possess very much control over world affairs Lets learn from our mistakes Selling difficult assets such as in India is good Selling profitable assets such as Portland General is bad just to make the bottom line revenue Warren Buffet an Omaha native does not look like such an old fuddyduddy as he once did as recently as last year Strong solid fundamentals do count and Short sellers will always be around and DOING GOOD THINGS FOR THE RIGHT REASONS truly works Sincerely Neal Shaw
Original Message From KennethLayenroncom mailto:KennethLayenroncom Sent Monday, October 11, 2002 1:00 PM To: Shaw Neal Subject: RE: Any responses to this email should be sent to kennethlayenroncom Neal I appreciate your recent email concerning the decline in Enrons stock price I share with you a very deep disappointment and frustration about this decline The decline has occurred for a number of reasons First overall stock values have declined significantly this year Enrons stock

price has declined more than averages primarily because of the total melt down in the broadband and telecom business difficulties with getting paid by the California utilities and trouble with our large power plant and LNG project in India. These problems have been further compounded by endless misinformation and rumors probably promulgated by short sellers. In any event I believe we are making progress in addressing these various problems. I believe our stock price will increase over the short to intermediate term. With good success we will be able to restore most or all of the value we lost this year over the not too distant future. I appreciate your concerns and your suggestions and I will certainly do everything I can to restore your confidence in Enron. Sincerely, Ken

Original Message From: Shaw Neal
 nshawusenergyservicescom@ENRON
 mailto:IMCEANOTEShawCNealCnshawusenergyservicesE.com@ENRONENRONcom
 Sent: Monday, September 13, 2002
 To: Kenlay@enron.com
 Subject: Ken

My name is Neal Shaw and I worked for Northern Natural Gas Company in Midland, Minneapolis and Omaha in the Marketing Department of Enron's Gas Pipeline Group for almost 15 years. I left the company in December 2001. I have a major portion of my investment portfolio in Enron shares. I just read an interesting article titled "Sizing up CEO aplomb under duress: a major concern by Jamie Lareau." This article focused on how to recognize CEOs and CEO candidates who were not up to the requirements of their job and used Jeff Skilling as an example. I have agreed with the views of this journalist for some time, especially since Jeff called a fund manager an asshole. Publically calling someone is simply not something any CEO should do and you and Enron's board should have done something about Jeff then. My point is as follows: Where were you and the Enron Board during all this? Why have you let people like Jeff Skilling and Stan Horton virtually destroy all growth prospects for the pipelines and totally concentrate on trying to make money without an asset base? A lot of people believed in Jeff's hype and many people have suffered. Has Jeff suffered? I think not, especially since he has left Enron with millions of our dollars in his pocket. Hopefully he will be able to afford the time off to find himself. Did you see the movie Top Gun? Toward the end of the movie Tom Cruise, otherwise known as Maverick, blamed himself for the loss of his friend and simply disengaged from combat flying. However, when things got really rough, Maverick reengaged the enemy and did what he was hired to do. Do you know where this is going? You are once again Enron's Top Gun. The enemy is Enron's depressed stock price. It is time for you to reengage and live up to your title of Top Gun and CEO. I and the rest of Enron's stock holders need you to repair the damage Jeff did and STOP the damage people like Stan Horton are currently doing and get Enron back in the mix. I sincerely hope you are still capable of doing a good job. If you are not, refund your salary since Jeff took over and stepped down. Sincerely, Neal Shaw
 US Energy Services Inc. Phone: 713.851.1111 Cell: 713.851.1111 Fax: 713.851.1111

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Sender: craig.buehler@enron.com

Date: 2001-09-24 08:52:09-07:00

Subject: Security Idea

Text: Dear Ken With everything that has happened in the past few weeks I think we all realize how dangerous this world truly can be As an employee I appreciate the security measures that Enron has implemented over the years however I think the events of September show that maybe we haven't gone far enough Although we could do little about a suicide attack from the air there are many other types of attack we could prevent or minimize The Houston Police Officers around the buildings and on regular patrol provide good basic protection However in the event of a citywide attack the Police would be unavailable and we would have to take some type of action ourselves The Security firm contracted for the building lacks the training to respond to life and death situations I would recommend and volunteer for a security team comprised of Enron employees with prior military or police service There may come a time God forbid when we just have a few moments to act and the police may not be available If we can't defend ourselves in the first few minutes of an attack it could be too late I served in an antiterrorist unit in the US Army and have a few ideas that I think could help If this is in the realm of possibility I would be happy to discuss this with whomever you designate I do feel safe here at work but planning for the worst before it happens seems very prudent in these times Thanks Craig Buehler

Sender: shelley.farias@enron.com

Date: 2001-09-17 07:16:27-07:00

Subject: nan

Text: Mr Lay My name is Shelley Farias and I work for EES in the Allen Center On Friday September 14 at 4 PM as I was leaving work I saw something that frightened me outside the Allen Center In a car parked in the circle drive was a young man about 20 years old of Middle Eastern descent taking pictures of the Enron building and the Allen Center Security was at the scene and asked the young man to stop taking the pictures he got back in his car and continued to take the pictures My husband wrote down the license plate number and make of the car and gave this information to security Security informed us that they would take care of the situation I spoke to security

ty this morning and they do not have any report of this incident or the police being notified Mr Lay with everything that has happened to this country I am scared that something may happen to us I would like to think I can come to work and be safe but with security not taking instances such as Friday seriously I have doubts Please let me know what I should do contact the police myself or wait on security Shelley Farias

Sender: billy.lemmons@enron.com

Date: 2002-01-10 12:10:39-08:00

Subject: Accounting Article From Fortune Magazine

Text: Ken Beth suggested that I forward a copy of this article to you I've highlighted some relevant points for your convenience Regards Billy ACCOUNTING IN CRISIS One Plus One Makes What The accounting profession had a credibility problem before Enron Now it has a crisis FORTUNE Monday January Where were the auditors People ask that question after every corporate collapse and lately they've been asking it with disturbing frequency At Waste Management Sunbeam Rit e Aid Xerox and Lucent major accounting firms either missed or ignored serious problems The number of public companies that have corrected or restated earnings since has doubled to according to a study by Big Five accounting firm Arthur Andersen Now following the stunning bankruptcy of Andersens own client Enron that question where were the auditors has become a deafening refrain I believe that there is a crisis of confidence in my profession Andersen CEO Joseph Berardi told a congressional committee investigating Enrons collapse in mid-December Real change will be required to regain the public trust The full story of the Enron debacle and what Andersen did or did not do in its audit will take months to emerge In the meantime no one disagrees with Berardinos diagnosis that there is a crisis in accounting even if his sudden emphasis on industrywide reform springs from a desire to deflect attention from Andersens own culpability But the kind of real change required is a matter of substantial debate The government gave the franchise of auditing public companies financial statements to the accounting industry after the stock market crash In the decades since the accountants have adroitly avoided significant government regulation by arguing that they can police themselves Now post-Enron they're doing it again The Big Five CEOs issued a rare joint statement outlining how they intend to strengthen financial reporting and auditing standards Self-regulation is right for investors the profession and the financial markets the release concludes But is it Accounting's main self-regulatory body the Public Oversight Board is a monument to the professions failures The POB was created in the late s when Congress held hearings on a string of audit failures at public companies that had much like the recent rash shaken confidence in the major auditing firms The POB which has no enforcement power investigates alleged audit failures and oversees a triennial review process in which the major accounting firms examin

e one another's procedures. And yet problems persist; arguably they have grown more acute. Is accounting self-regulation working? On the face of it, it is not, says Representative John Dingell, the powerful Michigan Democrat who has long sparred with the accounting profession. In their defense, the auditors note that current accounting methods, many of which were designed years ago, are difficult to apply to today's complex financial transactions. And there is no way they insist to prevent sophisticated fraud. The American Institute of Certified Public Accountants (AICPA), the industry's professional association, points out that accountants examine the books of more than 100,000 public companies every year; they are accused of errors in just 1% of those audits. But on the price of those few failures, Lynn Turner, former chief accountant of the Securities and Exchange Commission, estimates that investors have lost more than \$1 billion because of financial fraud, and the accompanying earnings restatements since 1990. Perhaps the most glaring example of self-regulation's deficiency has been accountants' unwillingness to deal with conflicts of interest. Over the years, the major auditing firms have transformed themselves into professional services companies that derive an increasing portion of revenues and profits from consulting, selling computer systems, advising clients on tax shelters, and evaluating their business strategies. In accordance with the SEC, half of the Big Five's revenues came from consulting fees versus 10% in auditing. Meanwhile, auditing has become a commodity. Firms have even been accused of using it as a loss leader, a way of getting in the door at a company to sell more profitable consulting contracts. Auditing work is a marvelous marketing tool, says Lou Lowenstein, a professor emeritus of finance and law at Columbia University. You are already there doing the audit. You say their internal controls are not good. Well, who are they going to call to fix it? But this requires a firm to work for the public auditing and management consulting. You cannot serve them both, says former SEC commissioner Bevis Longstrech. This conflict may have played a role at Enron. Andersen received \$10 million in auditing fees from Enron last year. That's money Andersen was paid both as Enron's outside auditor certifying its financial statements and as its internal auditor making sure Enron had the right systems to keep its books and working to detect fraud and irregularities. This double duty alone raised a serious potential for conflict. Besides \$10 million in auditing fees, Andersen was paid \$10 million for consulting services. If you are auditing your own creations, it is very difficult to criticize them, says Robert Willens, a Lehman Brothers tax expert who disapproves of the accounting profession's recent move into selling aggressive tax shelters. Andersen has not revealed the details of its work on Enron's highly controversial off-balance sheet transactions, but the accounting firms have never believed consulting fees compromise their objectivity. They have militantly refused to ever acknowledge the possibility of a problem, Longstrech says.

Sender: wjheilman@worldnet.att.net
Date: 2001-10-30 23:14:37-08:00
Subject: A disappointed stockholder

Text: I have been an Enron stockholder for several years and I am very disappointed with the events of the last two weeks. I find the allegations of accounting irregularities incredible. I would like to know how closely the board had been monitoring the activities of the CFO and whether it approved the partnerships that have led to the SEC investigation and the dramatic decline in the company's stock price. I would suggest that the compensation of senior management may be too heavily weighted towards bonuses giving some the incentive to manipulate the numbers to increase their bonuses and not heavily weighted enough towards stock options. I would hope in the future the goals of the board and senior management will be aligned with stockholders increasing shareholder value. While I know it is not reasonable to have expected the stock price to stay in the highs, I consider the drop in the last two weeks apparently as the result of fraud to be inexcusable. I believe the board owes all stockholders an explanation that will finally clear the air about this mess. Maybe the markets will trust Enron again if it replaces evasion with candor. Please help return credibility and ethics to this company which apparently are badly needed. Wayne Heilman, Owner of Enron shares in my children's college fund.

Sender: wjheilman@worldnet.att.net

Date: 2001-11-13 22:59:53-08:00

Subject: Upset stockholder

Text: I have found the events of the last two months to be among the most unsettling in my years of owning stock in public companies. I have sold my shares of Enron Corp because I no longer have faith in the board to be a good watchdog for the best interests of the shareholders. I just don't understand how senior managers can manipulate the financial results of the company for the past five years and only recently be discovered. I expect the board to act as more than a lapdog for senior management. I am encouraged you turned down the chance to accept a million payday for this merger that salvages what little shareholder value remains in Enron. I would expect the board to seek repayment of any and all bonuses paid to senior managers based on these inaccurate financial results including the estimated million paid to the CFO who allegedly is the architect of this scheme to defraud stockholders. Had I known the company was apparently built on smoke and mirrors, I would have sold my stock long ago and not be forced to watch my children's college fund be pocketed by executives who have little regard for the stockholders they were hired to serve. I guess the only lesson I can take from this is that no company, no matter how large or prestigious, is safe from dishonest management. I do not include you in this group, but I do believe you and the board bear some blame for allowing this to happen for the past five years. Wayne Heilman, Former Enron Stockholder.

Sender: jeffrey_fountain@bankone.com

Date: 2001-10-24 05:44:16-07:00

Subject: Yesterday's Call: Feedback

Text: Ken Thanks for having the call yesterday I am a believer in Enron and we are buying your debt Heres short feedback on the call I give the call a BC grade If you want a good example of a company call listen to the tougher calls So Cal Ed had for investors They t alked with investors twice weekly for months There is an honestess and openess about the calls that worked to keep investors informed The angry exchange with the short seller was a blunder No matter wh at the question no matter how stupid or obnoxious the Enron answer s hould always be empathetic and pointedly factual Yes you will have to open the kimono more than Enron ever has to restore confidence E NE has become more a financial institution and less an energy compan y with hard assets You are in a confidence game pure and simple An y attempt at keeping things close to the vest will backfire and exac erbate the current crisis If you want to see disclosure in financia ls look at Citis ENE is having an encounter session with the entire investment community This is not a time to be aggressive and smart It is a time to be open honest and selfeffacing Third party confirm ation will go a long way in restoring confidence which means Moodys maintains their rating or limits the change to a onenotch downgrade bond rating with stable outlook restored the Moodys analyst is pisse d you surprised with the writeoff the SEC gives ENE a fairly clean report no selfdealing found on their transactions with private equit y partnerships no more large surprise writeoffs outside auditors c ontinue with unqualified audit reports operating earnings targets a re met for this year and next and fuller disclosure is made in quart erly releases Of course if any fraud or malfeasance is found you gu ys and ENE are history I have my ass on the line because I believe in ENE We have made investments ENE is in the shitter because of E NEs past communication and behavior mistakes Be humble be smart and change Good Luck Jeff PS You state there is a Chinese wall betwe en LJM and ENE Why in the world then would you have the same guy Fa stow play key controlling roles in both organizations If you want t o pay him pay him Keep it simple I am glad Skilling is gone I wou ldnt touch your companys debt while he was there I hated him and hi s attitudeand my past exposure to him was extremely limited Thi s transmission may contain information that is privileged confidenti al andor exempt from disclosure under applicable law If you are not the intended recipient you are hereby notified that any disclosure c opying distribution or use of the information contained herein inclu ding any reliance thereon is STRICTLY PROHIBITED If you received thi s transmission in error please immediately contact the sender and de stroy the material in its entirety whether in electronic or hard cop y format Thank you

Sender: jim.schwieger@enron.com

Date: 2001-10-19 11:02:44-07:00

Subject: Financial Disclosure of \$1.2 Billion Equity Adjustment

Text: For the first time in years of service for Enron Im ashamed t o admit th at I work for Enron I have lost all respect for Enron Se

nior Management and agree with the Financial Analyst when they say that Enron Senior Management can not be trusted. Ethics and Morals are either something everyone else needs to have except Senior Management or somewhere along the way Senior Management started believing the end justifies the means. The communication to the Employees have received over the last few years about values such as Respect Integrity Communication and excellence must be propaganda intended to get Employees to believe Senior Management really supported these values so that no one would really notice that their actions represented something just the opposite. I can not believe that Senior Management lacks the understanding of human nature to totally ignore the fact that if someone does not trust what you have said in the past you should not try and conceal pertinent information in the future. Then to allow an Enron Spokesperson to speak for Enron with the statement "It's just a balance sheet issue" implies to me that this individual does not know what a Balance Sheet or Income Statement is and certainly should not be speaking to the public. If you are going to play the game of lying cheating and stealing at least be intelligent enough to present a plausible story. To use phrases such as "it was a hedge against fluctuating values in some of Enron's broadband telecommunications and other technology investments" is a complete insult to my intelligence and to the definition of the word HEDGE. A hedge by definition implies that the upside and downside exposure has been limited. It frightens me that we are out asking customers to let Enron help them HEDGE their risk when I'm not sure Enron's Senior Management understands what a hedge means. I'm also confused as to the personal financial involvement of Andy Fastow in the investment vehicle that generated this write down. I must be confused in that as a Trader Enron has asked me to sign documents declaring that I will not have any personal financial involvement in anything involving the Natural Gas Business. This must be an example of as my father used to say "do as I say not as I do." I guess we need to have audits performed of Senior Management's financial interest to insure their actions are as good as their word. The fact that Senior Management and the ENE Board of Directors knew these transactions were being used to manipulate earnings and the stock price and took advantage of that knowledge to sell their ENE stock options in my opinion is CRIMINAL. It provides me no comfort to know that the biggest perpetrators of this fraud have left Enron in recent months. These individuals have stolen billions of dollars from ENE stockholders and Employees and need to pay the price for such fraudulent activity. They are set for life having all the money they could ever need while Employees and Stockholders have lost their life savings. You have completely failed at the job you were hired to perform. If this type of activity would have occurred farther down the organization no one would hesitate to fire the individuals involved and to institute criminal charges. I for one can not wait until the All Employee meeting next week. I do not think anyone wants to hear about third quarter results because how could we trust what is said anyway. Instead I feel you owe the ENE Employees a thorough explanation of how you

failed to perform your responsibilities what actions are going to be taken and most of all apologize for the job performance to date

Sender: wade.cline@enron.com

Date: 2001-09-26 14:07:52-07:00

Subject: Reaction to Ken Lay Letter to Indian Prime Minister

Text: XOrigin LayK XFileName KLAY NonPrivilegedpst Ken I wanted to update you on the reaction to your most recent letter to the Indian Prime Minister You recall that we recommended you write again to the Prime Minister and express disappointment at the lack of progress since your July trip and your August letter containing our offer to sell our equity at costs I believe writing this letter was the proper response but only time will tell what reaction if any finally comes from the Indian government I think you should know about the press coverage of the letter just in case the letter were to come up in any conversation you might have with someone from the US government I am not anticipating this at all but I would not want you to be unprepared about the press coverage The US embassy over here is very much up to speed I met again with Ambassador Blackwill on Tuesday of this week and gave him a general update on the current status His view is that it is very difficult in the postSept environment to get anyone in Delhi or Washington to pay attention to economic matters such as Dabhol but he is trying as best he can He is meeting with Brajesh Mishra Prime Ministers principal secretary on Saturday who will have just returned from Washington meetings with Ms Rice among others principally to discuss antiterrorist matters John Hardy of our DC office briefed the State Department last week in advance of these meetings and we are awaiting to hear any discussion or outcome regarding Dabhol Regarding press coverage of the letter as we anticipated the entire letter was leaked to the press Several articles have appeared that describe the harshly worded letter and many articles have quoted verbatim sections from the letter The Wall Street Journal article from last week presented the letter fairly and I think it came out rather sympathetic to our position The Indian papers have been neutral to negative For example an editorial reprinted below was in Wednesdays Financial Express a business daily in India but not as widely circulated or respected as The Economic Times or The Business Standard Note the editorial below says your letter states that any government found to have expropriated the property of US firms automatically faces sanctions from that country Your letter did not state that but this is a holdover from the earlier Financial Times interview Many people I have met with in the Indian government have made references to the letter saying they do not think it was appropriate I respond by saying that given our year history of nothing but frustrations and the lack of progress over the past months we do think it is appropriate and it reflects our current views regarding our experience in India Generally when they mention it time and again it probably means the letter is having at least some of its intended effect Ill keep you Stan and Jim updated as we hear more from the Indian government Wade Nikita Varma

PM ToNikita VarmaENRONDEVELOPMENTENRONDEVELOPMENT cc bcc Wade ClineENRONDEVELOPMENT SubjectFrom The Enron India Newsdesk September th Newsclips THE FINANCIAL EXPRESS Wednesday September Lay off Mr Lay Editorial Enron tries terror tactics Enron Corporations CEO Kenneth Lay has reportedly written a letter to Prime Minister Atal Bihari Vajpayee warning him of adverse consequences to the Indian economy if the Dabhol Power Company imbroglio is not resolved quickly He says that if Enron receives anything less than its full investment in DPC it would amount to an act of expropriation He further points out that any government found to have expropriated the property of US firms automatically faces sanctions from that country Reportedly the letter was written three days after the attack on the World Trade Centre So Mr Lay probably ought to be forgiven for reading more than he should into the dead or alive rhetoric of his pal George W Bush whose election campaign Mr Lay generously funded Saner counsel has since prevailed even at the White House and far from imposing fresh sanctions the US government is busy buying support even from countries such as Pakistan by lifting sanctions and offering a hefty aid package Enron has never hesitated to use the considerable economic and political clout of the US government in pushing the Dabhol project at various times Post September the US government which is in fact rewarding Pakistan despite its clearly identified role in funding terrorist groups ought not to be terrorising India on Enron Hence it is entirely appropriate for the Prime Minister to borrow that little Americanism recently made popular by Pervez Musharraf and ask Kenneth Lay to lay off Interestingly Mr Lays letter apparently makes no mention of several important facts that will dictate how much India may have to pay Enron These include the findings of the Madhav Godbole committee report which expose substantial overcharging by DPC on several counts and reveals excess capacity created for port handling and regassification Moreover DPCs inability to ramp up the power plant to full contracted capacity within the specified time period has enormous penal provisions attached to it This serious technical deficiency apart which alone is grounds enough for repudiating the DPC contract the government also has a good case to charge the US company with fraud and misrepresentation The Maharashtra government's judicial inquiry only makes Indias case stronger Let us not allow ourselves to be pushed around by Enrons threats and political connections

Sender: wms@kainon.com

Date: 2001-11-28 09:52:46-08:00

Subject: Enron Is History, Says History per the WSJ Page A19

Text: Hello again Out of all of the stuff in the media this is the most informative of all we have seen Very well said We wish all the best for those effected and Houston as we move through this When the dust clears Enron will be remembered as a pioneer and great corporate citizen Best Mark W Mark Shirley CPA x wwwkainoncom Enron Is History Says History By HOLMAN W JENKINS JR November Business World Back in the mids a pipeline executive called Ken Lay was fishing

around for a name for his company produced by a merger of Houston Natural Gas and Omaha-based InterNorth. He consulted with consultants, politicked with politicians and came up with a moniker. The company would be called Enteron. Three weeks later fed up with the wisecracks from a press that had looked up the dictionary definition of enteron in the intestine, he changed the company's name again. Henceforth it would be known as Enron. A columnist less devoted to high standards of decorum might be tempted to extend the metaphor of the company's misbegotten name. In recent weeks, after all, we've seen Enron's stock collapse over indigestible accounting and the emergence of dealings between the company and its senior officers that exude an odor of genuine malfeasance. The evidence is far from clear, but for the sake of Mr. Lay's reputation, one hopes these missteps will prove one more case of a company fooling itself rather than setting out deliberately to defraud the markets. Enron grew to be much more than a pipeline hauler of natural gas, becoming the preeminent trader and marketer of all kinds of energy contracts and a vocal proponent of deregulation. Now, all but overnight, it's kaput, just waiting to find out if its fate will be bankruptcy or absorption by an erstwhile rival. We cannot help be put in mind of another commodity wunderkind in the '80s, Phibro, short for Philip Brothers. Hard to believe, but Phibro was once a name that made grown men quiver on Wall Street, fattened by trading profits from the great commodity inflation of the '70s, which some mistook for a permanent new age of scarcity. It scooped up the Street's oldest partnership, Salomon Brothers, tucking it into its back pocket and renaming the combined firm PhibroSalomon. Here was a powerhouse of unlimited potential. Investors told themselves, Flash ahead to California's electricity meltdown earlier this year, Enron saw its revenues quadruple, partly as a result of the inflated prices being quoted in the California market. Many foresaw a new scarcity megatrend, but there was no true energy shortage. Posted prices on the California power exchange may have skyrocketed, but the effective price was zero dollars and zero cents, because the utilities had no cash to pay and politicians were thumbing their noses at piles of IOUs. When prices are zero, suppliers take a hike, that's what economics teaches. But once the state government started pumping its own cash into the market, the phony posted prices plummeted and supplies became plentiful again. Now California is swimming in power and nobody talks about an energy crisis anymore. You can date the loss of investor confidence in Enron almost exactly to the moment when the California fiasco began to repair itself. Fortune Magazine put the inaugural nail in Enron's coffin in March, noting that the company's growing dependence on trading had turned it into an oilpatch version of Goldman Sachs. Goldman's stock sells at a price-earnings multiple of 10, reflecting investors' well-founded distrust of trading earnings to be reproduced reliably year after year. So why the magazine asked was Enron awarded a multiple of plus infinity? Enron did yeoman service as a champion of deregulation. Boss Ken Lay, a believer in technology and the power of markets, was a true visionary to the point of annoying people who didn't care for his air of being a man on the right side of history. The moldering pipeline he took over would cease

rtainly have been an alsoran if he had not thrown Enron headlong into trading and marketing But deregulation doesnt confer permanent advantage on anybody A deregulated environment favors constant innovation and a continual upsetting of plans and strategies Add the fact that despite the California bubble there is no reason to believe energy prices wont continue their longterm relative decline as technology advances more quickly than the depletion of conventional resources Add also the likelihood that information technology will continue to lower the barriers to entry to Enrons trading business which means more competition and shrinking margins Enron begins to look a lot like Phibro The great commoditytrading machine was already running down by when it bought Salomon and Wall Street was swooning Inflation was being quelled by Paul Volcker The products that Phibro traders bought and sold were increasingly being traded transparently on electronic exchanges Four or five years ago they used to be able to take other companies to the cleaners because they knew where the market was and others didnt a trader explained With everyone knowing within a few cents where the price of any product was Phibros ability to make a profit off its superior knowledge disappeared Not only is this true of Enron but of its wouldbe bottom fisher Dynegy run by Mr Lays Houston homeboy Chuck Watson Dynegys proposed takeover of its former nemesis was hanging by a negotiation yesterday While Enron in recent years was selling hard assets and concentrating on electronic marketmaking Mr Watson was doing the opposite His big play in the Enron deal is to get his hands on the original HNGInterNorth pipeline now known as Northern Natural Gas By having both feet planted in the real business he claims his firm will be able to make a profitable sideline out of trading despite growing competition and transparency Well see Dynegy and Enron were born at the same time and of the same motive Dynegy was originally created by six pipeline companies a Washington law firm and Morgan Stanley to take advantage of new opportunities in deregulated natural gas But the gnats are already circling Gas producers who have claimed for years that the duo control too much of their fate now insist they shouldnt be allowed to merge Dont listen to the fussbudgets If this was a business in need of trustbusting Enron wouldnt have been resorting to funny accounting to make its earnings As Merrill Lynchs Donato Eassey has pointed out wholesale margins have been steadily thinning as trading becomes more transparent and competitive Wishful accounting has time and again proved the last refuge of companies whose dearly held visions were not panning out Enron prided itself on being realistic and adaptive but it failed to see that its own beliefs about the world needed overhauling It aint what you dont know that gets you in trouble its what you know for sure that aint so Mark Twain K A I N O N G R O U P Consulting Staffing Recruiting

Sender: cannon_craig@yahoo.com

Date: 2001-11-29 07:03:29-08:00

Subject: GREED

Text: Dr Lay What a joke Do realize how lives you and your board of

directors have ruined all because of greed and power I looked up to for a while building a great company nice place to work but then greed got in your way Lets hear again why Skilling quit because of family BS Over the past ten years i have worked at Enron as a computer contractor in payroll and i saw the outlandish executive bonuses and money to the islands I hope you get justly fined and sent to prison for the fraud you have committed The few shares of enron i have left are not worth the paper they are printed on i also saw all the stock options you and the board have exercised over those few years of millions of dollars what a shame When you opted to replace the Oracle Payroll with SAP I knew you were losing your mind all the great people that made you now have to find a job replace their retirement and hope for the best I hope we never meet Craig Cannon a stock holder Do You Yahoo Yahoo GeoCities quick and easy web site hosting just month <http://geocities.yahoo.com/info>

Sender: kenneth.lay@enron.com

Date: 2001-09-25 11:39:46-07:00

Subject: RE: Media Reports

Text: Hasan I fully understand and agree with your comments Unfortunately I did not see the Travel Security Update email before it was sent out We will do better Ken Original Message From tKedwaili Hasan SenttFriday September 21 10:45 AM To: Lay Kenneth SubjecttRE Media Reports Sir I read your note with great deal of interest and care I was pleasantly surprised to see that this email was devoid of any stereotypical remarks that are so prevalent in the mass media today Unfortunately such is not the case with other communications being sent out on behalf of Enron Corp A case in point is the corporate security email titled Travel Security Update that was sent out yesterday In this email reaction to possible US military retaliation has been tied to extremist Islamic violence Truth of the matter is that any reaction to the US military action could be because of extreme nationalism most likely to be the case or even extreme regionalism References to Islam extremism and violence in the manner used in the security communication only perpetuates the stereotypes I would like for you and my coworkers at Enron to know that MUSLIMS DO NOT HATE AMERICANS regardless of what Frank Graham wants to believe Muslims do have deeprooted disagreements and distrusts of the American foreign policy but that in no way translates to what the mass media would have us believe thanks Original Message From tEnron AnnouncementsCorpEnronENRON mailto:IMCEANOTES@enron.com SubjecttMedia Reports On Behalf Of Ken LayENRON SenttThursday September 20 11:45 AM To: All Enron WorldwideENRON SubjecttMedia Reports As you know the US government is investigating hundreds if not thousands of relatives acquaintances and associates of the individuals who may have been involved in the terrorist attacks on Sept 11 We believe that the media will soon be reporting that one of the many individuals being questioned is an Enron employee in Houston It is appropriate for us to with

hold judgment and to continue to cooperate fully with federal authorities. Because this is a matter in the hands of the federal authorities we cannot provide additional information at this time. However we will keep you informed to the greatest extent possible. Please keep in mind that thousands of people who may or may not have any information about the terrorist attacks are being questioned as part of this investigation. We continue to have every reason to believe that our employees and facilities are safe. If you have concerns please call Corporate Security at . If you receive any media or external inquiries about this matter please call Public Relations at . At Enron diversity is one of our strengths and we respect and embrace all people of all faiths and beliefs. Please continue to keep our employees who have been impacted by this tragedy in your thoughts and prayers.

Sender: steven.kean@enron.com

Date: 2001-04-26 08:55:00-07:00

Subject: FERC's Prospective Mitigation and Monitoring Plan for CA Wholesale

Text: XFileName skeannsf fyi Forwarded by Steven J KeanNAEnron on PM Ray Alvarez PM To Tim BeldenHOUECTECT Mike SwerzbinHOUECTECT Michael M DriscollPDXECTECT Matt MotleyPDXECTECT Robert BadeerHOUECTECT Diana ScholtesHOUECTECT Sean CrandallPDXECTECT Chris MalloryPDXECTECT Jeff RichterHOUECTECT Tom AlonsoPDXECTECT Mark FischerPDXECTECT Phillip PlatterHOUECTECT Carla HoffmanPDXECTECT Christopher F CalgerPDXECTECT Michael EtringerHOUECTECT Steve C HallPDXECTECT Christian YoderHOUECTECT Tim HeizenraderPDXECTECT Stephen SwainPDXECTECT Jeff DasovichNAEnronEnron Susan J MaranaNAEnronENRON Joe HartsoeCorpEnronENRON Ray AlvarezNAEnronENRON Elliot MainzerPDXECTECT Bill Williams IIIPDXECTECT Paul KaufmanPDXECTECT James D SteffesNAEnronEnron Phillip K AllenHOUECTECT Mike GrigsbyHOUECTECT Don BlackHOUEESEES Neil BresnanHOUEESEES Jubran WhalanHOUEESEES Dennis BenevidesHOUEESEES Jess HewittHOUEESEES Louise KitchenHOUECTECT John J LavoratoEnronEnronXGate Greg WhalleyHOUECTECT Richard ShapiroNAEnronEnron Steven J KeanNAEnronEnron Linda RobertsonNAEnronENRON Rebecca W CantrellHOUECTECT Leslie LawnerNAEnronEnron rcarrollbracepattcom Sarah NovoselCorpEnronENRON Mark PalmerCorpEnronENRON cc Subject FERCs Prospective Mitigation and Monitoring Plan for CA Wholesale Electric Markets The following report is comprised of what was discussed at the Commission meeting held tonight at approximately PM EST and additional intelligence gathered from FERC staffers after the meeting by Joe Hartsoe Physical Withholding To prevent physical withholding the plan will require sellers with PGAs to offer all their available power in real time All California generators even those not subject to FERC price regulation will be required to sell into the ISOs real time market as a condition of their use of the ISOs interstate transmission lines Hydroelectric facilities will be exempted for yr Price Mitigation The plan will establish a single market clearing price auction for the real time market During Stage and emergencies in the ISOs real time market each generator other than

hydro with a participating generator agreement is required to offer all available power and bid its marginal cost based on the generator's heat curve, emission rates, gas costs, and emission costs plus for OM. The gas cost will be the average daily cost of gas for all delivery points in California. Emissions are to be based on Cammon Fitzgerald. The gas cost and emissions will be published the day after for use on the following day. A single market clearing price is determined in real time for all generators. Highest bid sets the clearing price. Each gas-fired generator must file with FERC and the ISO on a confidential basis heat and emission rates for each generating unit. The ISO will use these rates to calculate a marginal cost for each generator including maintenance and operating costs. In the event a generator submits a bid higher than the proxy price, the generator must within days of the end of each month file a report with FERC and the ISO justifying its price. FERC has days to review. No opportunity costs in real time. Marketers are in the same boat as they must be prepared to justify bid at purchased cost based on specific purchases or portfolio with no opportunity cost. However credit sleeves are permissible. Demand Response. Beginning June, only public utility load serving entities must submit demand side bids to curtail load and identify the load to be curtailed under those bids. FERC is attempting to break the demand curve. Outages. PGA generators will coordinate planned outages and report forced outages in accordance with the Commission Staff proposal adopted by FERC. Term Order expires one year from date of issuance. RTO Filing. California ISO and two Utilities must make RTO filing by June, or Order lapses with no further effect. ISO Reporting. On September, ISO must file a status report on how things are working and how much generation has been built. Comments are due in days. Quarterly reports thereafter. Revocation of Market Based Rate Authority and Refunds. The market based rate authority of all public utilities is conditioned on no physical withhold of capacity and no inappropriate bidding behavior. Inappropriate bidding behavior includes bidding unrelated to known characteristics of the generation unit or without an input cost basis or bidding not based on unit behavior. An increased bid based on increased demand could apparently be inappropriate. In addition, hockey stick bids are expressly prohibited, i.e., bidding at marginal cost and at a much higher level. Limited filing. Applies to sales in the WSCC outside California. Refund conditions apply in real time spot markets when contingency within a control area falls below. Control areas are not required to publish when this condition occurs. Apparently anything over marginal cost must be justified. All marketers and nonhydroelectric generators must offer to sell contractually and physically available capacity/energy to a location within WSCC. FERC is attempting to mirror the rules applied in California. Comments are due in days on the investigations. The refund effective date is days from publication of the Order. Nox Limits in California. Must sell requirements do not apply if a unit is prohibited from running by law. However, it appears that incurring fines does not overcome the must sell requirement; just include the fines as

s part of the price bid Also if Nox is limited may seek to show that generation would have been sold elsewhere or at different times for determining price Surcharge to pay past amount due Comments are due in days on whether FERC should require the ISO to surcharge parties for payment into an escrow account to pay past costs and the effect this surcharge would have on the PGE bankruptcy filing No mention was made at the meeting as to issue of exports of power from California The Order is not finally drafted as of yet and the status of the foregoing items could change upon issuance of the Final Order We will keep you posted RA

Sender: jeffrey.sherrick@enron.com

Date: 2000-08-30 06:39:00-07:00

Subject: India "CPIL" Supreme Court Case

Text: The Supreme Court hearing for the case in India regarding the alleged improper bidding and award of the PannaMukta block concluded today Our legal teams opinion is very optimistic based on the way the proceeding progressed and also on the actions of the chief judge during the concluding arguments of the case today in India The panel of three judges will now take approximately months to write their opinion and that should complete this case While I probably shouldn't speculate on the outcome I will summarize my opinion of the important points there is little doubt that the PannaMukta award to EnronRelianceONGC will stand and it is highly unlikely that the judges will request the PSC to be renegotiated the contract was portrayed and generally accepted by the panel as a very fair deal for the GOI According to my general counsel Stephen Wallace the only concern our team has is that the judges were quite critical of the CBI the government group that investigated Reliance for wrong doing in the bid process during that portion of the testimony and there is a possibility that they could request an additional investigation Our team puts the likelihood of the judges ordering a new investigation at less than There is downside to such a decision in that it creates uncertainty but the focus would be on Reliance not Enron Enron was very prepared on the commercial and the legal front and our team as expected carried the load for this case even though we were not the primary defendants Enron presented the major rebuttal to the CPIL assertions because the others were not prepared and then later coached the others to help them prepare appropriately This was a much more intensive case than people were assuming it would be last year and we were very fortunate to be extremely well prepared and well represented Based on the above information I do not think this issue CPIL lawsuit should impact any future decisions we make regarding the Panna MuktaTapti assets This outcome basically eliminates one of the two issues impeding the progress of the project I showed Joe our proposal to sell PannaMuktaTapti that we call Project Janus We believe we have a unique opportunity to realize exceptional value for these assets through an arrangement with our partner The strategy we have mapped out should allow us to close the transaction prior to yearend and it has very positive cash

flow and neutral financial implications minimal if any gain due to the stepup last year for the company The only remaining hurdle is a tax issue that we are currently working jeff

Sender: wjheilman@worldnet.att.net

Date: 2001-10-30 23:14:37-08:00

Subject: A dissapointed stockholder

Text: I have been an Enron stockholder for several years and I am very disappointed with the events of the last two weeks I find the allegations of accounting irregularities incredible I would like to know how closely the board had been monitoring the activities of the CFO and whether it approved the partnerships that have led to the SEC investigation and the dramatic decline in the companys stock price I would suggest that the compensation of senior management may be too heavily weighted towards bonuses giving some the incentive to manipulate the numbers to increase their bonuses and not heavily weighted enough towards stock options I would hope in the future the goals of the board and senior management will be aligned with stockholders increasing shareholder value While I know it is not reason to have expected the stock price to stay in the highs I consider the drop in the last two weeks apparently as the result of fraud to be inexcusable I believe the board owes all stockholders an explanation that will finally clear the air about this mess maybe the markets will trust Enron again if it replaces evasion with candor Please help return credibility and ethics to this company which apparently are badly needed Wayne Heilman Owner of Enron shares in my childrens college fund

Sender: hwc@cnyc.com

Date: 2001-11-02 10:40:04-08:00

Subject: Follow-up/Next Steps

Text: Ken Let me expand on some of issues we covered in Houston earlier this week Some of this is outside my purview but want you to have the benefit of my objective outside reasonably wellinformed perspective Please call to discuss any of this at any time Establish your own internal advisory group to plancoordinate all company actions during this period Meetcall with full group at end of each day to assess developments adjust strategies set next days actions In my view that group should include Bowen Derrick Delainey Frevert McMahon Tilney I am happy to participate at any time I'd assign specific tasks to this core group and other senior execs as follows tBowen new IR point person Have him visit and revisit sellside analysts provide update on status of core business financing promise on going communications full disclosure renewed commitment to candor clarity I can help prepareadvise him on this new role tDerrick monitor SEC investigation shareholder suits etc Keep tight leash on MacLusas and Wilmer Cutler Engage outside lawyers in discussion of SEC leak strategy endgame and public relations implications I have considerable experience in this space and would be happy to talkwork with Derrick to insure that the public face of this SEC investigatio

n is seriously evaluated as part of Enrons SEC strategy tDelainey have him spend his time meeting calling talking with wholesale and retail customers Quite similar presentation to that Bowen delivers to the Street Humility candor commitment to continue serving customers should be core thematic tFrevert have him devote his time to calling on talking with international customers with similar messages to those delivered by Delainey Also have him take charge of wholesale reviewpotential revamp of Enrons performance reviewcomp programs This is where Herb Allison Merrills former COO could be helpful tMcMahon hes your point person with lenders ratings agencies Id also have him work with Tilney to construct the clearest case statement possible explaining Enrons strategy for its core businesses and why they are so compelling Suggestion Irwin Stelzer is the single best writer who can simplify complex issues that I know He s offered to help I encourage you to have him see whomever he needs to see and then write the Enron business strategy story Hed also be a great spokesperson and advocate with Wall Street Might be worthwhile having Bowen take Irwin to a few key meetings with sellside analysts I think Irwin would be a huge asset in that role tTilneyt have Beth make sure that every communication from Enron internally and externally is clear concise candid and responsive to each audiences needs and expectations She should manage Mark Palmer and his staff Keepst people and any other communications resources internal and external that should be brought to bear during this period tWhalley have him spend all his time with your traders and those among counterparties with whom he is a critical factor Id keep him away from the Street and from the media tKeant have him focus solely on regulatory and legislative audiences He should personally work federal and state regulators Capitol Hill members and staff and present updated presentation about the companys business status of financials status of internal reviews and SEC investigation I do think Steves core presentation should be vetted carefully by Derrick McMahon and Tilney before he goes on the road tPalmer Id leave it to Tilney as to whether Mark should continue as principal spokesperson for Enron Dont know if Tilneys right but I do think you need a new face and voice to the media tKoenig Id pull him back have him work under Bowen to craftrefine presentations to the Street in close coordination with MacMahon and Tilney As we discussed I think Koenig is damaged goods on the Street right now tLayt I think you should act as the general who sets strategy deploys your senior human assets and motivates your troops I think you should orchestrate every strategic action of the company talk regularly to employees selectively call on strategic customers and reassure the world that Enron touches that you are in charge hands on and doing everything possible to guide this damaged ship into safer waters tEncourage the board Special Committee to prepare an Executive Summary of its report to you and the board that is entirely suitable for public consumption I would be happy to help craft and edit that document Assuming the report fundamentally exonerates the company this is a critically important document You must assume that this report will become public eventually

It is be prepared and submitted with that clearly in mind tRetain a second investment bank to augment Goldman My suggestions talk with Jeff Holzschuh at Morgan Stanley or Bruce Wasserstein at Dresner Kle inwort Wasserstein Lehman's top energy people are gone and I think Rick GordonMerrill is seen as too close to you Ive gone on too long Let me know how I can be specifically helpful to you and/or your colleagues Ill stay in touch via voicemail or email if and as I have specific tactical suggestions Ive available to you or your colleagues at any time Harry W Clark Managing Partner Clark Wein stock hwccwnyccom office cell home office

Sender: hasan.kedwail@enron.com

Date: 2001-10-08 13:40:16-07:00

Subject: RE: Media Reports

Text: Thank you taking time to respond Original Message From tWell s Tori L On Behalf Of Lay Kenneth SenttMonday October PM TotKed wail Hasan SubjecttRE Media Reports Dear Hasan Thank you for sharing your thoughts I agree with you that we should avoid stereotypical remarks in our communication efforts and well do our best to be sensitive to this in the future Ken Original Message From tKedwail Hasan SenttFriday September AM TotLay Kenneth SubjecttRE Media Reports Sir I read your note with great deal of interest and care I was pleasantly surprised to see that this email was devoid of any stereotypical remarks that are so prevalent in the mass media today Unfortunately such is not the case with other communications being sent out on behalf of Enron Corp A case in point is the corporate security email titled Travel Security Update that was sent out yesterday In this email reaction to possible US military retaliation has been tied to extremist Islamic violence Truth of the matter is that any reaction to the US military action could be because of extreme nationalism most likely to be the case or even extreme regionalism References to Islam extremism and violence in the manner used in the security communication only perpetuates the stereotypes I would like for you and my coworkers at Enron to know that MUSLIMS DO NOT HATE AMERICANS regardless of what Frank Graham wants to believe Muslims do have deeprooted disagreements and distrusts of the American foreign policy but that in no way translates to what the mass media would have us believe thanks Original Message From tEnron AnnouncementsCorpEnronENRON mailtoIMCEANOTESEnronAnnouncementsCorpEnronENRONENRONcom On Behalf Of Ken LayENRON SenttThursday September PM TotAll Enron WorldwideENRON SubjecttMedia Reports As you know the US government is investigating hundreds if not thousands of relatives acquaintances and associates of the individuals who may have been involved in the terrorist attacks on Sept We believe that the media will soon be reporting that one of the many individuals being questioned is an Enron employee in Houston It is appropriate for us to withhold judgment and to continue to cooperate fully with federal authorities Because this is a matter in the hands of the federal authorities we cannot provide additional information at this time However we will keep you informed to the greatest extent possible Plea

se keep in mind that thousands of people who may or may not have any information about the terrorist attacks are being questioned as part of this investigation. We continue to have every reason to believe that our employees and facilities are safe. If you have concerns please call Corporate Security at . If you receive any media or external inquiries about this matter please call Public Relations at . At Enron diversity is one of our strengths and we respect and embrace all people of all faiths and beliefs. Please continue to keep our employees who have been impacted by this tragedy in your thoughts and prayers.

Sender: hasan.kedwail@enron.com

Date: 2001-09-21 09:59:01-07:00

Subject: RE: Media Reports

Text: Sir I read your note with great deal of interest and care. I was pleasantly surprised to see that this email was devoid of any stereotypical remarks that are so prevalent in the mass media today. Unfortunately such is not the case with other communications being sent out on behalf of Enron Corp. A case in point is the corporate security email titled Travel Security Update that was sent out yesterday. In this email reaction to possible US military retaliation has been tied to extremist Islamic violence. Truth of the matter is that any reaction to the US military action could be because of extreme nationalism most likely to be the case or even extreme regionalism. References to Islam extremism and violence in the manner used in the security communication only perpetuates the stereotypes. I would like for you and my coworkers at Enron to know that MUSLIMS DO NOT HATE AMERICANS regardless of what Frank Graham wants to believe. Muslims do have deeprooted disagreements and distrusts of the American foreign policy but that in no way translates to what the mass media would have us believe. Thanks. Original Message From tEnron AnnouncementsCorpEnronENRON mailto:IMCEANOTESEnronAnnouncementsCorpEnronENRON@ENRON.com On Behalf Of Ken LayENRON Sent Thursday September 20, 2001 4:58 PM Total Enron WorldwideENRON Subject: Media Reports. As you know the US government is investigating hundreds if not thousands of relatives, acquaintances and associates of the individuals who may have been involved in the terrorist attacks on Sept 11. We believe that the media will soon be reporting that one of the many individuals being questioned is an Enron employee in Houston. It is appropriate for us to withhold judgment and to continue to cooperate fully with federal authorities. Because this is a matter in the hands of the federal authorities we cannot provide additional information at this time. However we will keep you informed to the greatest extent possible. Please keep in mind that thousands of people who may or may not have any information about the terrorist attacks are being questioned as part of this investigation. We continue to have every reason to believe that our employees and facilities are safe. If you have concerns please call Corporate Security at . If you receive any media or external inquiries about this matter please call Public Relations at . At Enron diversity is one of our strengths and we respect and embrace all p

people of all faiths and beliefs Please continue to keep our employees who have been impacted by this tragedy in your thoughts and prayers

Subvariant: Sentiment Score

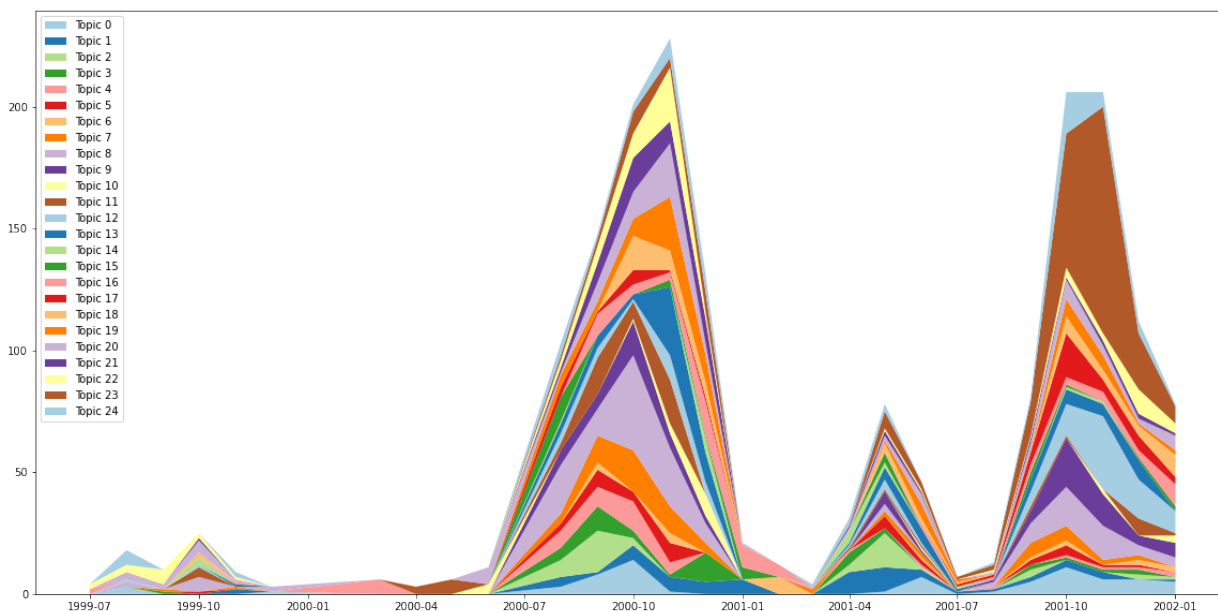
Next, we focused on the sentiment score, especially the negativity score. We wanted to see if the emails with highest negativity scores would have different topics, and if these topics could imply any signs of fraud. After we calculated the sentiment scores, we extracted the emails with top 100 negativity scores, and we trained a LDA on those emails to see their topics.

```
[ (0,
  '0.056*"would" + 0.055*"hope" + 0.047*"people" + 0.041*"know" + 0.038*"employees" + 0.034*"think" + 0.032*"many" + 0.027*"houston" + 0.024*"things" + 0.019*"could"',
  (1,
    '0.090*"pay" + 0.068*"information" + 0.059*"due" + 0.041*"since" + 0.037*"left" + 0.033*"business" + 0.029*"deal" + 0.025*"office" + 0.024*"enrons" + 0.023*"also"',
    (2,
      '0.060*"arena" + 0.046*"lord" + 0.043*"eckels" + 0.039*"agreement" + 0.035*"mayor" + 0.035*"sports" + 0.031*"judge" + 0.031*"chronicle" + 0.027*"authority" + 0.026*"look"',
      (3,
        '0.044*"enron" + 0.034*"lay" + 0.031*"questions" + 0.029*"former" + 0.029*"two" + 0.025*"stock" + 0.024*"company" + 0.023*"like" + 0.021*"time" + 0.020*"wanted"',
        (4,
          '0.029*"good" + 0.025*"thank" + 0.025*"sent" + 0.024*"robertson" + 0.022*"job" + 0.021*"money" + 0.021*"best" + 0.021*"made" + 0.020*"make" + 0.019*"layk"') ] ]
```

For each of the topic, we definitely saw some words that might involve in the fraud, such as "committee", "management", "agreement", "judge", "authority", and "stock". These words could imply false manipulation, legal process, and market impact. Since our focus was to correctly identify fraud, sentiment score could be associated with possible and thus became a metric to determine fraud.

Variant 2: How Topic Varies By Time and Person

In this variant, we will still run a topic model on the whole corpus using the LDA model with 25 topics as the baseline model. But we will further see what topic each email belongs to, and then visualize how the topic use varies with time.



From the stacked area chart above, it is obvious that topic use varies with the time, and there are some time periods that a specific topic is widely used. For example, there are three peaks of number of emails sent, one from 2000-06 to 2001-01, one from 2001-03 to 2001-07, and one from 2001-08 to 2002-01, however, in the first peak(2000-06 to 2001-01), the topics are relatively evenly distributed, and in the second small peak(2001-03 to 2001-07), topic 0, 1, 2 are the main topics, and in the last peak(2001-08 to 2002-01), topic 23 is the main topic. In addition, there are some other obvious changes in topics:

- Topic 22 occurred more often in the first peak(2000-06 to 2001-01) compared to other time.
- Topic 23 has occupied a large proportion of all email topics in the third peak(2001-08 to 2002-01) while emails that are topic 23 are very few in other time.
- Compared to other months, topic 10 occurred more often in the first peak(2000-06 to 2001-01).
- Compared to other months, topic 12 and 24 occurred more often in the third peak(2001-08 to 2002-01).

We will take a look at some of these topics changes, and see if there are any specific events behind these topics.

First, if we focus on topic 10, which occurred more often in the first peak(2000-06 to 2001-01), we can see 'gas' is a keyword for this topic. And there are many emails in topic 10 talking about gas, for example

- Attached are several documents which capture our positions in reaction to power and gas pricing particularly in California....The gas paper was prepared in September and needs updating but I have included it as well...
- It only took three years for them to get it right...The stricter consents policy moratorium on gas-fired generation has been lifted per this announcement...

And many emails in topic 10 talk about California and gas. It is worth noticing, and we searched online and found that 'California', 'gas' is closely related to 'Enron'. The 2000–01 California electricity crisis, also known as the Western U.S. energy crisis of 2000 and 2001, was a situation in which the U.S. state of California had a shortage of electricity supply caused by market manipulations and capped retail electricity prices. California had an installed generating capacity of 45 GW. At the time of the blackouts, demand was 28 GW. A demand-supply gap was created by energy companies, mainly Enron, to create an artificial shortage. (https://en.wikipedia.org/wiki/2000–01_California_electricity_crisis (https://en.wikipedia.org/wiki/2000–01_California_electricity_crisis)).

And this California electricity crisis is from April 2000, to the start of 2001, which is quite similar as the time of our peak 1(2000-06 to 2001-01).

Then, for topic 4, among all the three peaks, only peak 1 (2000-06 to 2001-01) contains a relatively large proportion of topic 4 emails, and peak 2 and 3 contains almost no topic 4 emails. And "vod" is one of these keywords of topic 4. In 1999, Blockbuster teamed up with Enron to create a video-on-demand(VOD) service and they ended up partnership in early 2001. That might be one of the explanation why topic 4 rarely occurred after 2001-01 in our model.

So the topic use changes with time, and there are some specific events behind some topics.

Variant 3: A Different Model: Top2Vec

For this variant, we are going to use embedding and clustering. Since one problem with LDA is that it uses bag-of-words and ignores syntactic and semantic word relationships. Even if it uses stemming and lemmatization, it still can not recognize similar words that do not share a word stem, for example, large and big. So in this variant, we use the model called Top2Vec (Angelov, D., 2020.), which uses word2vec to generate word embeddings.

Top2Vec first generates a semantic space by applying word2vec and doc2vec to generate word and document embeddings. Similar words and documents are close together in the semantic space. Then it uses UMAP and HDBSCAN to lower the dimension and do clustering. So documents with the same topics will be clustered together, and word vectors that are closest to a topic vector are the most representative of the topic.

Topic: 0
enron: 0.45388284
sincerely: 0.24727291
corp: 0.2301839
corporation: 0.22238864
ceo: 0.21980532
executives: 0.2077232
merger: 0.19914153
corporate: 0.19763461
pge: 0.19408052
integrity: 0.19102672
firm: 0.18957809

creditors: 0.18852708
kenneth: 0.18804622
investors: 0.18701327
affairs: 0.1866499
hr: 0.18576732
regards: 0.18493825
transaction: 0.17470804
venture: 0.17377639
managing: 0.17092115
executive: 0.16913609
employees: 0.16869622
re: 0.16735111
management: 0.16628933
manager: 0.16601479
risk: 0.16487938
committed: 0.16161439
inc: 0.15955892
equity: 0.15838847
stock: 0.15599176

Topic: 1

conference: 0.28345132
meetings: 0.2613675
meeting: 0.2511409
keynote: 0.22536683
participants: 0.2128766
committee: 0.21144038
secretary: 0.20955731
presentation: 0.19099352
agreement: 0.189361
event: 0.18868282
pge: 0.18699324
pm: 0.18054715
speaker: 0.1789936
discussed: 0.17149311
sincerely: 0.17014
session: 0.16683556
mayor: 0.16501251
participate: 0.16468361
leadership: 0.16181254
investors: 0.16098604
regards: 0.16039412
enron: 0.15880693
panel: 0.15871915
scheduled: 0.15783337
direct: 0.15517168
deputy: 0.15374118
dec: 0.15205191
communications: 0.15197861

participation: 0.15197173
involved: 0.14916073

Topic: 2

enron: 0.26555103
pge: 0.24271971
transaction: 0.2213454
negotiations: 0.2143452
agreement: 0.2104818
merger: 0.20620361
proposal: 0.20096877
interest: 0.19488691
discussed: 0.19372693
bid: 0.19320641
firm: 0.19271748
pipeline: 0.18723463
llc: 0.18586773
investors: 0.18573937
corp: 0.18437985
involved: 0.17834122
contract: 0.17734107
demand: 0.17732073
claim: 0.17673326
talked: 0.17668055
pm: 0.17184946
inc: 0.17018622
creditors: 0.16793
interests: 0.16612846
trading: 0.16612203
limited: 0.16562934
risk: 0.16409266
asset: 0.16391373
financing: 0.16376802
corporation: 0.16327208

Topic: 3

forwarded: 0.25631797
sincerely: 0.24342494
received: 0.24126396
recipient: 0.23059815
regards: 0.22670354
email: 0.21510918
letter: 0.2060493
sending: 0.20119111
pm: 0.20102495
agreement: 0.1967046
forward: 0.19413362
secretary: 0.18917787

send: 0.17084153
respond: 0.17055371
receive: 0.16466439
communications: 0.1620508
attached: 0.16201931
mail: 0.16185704
direct: 0.16183415
llc: 0.16050003
affairs: 0.15872276
sent: 0.15829511
message: 0.15772378
reply: 0.15618989
concerned: 0.15598187
concern: 0.15343359
exchange: 0.15336528
fax: 0.15329307
committee: 0.1518564
pge: 0.1510306

Topic: 4

merger: 0.2247285
pge: 0.18692315
broadband: 0.17878926
corp: 0.1751619
enron: 0.17452809
llc: 0.16087854
technologies: 0.15840629
ceo: 0.15433495
managing: 0.15158251
partnership: 0.1463265
venture: 0.13936226
corporation: 0.13906184
pm: 0.1371769
communications: 0.13479249
cable: 0.13256794
net: 0.1321944
keynote: 0.13151869
agreement: 0.12803626
affairs: 0.12676847
billion: 0.124423996
sincerely: 0.12225275
limited: 0.1221918
conference: 0.121970356
together: 0.12075801
corporate: 0.120371565
enrononline: 0.11990766
meetings: 0.11946889
solution: 0.11782954
ge: 0.11597042

regards: 0.11571872

Topic: 5

meetings: 0.24007224
discussed: 0.23184061
conference: 0.22770526
meeting: 0.20248309
secretary: 0.19808415
committee: 0.19185475
concerned: 0.18970467
concern: 0.18755269
pm: 0.18108046
keynote: 0.17960969
presentation: 0.17870611
regards: 0.17529191
calls: 0.17472792
memo: 0.17281249
thursday: 0.17263392
pge: 0.1695275
document: 0.16827786
call: 0.16565788
office: 0.16095741
forward: 0.15990031
monday: 0.15853788
deputy: 0.1582394
project: 0.15682541
session: 0.15592048
plans: 0.15442003
communications: 0.1543202
dec: 0.15305492
scheduled: 0.152669
wednesday: 0.14985377
direct: 0.14953637

Topic: 6

sincerely: 0.2519768
regards: 0.24025717
enron: 0.20240292
discussed: 0.19967076
regarding: 0.19842139
received: 0.19640797
secretary: 0.19388828
ken: 0.19304343
interview: 0.19045635
affairs: 0.18539968
robertson: 0.18216383
concern: 0.18142037
hr: 0.1773745

concerned: 0.17682302
thank: 0.17610434
kenneth: 0.17194456
executive: 0.1713009
hear: 0.17047209
expressed: 0.17004871
department: 0.16924044
direct: 0.16922665
forwarded: 0.16821995
according: 0.16761686
informed: 0.16690826
letter: 0.16412598
pm: 0.16402996
deputy: 0.16187817
communications: 0.16135305
employees: 0.15890019
decision: 0.15843658

Topic: 7
enron: 0.2684524
leadership: 0.23269379
merger: 0.21780753
ceo: 0.20551687
managing: 0.19179314
ge: 0.187724
leading: 0.1869572
executives: 0.1791232
keynote: 0.17726086
meetings: 0.17194958
management: 0.16978502
firm: 0.16019079
interview: 0.15887639
corporate: 0.15809394
kenneth: 0.15602997
secretary: 0.15425251
leader: 0.15368587
executive: 0.15233877
venture: 0.15057382
communications: 0.14966485
direction: 0.14941213
forward: 0.14905274
conference: 0.14765865
affairs: 0.14619401
corp: 0.1447551
limited: 0.14237913
memo: 0.14135078
manager: 0.13808961
among: 0.13755304
leaders: 0.13751948

Topic: 8

ken: 0.27399862
pge: 0.26185733
agreement: 0.22363468
policy: 0.22073577
committee: 0.20199218
signed: 0.19864866
secretary: 0.19816875
kenneth: 0.1848925
governor: 0.18323863
discussed: 0.17920953
hr: 0.17909674
political: 0.17741379
richard: 0.17566203
bill: 0.17554477
enron: 0.17146039
robertson: 0.16954431
forwarded: 0.16904543
session: 0.16631056
sincerely: 0.16577923
llc: 0.16285653
deputy: 0.1553623
subject: 0.15406105
demand: 0.15339565
karen: 0.15208687
commission: 0.1513704
regards: 0.15072814
pm: 0.15070662
conference: 0.15009838
jim: 0.14909035
negotiations: 0.14897713

Topic: 9

houstons: 0.32593113
houston: 0.26919398
sincerely: 0.2132413
regards: 0.20213744
letter: 0.1940018
conference: 0.19068044
committee: 0.18633714
tx: 0.18499133
rockets: 0.17296053
uc: 0.17151287
center: 0.16659561
office: 0.1597231
secretary: 0.1596508
recipient: 0.15623769

merger: 0.15604877
signed: 0.15585627
csu: 0.15331367
cc: 0.15231907
expressed: 0.15044872
mayor: 0.15039995
sec: 0.14957783
received: 0.14861116
receive: 0.1382263
don: 0.13734935
llc: 0.1370906
sending: 0.13696131
pge: 0.13542122
forwarded: 0.1348259
policy: 0.1343632
texas: 0.13289198

Topic: 10
pge: 0.22488815
llc: 0.21568325
sincerely: 0.1977764
project: 0.19668826
agreement: 0.19569817
financing: 0.18772687
kenneth: 0.18178561
letter: 0.17546953
regards: 0.16949609
committee: 0.16866288
contribution: 0.16555223
partnership: 0.16287604
signed: 0.16040346
venture: 0.15990561
secretary: 0.15956196
forward: 0.15833311
involved: 0.15812713
merger: 0.15792257
enron: 0.15775205
interest: 0.15760727
capital: 0.15693414
robertson: 0.15482181
firm: 0.15452947
conference: 0.15363449
interests: 0.15315904
contact: 0.14934786
inc: 0.14884707
claim: 0.14794059
fund: 0.14772528
foundation: 0.14662984

Topic: 11

secretary: 0.24385801
liz: 0.23182447
hr: 0.2214063
meetings: 0.22058877
interview: 0.2152922
pm: 0.21480384
steven: 0.2134246
discussed: 0.20848048
steve: 0.20422703
ken: 0.19323623
subject: 0.19275051
agreement: 0.18980724
meeting: 0.18671942
tt: 0.18647173
deputy: 0.18417631
rosie: 0.18339226
related: 0.18273191
discussions: 0.18186873
joe: 0.17113158
forwarded: 0.16896485
documents: 0.16829675
karen: 0.16781263
email: 0.16771695
topics: 0.16578546
message: 0.16274397
project: 0.16025145
minutes: 0.15999746
regarding: 0.15968886
direct: 0.15833083
panel: 0.15663716

Topic: 12

sincerely: 0.26649812
keynote: 0.25264415
participants: 0.22814992
conference: 0.22524579
regards: 0.2217206
participation: 0.219585
presentation: 0.21730474
event: 0.20317954
attend: 0.20078114
meeting: 0.19938135
participate: 0.19359973
speaker: 0.191117
received: 0.1893156
recipient: 0.1874523
letter: 0.18078364

kenneth: 0.17807308
agreement: 0.17722726
giving: 0.1770516
invite: 0.17694879
among: 0.17552081
secretary: 0.17444582
committee: 0.17210838
dec: 0.17146093
speech: 0.17091599
senior: 0.1685181
speakers: 0.16779494
proposed: 0.16777636
signed: 0.16612151
meetings: 0.16470514
proposal: 0.16225721

Topic: 13

enron: 0.26889032
secretary: 0.2228204
meetings: 0.22070515
merger: 0.2105334
meeting: 0.20070854
deputy: 0.19343287
transaction: 0.19226739
venture: 0.19036578
investors: 0.1810567
managing: 0.17579916
hr: 0.17331807
executives: 0.17125891
executive: 0.16975722
governor: 0.16630599
corporate: 0.16476615
agreement: 0.16453709
consulting: 0.16439138
pm: 0.16254538
firm: 0.16217281
interview: 0.16062933
kenneth: 0.16049677
conference: 0.15986304
vice: 0.15827416
affairs: 0.15734261
session: 0.15729232
directors: 0.1568048
inc: 0.15418601
governors: 0.1536157
llc: 0.15260461
memo: 0.15232717

Topic: 14

enron: 0.41796315
pge: 0.22328429
sincerely: 0.20512764
corp: 0.20280346
office: 0.19600397
corporate: 0.19291775
transaction: 0.18777308
pm: 0.18293051
dc: 0.18208203
governor: 0.18184249
corporation: 0.1803244
hr: 0.17977655
executives: 0.17658588
direct: 0.1764561
regards: 0.17560935
affairs: 0.17356715
llc: 0.17202637
businesses: 0.16646007
governors: 0.1661371
houstons: 0.15873551
employees: 0.15825571
transactions: 0.15821794
jim: 0.15497632
management: 0.15451832
bank: 0.15409707
firm: 0.15267947
business: 0.15112482
creditors: 0.15024978
employee: 0.14939821
executive: 0.14913315

Topic: 15

pge: 0.20251784
enron: 0.17942077
merger: 0.17512251
committee: 0.16989522
llc: 0.15646037
partnership: 0.15365462
ceo: 0.15269187
pm: 0.15150738
inc: 0.14968503
corp: 0.14861298
panel: 0.14195263
consulting: 0.14174533
ge: 0.14017153
secretary: 0.13381562
investors: 0.13081864
communications: 0.12928009

board: 0.12774433
participants: 0.12376303
managing: 0.12308977
corporation: 0.122756556
broadband: 0.12251001
concerned: 0.12000608
hr: 0.11878835
concern: 0.11875175
vanguard: 0.11647109
deputy: 0.113669164
cable: 0.11318289
ees: 0.112967156
speaker: 0.11149487
risk: 0.11119383

Topic: 16

pm: 0.23718838
elizabeth: 0.22844937
secretary: 0.22612268
sincerely: 0.20011324
regards: 0.19596416
received: 0.1947993
recipient: 0.19400845
sent: 0.19091637
services: 0.19046068
letter: 0.18877384
hr: 0.18632849
executive: 0.18563038
inc: 0.18306755
communications: 0.17767271
liz: 0.17700611
llc: 0.17515078
forwarded: 0.17430279
interview: 0.17311402
email: 0.17308632
service: 0.17056419
cc: 0.16976479
message: 0.16831231
department: 0.16777056
corporation: 0.16678351
enron: 0.16525751
yahoo: 0.16193566
interested: 0.16066635
corp: 0.15815136
sending: 0.15777726
deputy: 0.15446958

Topic: 17

letter: 0.28840864
ken: 0.28560215
direct: 0.21861675
jim: 0.21814129
sincerely: 0.20880881
mayor: 0.20678611
mike: 0.19963893
regards: 0.19289069
secretary: 0.19131334
houstons: 0.18529242
kenneth: 0.18414631
charles: 0.18175021
proposal: 0.17898703
meetings: 0.17668407
memo: 0.17596236
forwarded: 0.17484884
personally: 0.17426959
signed: 0.17341651
agreement: 0.170812
respond: 0.17032246
discussed: 0.16694963
rob: 0.16679676
requested: 0.16510928
pm: 0.16428858
response: 0.16408822
personal: 0.1622866
mr: 0.16174962
claim: 0.16118698
use: 0.16078642
committee: 0.16074057

Topic: 18
lord: 0.2982164
sincerely: 0.21817975
god: 0.21753368
layk: 0.17730547
strong: 0.1588241
hope: 0.15478182
regards: 0.14993078
respect: 0.14753205
said: 0.14736815
support: 0.14157562
integrity: 0.13860056
direct: 0.13859071
complete: 0.13839199
letter: 0.13756117
among: 0.13704243
limited: 0.1340925
stand: 0.13396528

prepared: 0.13238692
three: 0.13187227
able: 0.13095963
mary: 0.13001674
service: 0.1299621
job: 0.12991694
respond: 0.12953502
elizabeth: 0.12836203
above: 0.12795256
beyond: 0.1279139
executive: 0.12646905
proud: 0.1263046
services: 0.1258639

Topic: 19

governor: 0.34886986
governors: 0.30821073
pge: 0.26259306
mayor: 0.22710982
pm: 0.21282524
enron: 0.208395
secretary: 0.20776011
deputy: 0.20310366
agreement: 0.19797921
leadership: 0.19260469
conference: 0.19218348
executive: 0.19134548
jim: 0.19052453
vice: 0.18504371
political: 0.17613062
hr: 0.1749938
approval: 0.17415991
committee: 0.16963217
leaders: 0.1695838
tim: 0.16879526
co: 0.16867264
pipeline: 0.16772285
policy: 0.16741492
senator: 0.16717832
member: 0.16620038
state: 0.16466214
speaker: 0.16422446
authority: 0.16317424
department: 0.16241312
president: 0.16151793

Topic: 20

proposal: 0.24706075

subject: 0.21503195
project: 0.20688218
regards: 0.20503175
requested: 0.20244408
secretary: 0.20061862
presentation: 0.19510363
direct: 0.18989089
proposed: 0.18980753
interview: 0.18289804
agreement: 0.17558095
planning: 0.1745265
asked: 0.17334339
clients: 0.1711658
plans: 0.16984707
foundation: 0.16797207
involved: 0.1654844
topics: 0.16406667
affairs: 0.1625917
liz: 0.1625872
sincerely: 0.16160107
discussed: 0.15969439
invite: 0.15937592
forwarded: 0.15874457
pm: 0.15856445
request: 0.15557043
customer: 0.15539
sending: 0.15396848
received: 0.15246634
advise: 0.15156661

Topic: 21

committee: 0.2349074
session: 0.22459447
deputy: 0.22038025
mayor: 0.22020578
governors: 0.20896661
pge: 0.20885035
governor: 0.20827419
member: 0.19878806
policy: 0.19372725
bill: 0.19202021
secretary: 0.18803823
vice: 0.18789819
dan: 0.18550667
conference: 0.18483374
bob: 0.18194371
agreement: 0.18084085
commission: 0.17997417
decision: 0.17912903

political: 0.17846707
matter: 0.1772421
enron: 0.17636871
sec: 0.17629717
board: 0.17559084
article: 0.17274004
participants: 0.17234498
affairs: 0.17056867
project: 0.17050351
llc: 0.16956574
department: 0.16909832
security: 0.1679673

Topic: 22
ceo: 0.27700636
enron: 0.26252177
managing: 0.23841947
executives: 0.23828436
jeff: 0.23398262
executive: 0.23221503
management: 0.2257911
manager: 0.2206567
leadership: 0.21909311
director: 0.21211359
direction: 0.20965913
merger: 0.20295756
directors: 0.19010344
committee: 0.1859127
pge: 0.1857625
jim: 0.18447463
deputy: 0.18411265
vice: 0.18358545
secretary: 0.17329173
ken: 0.17043185
partnership: 0.17039526
according: 0.16904819
jeffrey: 0.16544323
governor: 0.16510782
governors: 0.1607135
rob: 0.16060668
employees: 0.15881518
office: 0.15814808
department: 0.15762995
hr: 0.15528652

Topic: 23
agreement: 0.29666597
signed: 0.267767

partnership: 0.24598792
rockets: 0.23242685
proposal: 0.22692409
investors: 0.22220843
contribution: 0.22130454
participation: 0.2193787
contract: 0.21671602
houstons: 0.21458891
expressed: 0.21185058
claim: 0.20246382
meetings: 0.2024006
financing: 0.20172884
fund: 0.19925642
participants: 0.19598013
conference: 0.19436926
campaign: 0.18983446
negotiations: 0.18883176
pge: 0.18857428
involved: 0.18819323
received: 0.18764812
requested: 0.18484774
giving: 0.18336499
discussed: 0.18316491
llc: 0.18119252
pm: 0.18114302
secretary: 0.17628007
per: 0.17547622
attached: 0.17518291

Topic: 24

pge: 0.26095107
governor: 0.25641286
signed: 0.20602322
governors: 0.17283422
california: 0.17158258
enron: 0.16715331
demand: 0.16363654
expressed: 0.1615143
energy: 0.15676613
uc: 0.15667027
billion: 0.15430628
gas: 0.15357101
prepared: 0.15169913
rice: 0.15047747
paper: 0.14817214
proposal: 0.14813265
contribution: 0.14556804
crisis: 0.14409527
presentation: 0.14197314

pm: 0.14045444
broadband: 0.13931288
decided: 0.13832632
process: 0.13606909
merger: 0.13545945
conference: 0.13429698
agreement: 0.13191295
global: 0.13170624
document: 0.13160533
investors: 0.12947606
csu: 0.12885094

Topic: 25
liz: 0.26908576
secretary: 0.24232078
steven: 0.23721823
stan: 0.22893558
steve: 0.21878114
meetings: 0.21668258
meeting: 0.21396278
cindy: 0.21323791
karen: 0.20248446
consulting: 0.2015703
bob: 0.19742098
agreement: 0.19356617
bill: 0.19339518
discussed: 0.19224644
advise: 0.18798417
kenneth: 0.18565433
affairs: 0.17793605
related: 0.17774767
jeff: 0.17660663
involved: 0.17641167
jeffrey: 0.17619142
greg: 0.17058155
committee: 0.16957924
ken: 0.16848105
keynote: 0.16740465
pm: 0.16701567
interview: 0.16588552
david: 0.16195329
session: 0.1614688
participants: 0.16071844

Topic: 26
memo: 0.35109437
note: 0.20970604
sincerely: 0.17951

thursday: 0.17324188
wednesday: 0.15824376
attached: 0.1578744
letter: 0.15657133
secretary: 0.15209112
confirmed: 0.1507729
xorigin: 0.14519113
consider: 0.1442216
sent: 0.13822128
approval: 0.13516928
office: 0.12692729
attention: 0.12687096
regards: 0.12654015
check: 0.12382913
houstons: 0.121590145
meetings: 0.12089342
agree: 0.12069777
ees: 0.115881816
tuesday: 0.11019147
consulting: 0.108937785
calls: 0.1075021
directors: 0.10695498
monday: 0.104195684
dear: 0.10353312
executives: 0.10036693
steve: 0.09891977
friday: 0.097751975

Topic: 27

xfilename: 0.2880965
agreement: 0.26849005
pm: 0.23849401
negotiations: 0.23349904
demand: 0.22721979
pge: 0.224495
discussed: 0.22426906
specific: 0.22386254
proposal: 0.21711922
merger: 0.20619291
transaction: 0.20590621
partnership: 0.20129752
claim: 0.20093626
particularly: 0.19846141
completed: 0.19467452
asked: 0.19404809
llc: 0.19164953
direct: 0.18917856
signed: 0.18687516
response: 0.18544436

financing: 0.18471651
bid: 0.18375598
conference: 0.18252122
decided: 0.17913799
policy: 0.17873216
investors: 0.17718536
governor: 0.1768772
pipeline: 0.17537007
proposed: 0.17528763
ees: 0.17498003

Topic: 28

governor: 0.38827884
governors: 0.2828945
pge: 0.2369889
senator: 0.2201185
mayor: 0.21958137
signed: 0.20334935
meeting: 0.20275113
sincerely: 0.19942427
meetings: 0.19745389
california: 0.19577691
conference: 0.19040833
deputy: 0.18758428
re: 0.18635572
government: 0.18605582
political: 0.18492159
session: 0.18491493
csu: 0.18293326
enron: 0.1796035
ken: 0.17935495
solutions: 0.17896184
agreement: 0.17835806
leadership: 0.17717254
leaders: 0.17529297
leading: 0.17143103
crisis: 0.17107832
general: 0.16912517
assistance: 0.16856453
speaker: 0.16805008
dr: 0.16482177
letter: 0.16165635

Topic: 29

partnership: 0.20769948
llc: 0.20504093
corp: 0.1901708
walker: 0.18326843

link: 0.17919672
corporation: 0.1743045
co: 0.17268836
agreement: 0.17241648
comments: 0.16084114
participants: 0.15783554
immelt: 0.15663545
merger: 0.15659143
recipient: 0.14877097
approval: 0.14605954
enron: 0.14556977
rate: 0.14551291
security: 0.14550108
regards: 0.14322795
company: 0.14115018
following: 0.14043418
and: 0.13715981
related: 0.13596335
side: 0.1336593
venture: 0.13301231
products: 0.13232028
pge: 0.13198204
cable: 0.13101579
partners: 0.12762396
both: 0.12629254
open: 0.12572682

Topic: 30
report: 0.31788278
reports: 0.261211
regards: 0.21215919
enron: 0.2035651
bill: 0.20020536
expense: 0.19679837
sincerely: 0.18414326
jim: 0.17484875
accounts: 0.17189203
customer: 0.15623413
office: 0.15412673
another: 0.15259515
creditors: 0.15229109
efforts: 0.15160479
employee: 0.15059745
chair: 0.14823633
hr: 0.14760295
mark: 0.14661925
inc: 0.14613745
integrity: 0.14349493
pge: 0.14265333

further: 0.14263907
clients: 0.14194347
additional: 0.14104477
greg: 0.14011335
effort: 0.13930778
cindy: 0.13930264
agreement: 0.13571143
related: 0.13564
consideration: 0.13552113

By applying Top2Vec to our emails, we get 31 topics. By simply looking at the top few words, it's hard to get an idea on its topic, so I further looked at the documents that are clustered to be topic 0, 1, and 2. Here are 3 examples of each of them.

Topic 0

Example 1: Mr Lay I would like to take this opportunity to thank you from the bottom of my heart for all the hard work you are trying to do and continue to try to do...Know that there are still many at Enron who admire the enormity of what you have done for energy markets in the United States...

Example 2: Ken, I just wanted to say thanks for all that you and Enron have done for me. I know you trusted people close to you and they let you down for that. I'm sorry I have always believed in you and what you stand for...

Example 3: Good evening Mr Lay, I just wanted to give you a positive note on my behalf. I really don't know if you will read this but if you do I wish you all the best with Enron. I don't know if I'm one of those employees who will be laid off but on the good side of things I respect you profoundly...

And it is clear that topic 0 is about showing gratitude and belief in Kenneth Lay after leaving the jobs.

Topic 1

Example 1: ...Here is the background on a possible acquisition that we have brought up with them. Enron Metals is very interested in pursuing further discussions with Atlantic Copper on the acquisition of their smelter in Spain. Estimated capital would be US Million...

Example 2: ...i was one the initial companies contacted by Enron Net Works ENW for the EnronOnline commercial discussion. The focus of the Enroni discussion earlier this year was a complete sale of the software asset that drives EnronOnline to i...

Example 3: ...We are currently pursuing two important Q transactions with Sysco an electricity supply contract for their Texas facilities and a demand side management contract for all of their facilities. We had planned to close the Texas supply transaction today. However in a phone conversation I had this morning with Syscos Director of Procurement Terry Taylor, I was informed that Syscos CEO Charles Cotros has instructed Mr Taylor not to enter into any further transactions with us until Enron's financial picture clears up...

Topic 1 is about business, since from these emails, there are key words like acquisition, sale and contract.

Topic 2

Example 1: ...Dean of the UT School of Engineering tells me that he will be in Houston on November and would like to meet with you. I realize that your schedule is overflowing these days however should time permit the Dean would sincerely appreciate...

Example 2: ...In reply to your request for Dr Lay to speak, he has asked that I reply to you with the following message. Advise that the date just doesn't work because of our Managers Conference but on a different date either I or one of my officers could probably participate...

Example 3: ...May I use you as a reference? Let me know if this meets with your approval. I enjoyed seeing you and your family at the convention...

Topic 2 is about making an appointment with Kenneth Lay. For example, the first email is an appointment between Lay and Dean of UT school of engineering. Second one is also for appointment arrangement.

So Top2Vec has actually given much information about the topics, and since topic 0 is about showing gratitude and personal emotion to Kenneth Lay, and little useful information is contained, so if time is limited, we can temporarily ignore emails that are topic 0. And since topic 1 is about business, we can further take a deeper investigation on these emails to see evidence of fraud. And topic 2 is about some personal relationships and appointments with Kenneth Lay, so we can focus on emails in topic 2 to see the network relationship with Kenneth Lay.

Variant 4: Dynamic Topic Model

The dynamic topic model extends the idea of the original LDA to allow topic representations to evolve over fixed time intervals such as years. Since the create time of the emails ranges from 1979 to 2002, with such a large time difference, we want to see if the topics change over time. The generative process of LDA almost remains the same, except for that the overall topic distribution and the term distribution for each topic differ depending on the time slice.

Our implementation was based on the Lda Sequence model, inspired by David M. Blei, John D. Lafferty: “Dynamic Topic Models”, which is a pure Python implementation of the original dynamic topic model. We used this implementation because the code will be easier to understand.

The codes below are the pre-processing of the data. Simply speaking, we rearranged the dataset in a ascending year order, tokenized the emails, and got a bag of the top 100 words as the corpus. The reason we shrunk our corpus was that the DTM took a great amount of time processing, and our topic would still be representative.

```
1980      4
1999     69
2000    837
2001    817
2002     78
Name: year, dtype: int64
```



```

0      [Xbcc, XFolder, StevenKeanDecNotes, FoldersAll...
1      [Xbcc, XFolder, StevenKeanJuneNotes, FoldersDi...
2      [Xbcc, XFolder, StevenKeanDecNotes, FoldersCal...
3      [Xbcc, XFolder, StevenKeanDecNotes, FoldersArc...
4      [XOrigin, TaylorM, XFileName, mtaylor NSF, Here...

...

1800   [XOrigin, LayK, XFileName, klay, NonPrivileged...
1801   [Dear, Uncle, Ken, and, Aunt, Linda, Hi, Im, s...
1802   [Dear, Ken, Second, I, want, to, give, you, ah...
1803   [An, anonymous, visitor, stopped, by, Advicebo...
1804   [I, would, very, much, like, to, catch, up, wi...
Name: text, Length: 1805, dtype: object

```

Topic 0

```

1980
enron: 0.041216765206703136
employees: 0.03314224624970701
company: 0.025730530800971825
know: 0.02458285001196428
would: 0.02326984443265596
many: 0.020423275744552365
work: 0.020205143874594985
people: 0.019667767972487028
great: 0.019403467725474615
time: 0.01912130216763315
like: 0.016951217705578444
business: 0.016910170558921883
get: 0.01675758965705928
going: 0.01668020951163598
want: 0.016544387182414137
back: 0.016481097705148297
thank: 0.016395978776064486
believe: 0.016101818434892577
years: 0.01603357642737179
good: 0.015740870723144413
1999
enron: 0.041343467527978316
employees: 0.03317436711435499
company: 0.025755090037503682
know: 0.02461393271014421
would: 0.02325544098423073
many: 0.020422157560984106
work: 0.0202383616517016
people: 0.019695891119724585

```

great: 0.01942185614908927
time: 0.01913494848355509
like: 0.016973962226531938
business: 0.016911762929504658
get: 0.01675601814856281
going: 0.016687804753370776
want: 0.016557822145215232
back: 0.01649989239727962
thank: 0.01640124712898639
believe: 0.016089339662454984
years: 0.016019463601570434
good: 0.01575197126992758
2000
enron: 0.04153151876758078
employees: 0.03336559057510136
company: 0.025821735417653383
know: 0.024747773479721846
would: 0.02313876708620055
many: 0.020428902554248427
work: 0.020277758863306523
people: 0.019800350194132964
great: 0.019411143396108693
time: 0.019121457419531744
like: 0.016988413374555363
business: 0.01686664246656528
get: 0.016768942559440597
going: 0.016729576166478296
want: 0.016549544794010083
back: 0.016546016329857843
thank: 0.01638682803519454
years: 0.016016569368225986
believe: 0.015947574823438837
good: 0.015750162936946595
2001
enron: 0.04168760777401776
employees: 0.03382248877687298
company: 0.026365631374310392
know: 0.025299770941723514
would: 0.022751571140132307
many: 0.020465149402150218
work: 0.020223789888237025
people: 0.020043440470347493
great: 0.01926751326125876
time: 0.01901949368735416
like: 0.01689801939642766
going: 0.016891849610578553
business: 0.01663098478463987
back: 0.01656715775558735
get: 0.016534507488409098
want: 0.01650730870900529

thank: 0.016234565323821396
years: 0.01612412320478485
believe: 0.01596381691506271
good: 0.015712517644906415
2002
enron: 0.04179402125356749
employees: 0.03388819562207319
company: 0.026395804554880494
know: 0.025350932317688046
would: 0.02261264739500736
many: 0.020474197994109045
work: 0.020219042545879844
people: 0.02012945630611709
great: 0.01922466440420577
time: 0.018998964757466458
going: 0.016905990299217927
like: 0.016875862832412342
back: 0.016575686479670174
business: 0.016551775757975826
get: 0.016519101395653657
want: 0.01650746681568947
thank: 0.016191268682682575
years: 0.01610674903022732
believe: 0.01599859051146303
good: 0.01571312693208912

Topic 1

1980
attached: 0.04032393354142033
klaynsf: 0.03548923852116673
xfilename: 0.035116327172314894
letter: 0.03493191724241718
xorigin: 0.034745370221187066
layk: 0.03321757354027284
energy: 0.030185932359104252
please: 0.028614845244345138
meeting: 0.027906539473972015
president: 0.025517040016443244
questions: 0.024598230273125177
chairman: 0.022284403698091763
call: 0.021348668482132835
would: 0.019547995858789642
board: 0.01876903172944714
ken: 0.01690095747374691
enron: 0.01688107203588255
business: 0.016384428612895345
regards: 0.015451704352545594
see: 0.015320405718500726
1999
attached: 0.04040131876569288

klaynsf: 0.03539969706659216
xfilename: 0.03514688543666458
letter: 0.035005521354864844
xorigin: 0.0347598384540195
layk: 0.033228102972422784
energy: 0.03026165597564505
please: 0.028617968180014282
meeting: 0.02792242348261597
president: 0.025486488183845416
questions: 0.02462568962488331
chairman: 0.02230174038917396
call: 0.02137144837877752
would: 0.01956923464124236
board: 0.0187864698864998
enron: 0.016906883943106556
ken: 0.016906751938552348
business: 0.016386016030654857
regards: 0.015449759297321721
see: 0.015344672611676253

2000

attached: 0.04041558701542997
letter: 0.03546953086089072
xfilename: 0.03505599416081446
klaynsf: 0.03496890712814429
xorigin: 0.03463634117587905
layk: 0.03307088473131487
energy: 0.030598449151236072
please: 0.02859520359714663
meeting: 0.0279455291986072
president: 0.02552162110038993
questions: 0.02472372694268379
chairman: 0.022376697566262028
call: 0.0215133195026405
would: 0.019619034509507187
board: 0.018845478427260767
enron: 0.017012534155643334
ken: 0.016930424805949685
business: 0.016459824171302196
regards: 0.015486478522487156
see: 0.015345399722982647

2001

attached: 0.04023478794636361
letter: 0.037289652944291374
xfilename: 0.03468892938884446
xorigin: 0.03425100601709253
klaynsf: 0.03401520543034979
layk: 0.032658765513132015
energy: 0.031043190973653222
please: 0.028764768342370628
meeting: 0.027796254443770107

president: 0.025483781278689586
questions: 0.025354928501851406
call: 0.022023970188195924
chairman: 0.02199097726259338
would: 0.01958510992907219
board: 0.01890862731475112
enron: 0.017227804659287662
ken: 0.017033518261541532
business: 0.016583638618396058
regards: 0.015332906369096866
see: 0.015253130076308113
2002

attached: 0.040244918802310695
letter: 0.037368819360621884
xfilename: 0.034615061460113644
xorigin: 0.034166639780337564
klaynsf: 0.03368494339764184
layk: 0.03256593929255004
energy: 0.031177081365105035
please: 0.028850757967362046
meeting: 0.027769011642248955
questions: 0.02539216925029121
president: 0.02536880112584029
call: 0.022091819054659508
chairman: 0.021960862400204437
would: 0.01960591179282873
board: 0.018911573527968073
enron: 0.01724883153078502
ken: 0.017048208192417844
business: 0.01658200785396127
regards: 0.015348177409153556
see: 0.015259359057516192

Topic 2

1980

gas: 0.030210885996866912
may: 0.03011872195750351
team: 0.02816050470401624
new: 0.02795279359540199
power: 0.0267955043865357
market: 0.02637441400908097
million: 0.025124989050818218
opportunity: 0.02130204397989004
enron: 0.020079240856601767
interest: 0.01974106046659834
year: 0.018019087391995654
would: 0.01779113222915996
time: 0.017117156669843894
need: 0.01668847048300371
one: 0.016112069004579503

current: 0.01608251644410019
group: 0.015321541407590674
future: 0.01502539549670876
thank: 0.014682908174466169
xfilename: 0.014290947530358294
1999
gas: 0.03027837321496556
may: 0.02986518627699565
team: 0.02825192258301674
new: 0.0280000666051221
power: 0.026878612948259394
market: 0.02644407810500857
million: 0.025164365986954693
opportunity: 0.021335850182140105
enron: 0.0201091125989322
interest: 0.019770824530075132
year: 0.01805498374703218
would: 0.01781095377475388
time: 0.017000817379702278
need: 0.016705423332202762
one: 0.016122788458041996
current: 0.016097154782868384
group: 0.01533680703347491
future: 0.01503659075546612
thank: 0.014688881889965668
company: 0.014247611118874204
2000
gas: 0.03034190894623546
may: 0.029806267887619337
team: 0.02830996829518577
new: 0.027992968397057064
power: 0.026850151034776813
market: 0.026661407569102076
million: 0.025054930263120286
opportunity: 0.02144921891003684
enron: 0.020153280457334145
interest: 0.019845659401119903
year: 0.01815241406516609
would: 0.017794354462379012
time: 0.01691992558577065
need: 0.016771036591374643
one: 0.016138305786219366
current: 0.016126093901848344
group: 0.015393599477252079
future: 0.015060512390596782
thank: 0.01473186492860372
company: 0.014294577850084174
2001
may: 0.03070836305090619
gas: 0.030151292319444998

new: 0.028214758457016476
team: 0.028181973783178688
power: 0.027053796533139426
market: 0.026421339755921525
million: 0.02465317528917648
opportunity: 0.022113250164082075
enron: 0.020272867383934336
interest: 0.020008269019295172
year: 0.018088075055162925
would: 0.017746269764322812
time: 0.017121139373826092
need: 0.016922136898349774
one: 0.01611411082339671
current: 0.015967241771330777
group: 0.0152570443498393
future: 0.015084779859280193
thank: 0.015070202029065026
company: 0.014428044276149537
2002
may: 0.030817246397396338
gas: 0.03008812051575497
new: 0.028214568963528308
team: 0.028175775104036616
power: 0.027044311444148983
market: 0.02644659469179187
million: 0.024680804515926545
opportunity: 0.022121440369268514
enron: 0.02027726754095787
interest: 0.020002039233753616
year: 0.01810702009832957
would: 0.017752379043803966
time: 0.01710966688359584
need: 0.01692282991097717
one: 0.016114829944837965
current: 0.01596275513072449
group: 0.015261707882987965
future: 0.015078466593848082
thank: 0.015062888659281288
company: 0.014425756870830194

Topic 3

1980

message: 0.037355554984084195
subject: 0.03651589437730438
email: 0.03223856907869741
original: 0.030725663768012904
sent: 0.029464731413669707
october: 0.026437044299600032
lay: 0.025485848255697864
information: 0.02454934840232702

please: 0.02303255031452405
ken: 0.020506775254730304
communications: 0.01977185172402718
houston: 0.019057780090682052
fax: 0.01888893732172005
let: 0.018857670841271042
attached: 0.018287012102191066
thanks: 0.017634395863788545
know: 0.017113092356455917
received: 0.017049310099718065
also: 0.01655028248996543
need: 0.015777341887847147
1999
message: 0.03750428436370069
subject: 0.03653276324523975
email: 0.032315473704614905
original: 0.03074487892167983
sent: 0.0295052158440679
october: 0.026457370831263833
lay: 0.02553144912074715
information: 0.024564030301002585
please: 0.023055802954221043
ken: 0.02051975023767761
communications: 0.019784483875213345
houston: 0.019054124275281643
fax: 0.018887736376574437
let: 0.01888403096207184
attached: 0.01830479984863482
thanks: 0.017655135229290658
know: 0.017132140416903308
received: 0.017053504685226085
also: 0.016579015501449447
need: 0.01578413430026816
2000
message: 0.038113800809553504
subject: 0.036404793918606966
email: 0.03240192450185393
original: 0.031039011018068316
sent: 0.029506252235367243
october: 0.026398854588214213
lay: 0.02557176015026478
information: 0.02450805513357791
please: 0.02316745408641901
ken: 0.020522576643246585
communications: 0.019897541856491705
houston: 0.018978540692697905
fax: 0.018885356156136807
let: 0.018852561153702076
attached: 0.01829413063806048
thanks: 0.01772939944538669

know: 0.017069614043552454
received: 0.017021678045240803
also: 0.016521320357918583
need: 0.015779595649567966
2001
message: 0.03949003076644987
subject: 0.035920565785626
email: 0.03238222991054215
original: 0.03169155464134061
sent: 0.029345564150919948
october: 0.026234791307524985
lay: 0.025571081588413636
information: 0.024952705491283648
please: 0.023754485975395204
ken: 0.020577358573864033
communications: 0.01941920467395039
fax: 0.018885747418188954
let: 0.018877810421398158
houston: 0.01869429420576952
attached: 0.018198366072990198
thanks: 0.017732797279886695
know: 0.0170716746234807
received: 0.016707486162792846
also: 0.016122166689474218
need: 0.015874576082335945
2002
message: 0.039977500911076144
subject: 0.035774476426770445
email: 0.032396208667488026
original: 0.031689649667346706
sent: 0.02930431948645317
october: 0.026191637316640926
lay: 0.02558775166018745
information: 0.024959594261829088
please: 0.023754432813851006
ken: 0.020585190418099537
communications: 0.019433687848702426
let: 0.018908439886707915
fax: 0.018870806621761077
houston: 0.018651838272454875
attached: 0.018171617111801694
thanks: 0.017743986339661903
know: 0.01710600975748668
received: 0.016708179465059817
also: 0.016126566593603255
need: 0.015892348910266398

Topic 4
1980
mark: 0.027969270513697117

thanks: 0.0278228959440637
last: 0.027383541978458263
week: 0.026464113218418305
two: 0.02621906661654559
jeff: 0.02473017124243406
next: 0.024540782855192834
following: 0.02161784102938057
ken: 0.021560565617795353
office: 0.02067543735991551
energy: 0.02038280689645656
enron: 0.019685638209314647
would: 0.01798089962908526
john: 0.017207296157274718
meeting: 0.01693044787234415
think: 0.016691238846953668
new: 0.016677256139198952
time: 0.016451205266382184
business: 0.015935493133293503
interest: 0.01578570808977571
1999
mark: 0.027897683683263078
thanks: 0.027845060452949193
last: 0.027404458711841807
week: 0.026501626452833573
two: 0.026257910318260747
jeff: 0.02476283973439599
next: 0.024561334671542128
following: 0.02164845323690406
ken: 0.02161468585051269
office: 0.02070435520473727
energy: 0.02042479182420477
enron: 0.019691578180771496
would: 0.017989417873696754
john: 0.01721604724812969
meeting: 0.016930315277404094
think: 0.016702145723589468
new: 0.01667433768012709
time: 0.01645216220848934
business: 0.01594629551381701
interest: 0.015782415857684175
2000
mark: 0.02782183922301185
thanks: 0.027543088411631653
last: 0.027476856007793354
week: 0.0263270621929493
two: 0.026144400174661513
jeff: 0.024916791068390128
next: 0.02448656455443969
following: 0.021758435423427838
ken: 0.021700302731000463

office: 0.020809830762111816
energy: 0.020485863594812297
enron: 0.019752730452536085
would: 0.018045436010474484
john: 0.01723294028044674
meeting: 0.01687418548359813
think: 0.01675355638579746
new: 0.01665372399628262
time: 0.01643141676416589
business: 0.015984305417439483
interest: 0.01581793006090557
2001
last: 0.027924891605554187
mark: 0.027751397617265378
thanks: 0.027321956457823243
week: 0.026217345001309594
two: 0.02606340795390444
jeff: 0.025322776448458137
next: 0.02439191316402886
following: 0.022396443936292743
ken: 0.021729069496135574
office: 0.02096339691164534
energy: 0.020431664950292777
enron: 0.019723971491472165
would: 0.01803869521278447
john: 0.017040767498197867
meeting: 0.016982310152959014
new: 0.016567412651575082
think: 0.016564868434552845
time: 0.0163254158784412
business: 0.016001644987734025
interest: 0.015854614253345556
2002
last: 0.02794400824071147
mark: 0.027759754351800708
thanks: 0.02732998695997996
week: 0.026238354809654748
two: 0.026107121316605246
jeff: 0.02535993485494171
next: 0.024397929658633407
following: 0.02240631534817544
ken: 0.021757783109694315
office: 0.020979484971746322
energy: 0.02042231596039158
enron: 0.019715722434913496
would: 0.018031974002638642
john: 0.017031016497492044
meeting: 0.01697529247315884
think: 0.016567442250272804
new: 0.01654838708155919

```
time: 0.016315052766285778
business: 0.016010006592879274
interest: 0.015846664255901796
```

It's not hard to summarize each topic from the top 10 words. Here are some guessed summary of each of the topic.

- Topic 0: Show gratitude to Kenneth
- Topic 1: Emails about meeting time, or meeting procedures
- Topic 2: Market and business
- Topic 3: Tell some information to Kenneth
- Topic 4: Show gratitude for creating such working environment in the farewell email

Next, we want to take a closer look of one of the email samples to see if its content matches the results of our topic. The email I chose to examine is the 223th email (my favourite number).

```
[0.00218503 0.00218503 0.00218503 0.99125989 0.00218503]
```

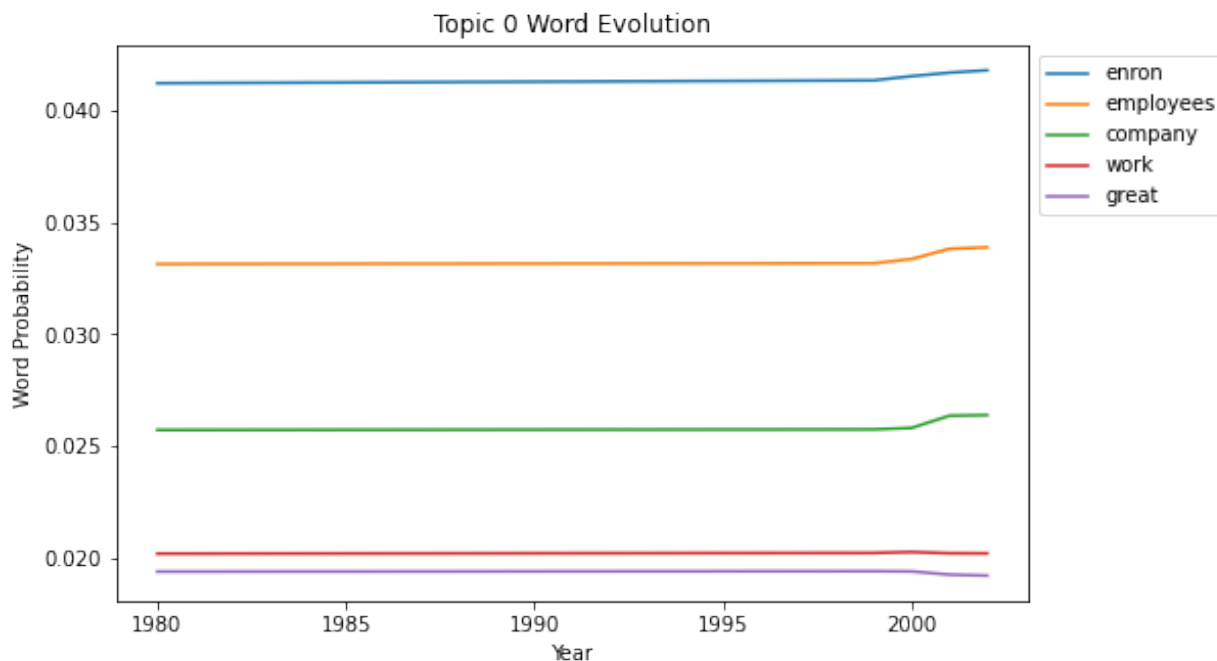
```
['enron', 'ken', 'know', 'call', 'thank', 'message', 'thanks', 'let',
, 'john', 'fax']
```

"Ken Fernley Dison Enron Europe left a message for me to call regarding real estate needs Thanks for setting me up Ill let you know how it goes Thank you John John B Poston Poston Yoder Commercial Real Estate N Central Expwy Suite Dallas TX direct fax johnpostonpostonyodercom"

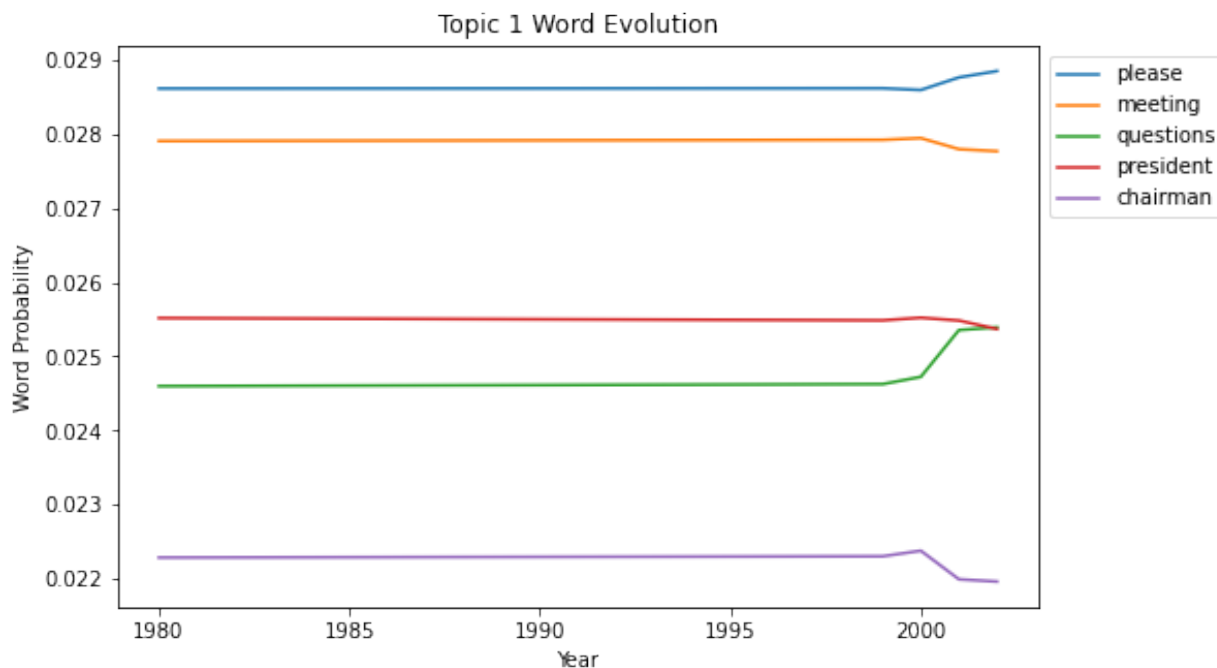
"2000"

The result of the topic model suggested that the 223th email should fall into topic 3, telling some information to Kenneth, because it has a probability of 0.9913. When we look at the original passage of the 223th email, we can say that it asked Kenneth to call regarding real estate needs. This corresponds to topic 3 because it actually told Kenneth some information.

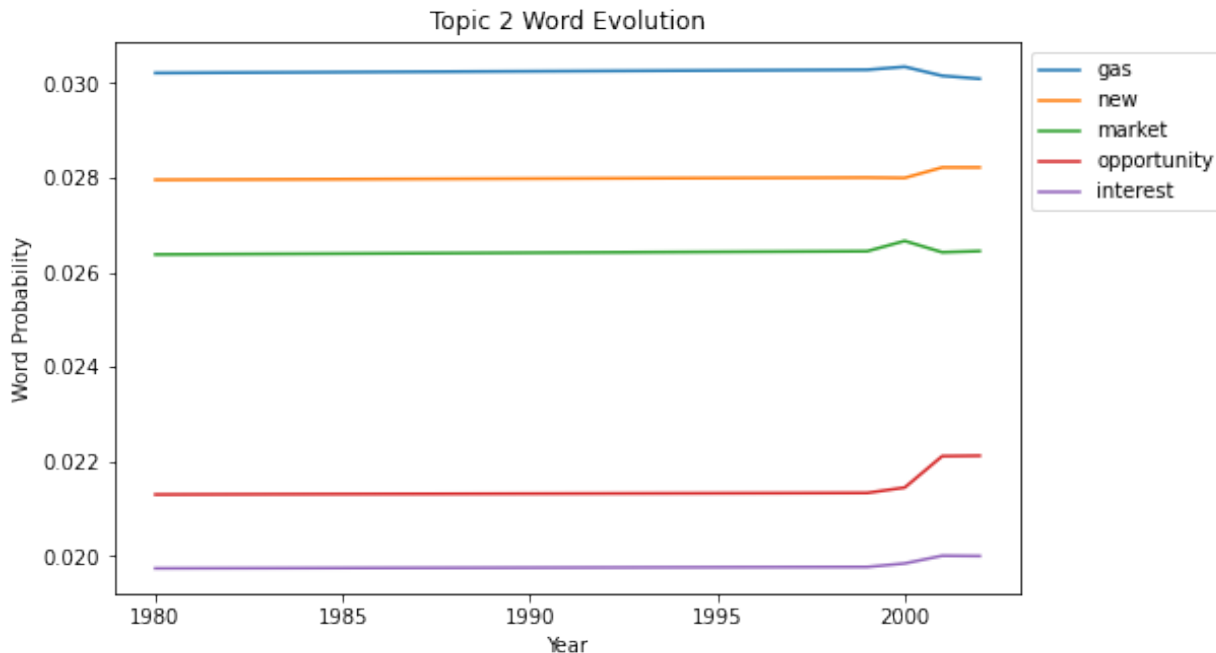
Next, we want to see how the topic words changes over time. We selected five words which could represent the topic from each topic, and we wanted to discover if they changed over time.



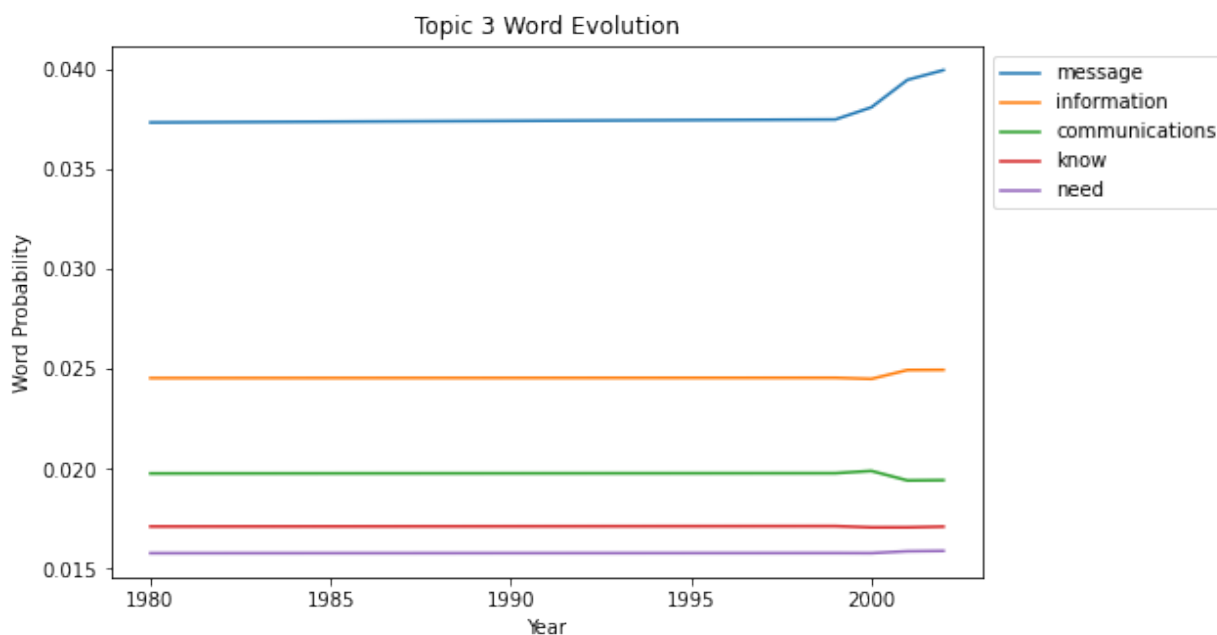
For topic 0, all five words didn't have much changes. The probabilities of "eron", "employees", and "company" went up slightly and the probabilities of "work" and "great" went down very slightly.



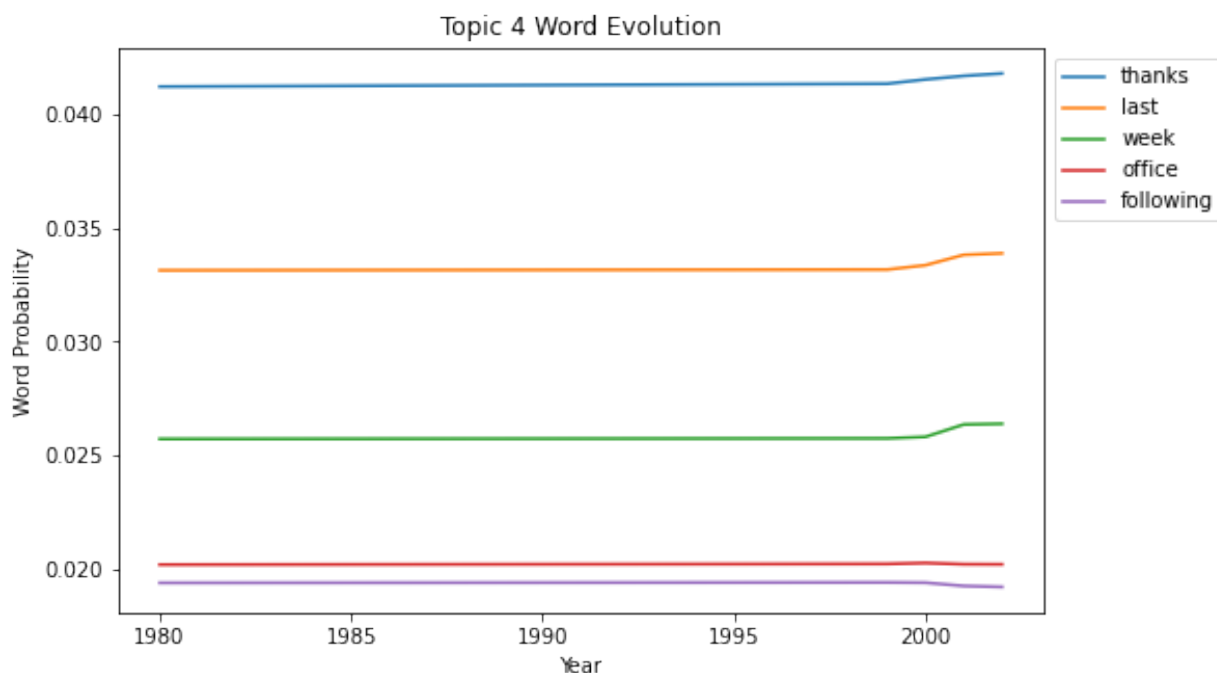
For topic 1, the probabilities of "please" and "questions" went up, and the probabilities of "meeting", "president", and "chairman" went down. One possible implication could be that the company increased its scale and more inquiries were made.



For topic 2, the probabilities of "new", "opportunity" and "interest" went up, and the probabilities of "gas" went down. The probability of "market" went up in 1999 and then went down. This could imply that as the economy during the millennium year grew, more new opportunities were coming. Also, gas could be replaced by new energy sources or Enron shifted their focus from energy sector to other fields.



For topic 3, the probabilities of "message" and "information" went up, and the probabilities of "communications" went down. The probability of "know" and "need" didn't quite change. This could imply that more messages came to Kenneth and the company was growing on the right track.

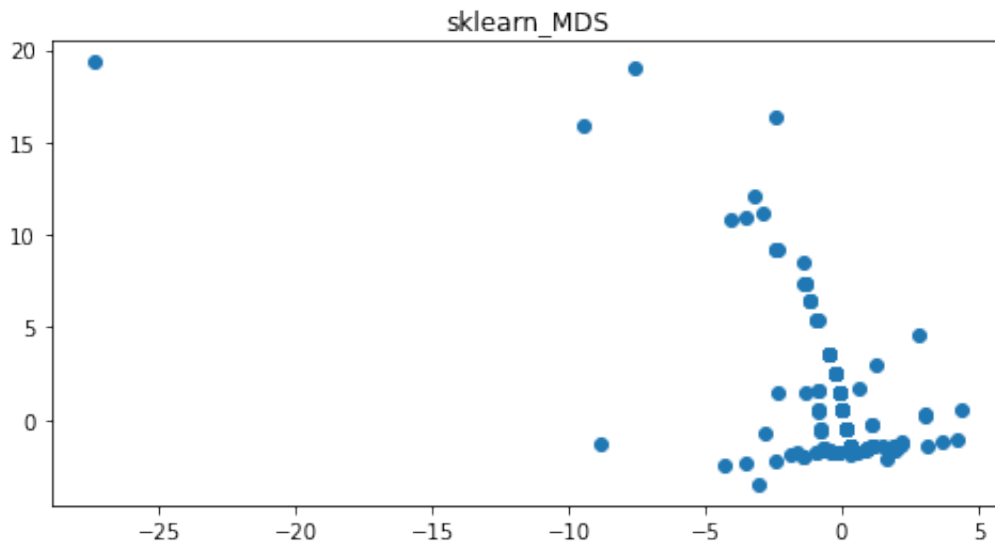


For topic 4, the probabilities of "thanks", "last" and "week" went up, and other words didn't change a lot. One possible explanation could be that more people chose to resign.

Variant 5: Network Analysis

Sub-variant: Multidimensional Scaling

First, we run a multidimensional scaling model on a matrix of how often each pair of people talks to each other. We extract all employees in the email systems that have ever sent or received emails and construct a square matrix. The ij^{th} entry of the matrix represents the number of emails sent from *employee_i* to *employee_j*. Then, we use the MDA model from sklearn for the analysis.

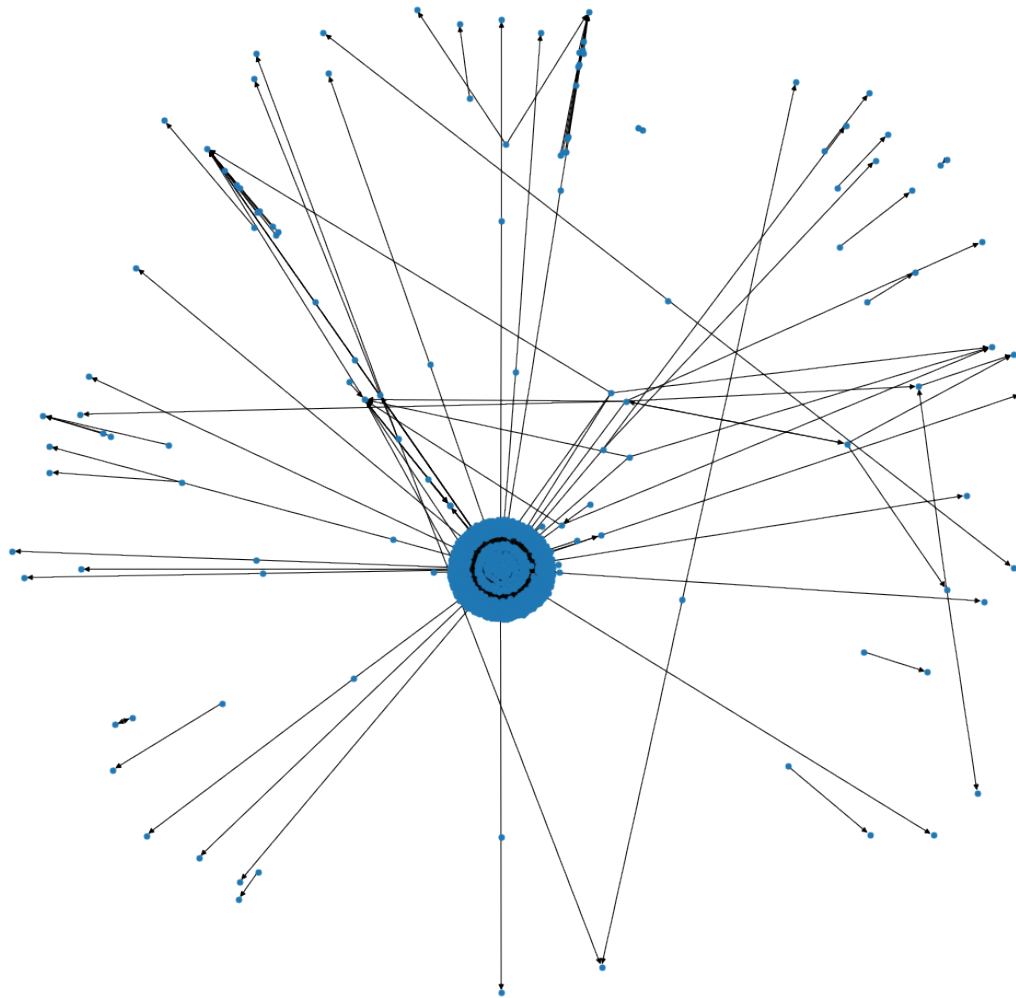


From the plot, we discovered that most points are located at the bottom-right corner of the graph while a point is at the upper-left corner.

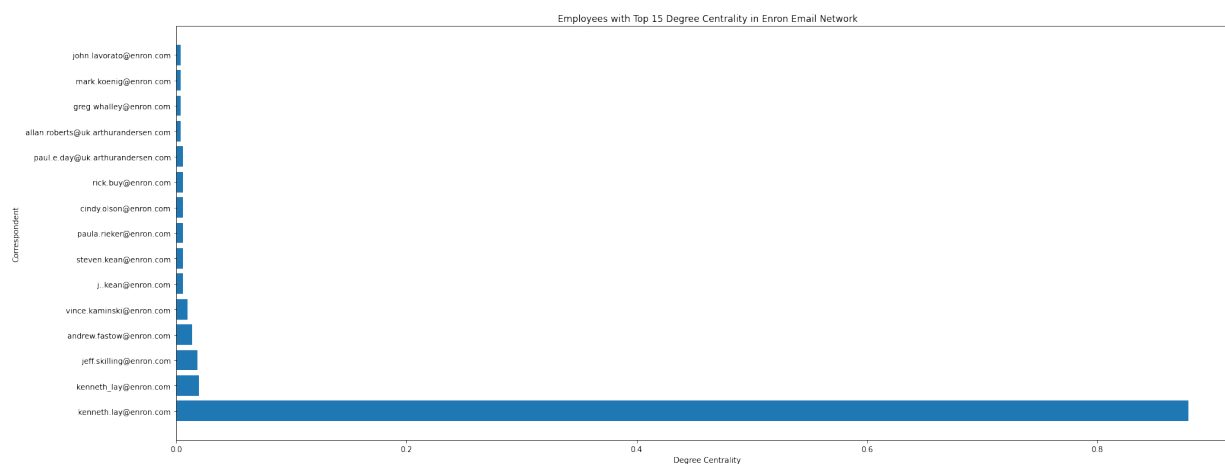
Sub-variant: Networkx

Then, we use the Networkx model to implement a network to demonstrate the connections between employees.

(-1.0808111518621444, 1.1349546998739242, -1.06009050488472, 1.195755206346512)



This graph shows the overall connections of all employees in Enron. We discovered that most employees are located around the center of the graph, representing they are closely connected and with high centrality. However, there are also nodes of employees spread far away from the center, some of them have weak connections with the central nodes and other are only connected to other nodes spread around.



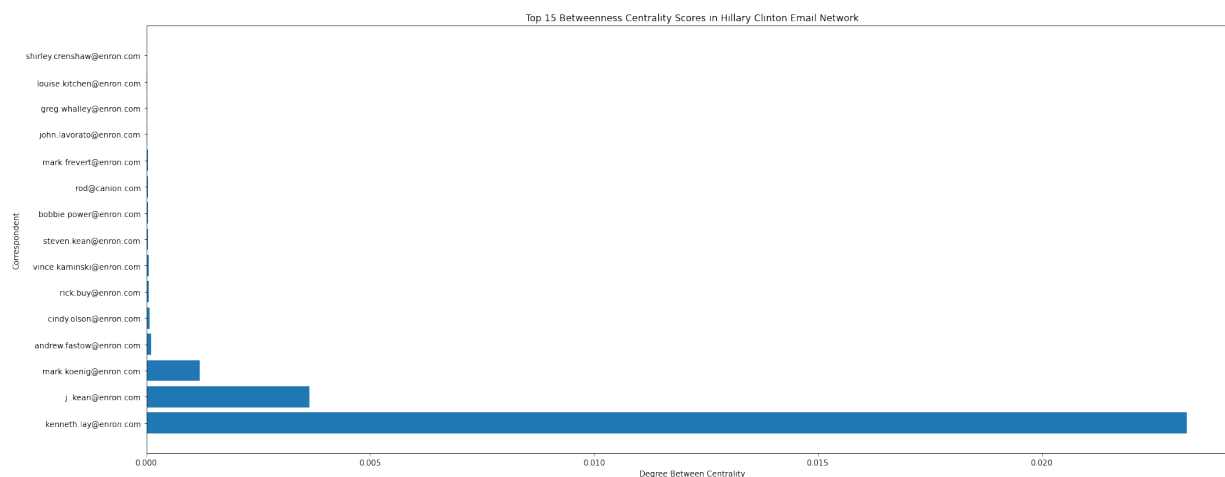
```

count      712.000000
mean       0.002876
std        0.032905
min        0.001406
25%        0.001406
50%        0.001406
75%        0.001406
max        0.879044
Name: centrality, dtype: float64

```

After that, we investigated the centrality degree of employees. Degree is the simplest and the most common way of finding important nodes. It represents the number of people to which a given employee is directly connected. The nodes with the highest degree in a social network are the employees who connect with the most people.

The figure above shows the overall centralities of all employees. It is obvious that Kenneth Lay has the highest centrality, primarily because he is the CEO of the company.

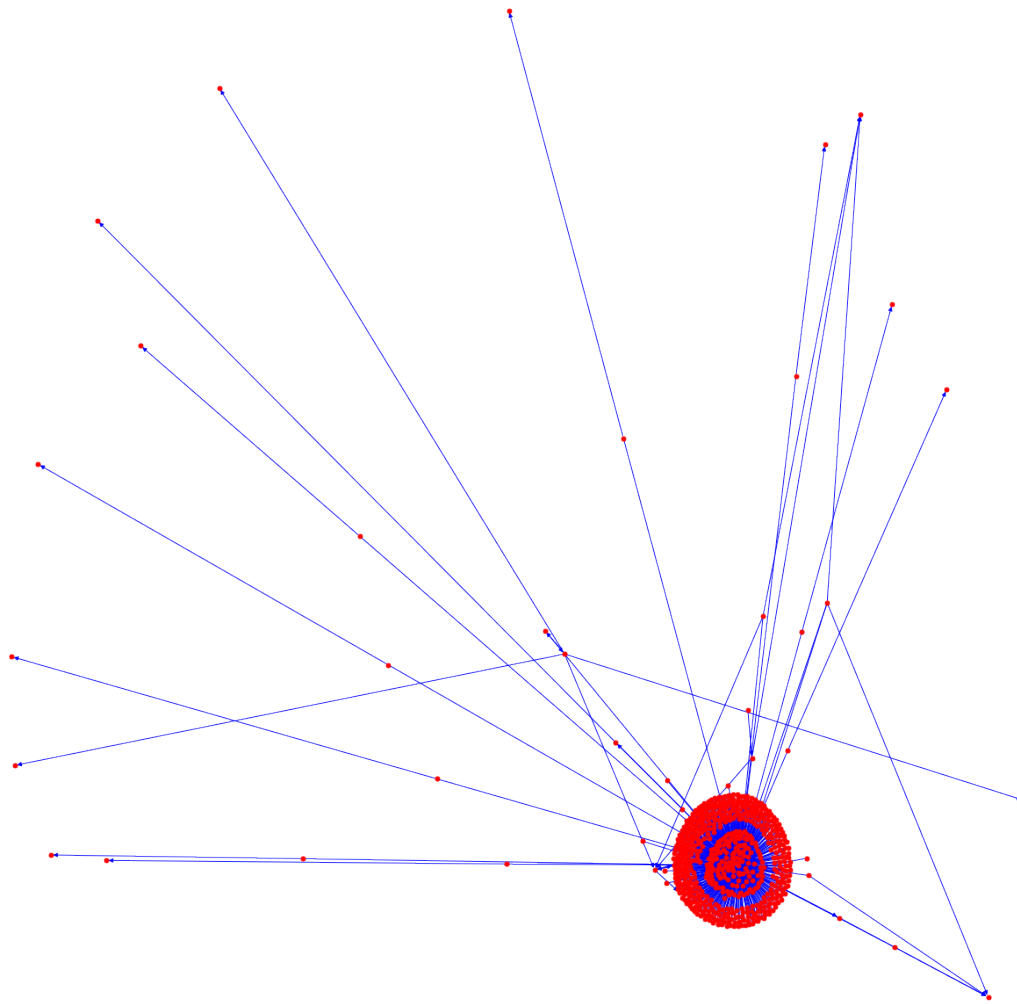


Then, we also look at the betweenness centrality of employees. Betweenness centrality looks at all the shortest paths that pass through a particular node and is good at finding nodes that connect two otherwise disparate parts of a network. If an employee is the only one connecting two clusters of employees, every communication between these clusters has to pass through it, then this employee is often referred to as a broker. Betweenness centrality is a quick way to find brokage and thus give us a sense of which employees are important because they stand between groups, giving the network connectivity and cohesion.

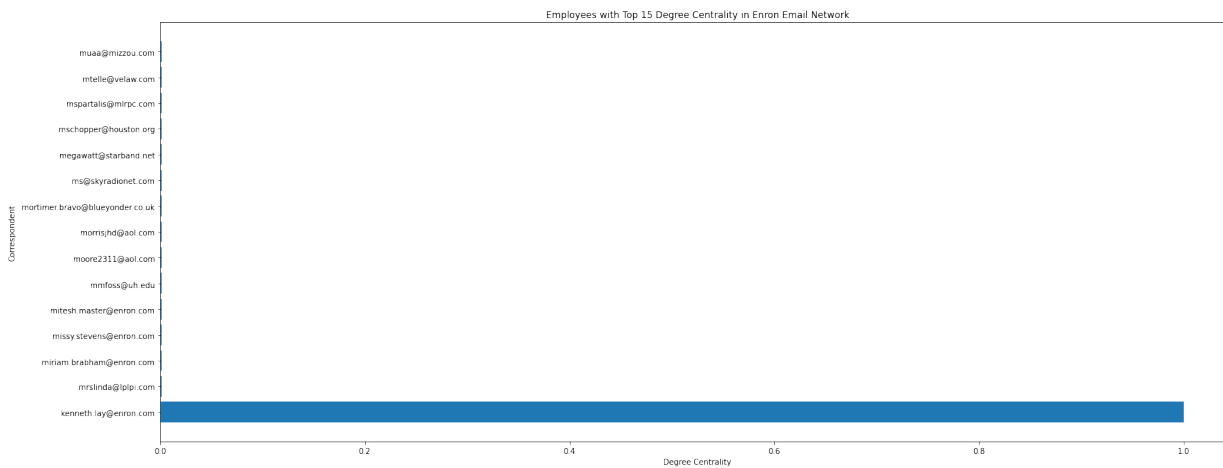
The figure above shows the overall betweenness centralities of all employees. It is obvious that kenneth.lay, j.kean, and mark.koenig are the three employees with highest betweenness centrality. These three people are three leaders in the company, so it is reasonable that they are important to the network connectivity.

After demonstrating the overall network, we are also interested in clusters around certain employees. In this way, as long as we find any suspicious employees, we could further look at employees that are closely connected with him. In order to demonstrate, we first investigate the cluster around the ceo of Enron as an example.

```
(-1.1080210219323636,  
0.5602482269704342,  
-0.3082637368142605,  
1.1243146537244322)
```



The above graph shows the network of all employees that have sent emails to the CEO of Enron.



The figure above show the centrality of all employees conneted with kenneth.lay. Without any doubt, kenneth.lay himself is with the highest degree centrality with him. However, because almost every employee in the company has connection with the ceo, so this analysis is not very meaningful.

Therefore, we would like to investigate the network for someone who is suspicious as an instance.

Here, we use the result found in Variant 2, where we find that the emails in `topic 1` is suspicious of fraud. Therefore, we take a deeper look into the all senders of emails in `topic 1` and discover that the account `steven.kean@enron.com` has sent the most amount of emails in this topic. Therefore, we consider him as a suspicious employee and use the network analysis method to investigate the clusters around him.

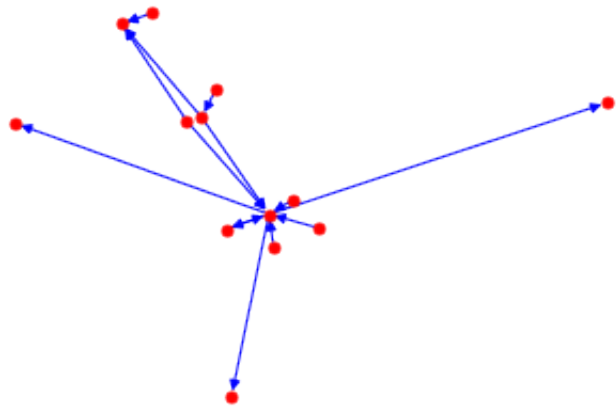
" `steven.kean@enron.com` "

```
[ ' andrew.fastow@enron.com',
  ' rosalee.fleming@enron.com',
  ' kathy.mcmahon@enron.com' ]
```

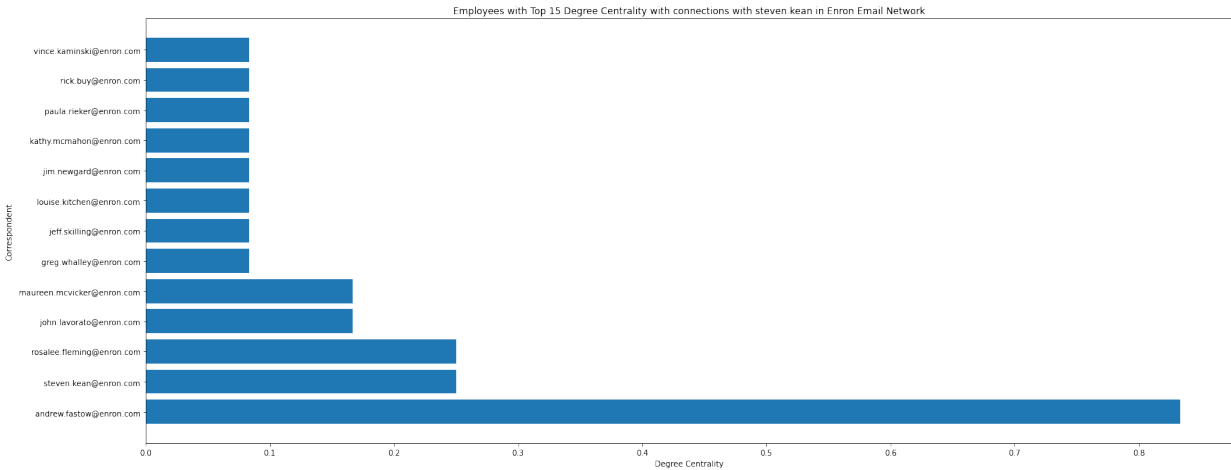
In total, we have found 4 employees that have sent emails to `steven.kean` or received emails from him and one of them is the ceo `kenneth.lay`. Because we have alrely demonstrated that the ceo is connected with almost everyone, exploring the network around him is not meaningful, we remove him from the suspicious list.

After that, we filter out all emails sent from or to the employees in the suspicious list and construct a network based on these email.

(-0.7470358547982427,
1.1217190966540178,
-1.1717842228244446,
0.8078244402001071)



The above graph shows the network around steven.kean, which is much simpler than all previous networks.



Similarly, we compute the degree centrality of all employees in the network of steven.kean. It demonstrates that andrew.fastow has the highest degree centrality, followed by steven.kean, rosalle.fleming, john.lavorato, and maureen.mcvicker, which means these employees are significant in the network of steven.kean. Therefore, if we have found evidence of steven.kean involved in the fraud, these employees can also be suspicious.