```
! pip install networkx
! pip install plotly
! pip install colorlover
```

```
Requirement already satisfied: networkx in /usr/local/lib/python3.6/dist-packages (2.
Requirement already satisfied: decorator>=4.3.0 in /usr/local/lib/python3.6/dist-pack
Requirement already satisfied: plotly in /usr/local/lib/python3.6/dist-packages (4.1.
Requirement already satisfied: retrying>=1.3.3 in /usr/local/lib/python3.6/dist-packa
Requirement already satisfied: six in /usr/local/lib/python3.6/dist-packages (from pl
Requirement already satisfied: colorlover in /usr/local/lib/python3.6/dist-packages (
```

```
import pandas as pd
import networkx as nx
from collections import Counter
import nltk
import re

nltk.download('stopwords')
nltk.download('wordnet')
from nltk.corpus import stopwords
stop = stopwords.words('english')
lemmatizer = nltk.WordNetLemmatizer()
stemmer = nltk.stem.porter.PorterStemmer()

import matplotlib.pyplot as plt
import random
from plotly.offline import download_plotlyjs, init_notebook_mode, plot, iplot
from plotly.graph_objs import *
import plotly.graph_objects as go
init_notebook_mode(connected=True)
```

```
[nltk_data] Downloading package stopwords to /root/nltk_data...
[nltk_data]   Unzipping corpora/stopwords.zip.
[nltk_data] Downloading package wordnet to /root/nltk_data...
[nltk_data]   Unzipping corpora/wordnet.zip.
```

Q1. Choose a hash-tag

'#iremember' is chosen

```
from google.colab import drive
drive.mount('/content/drive')
```

```
Go to this URL in a browser: https://accounts.google.com/o/oauth2/auth?client_id=9473
df = pd.read_csv("/content/drive/My Drive/tweets2009-06-0115.csv.zip", sep='\t', compressi
          -

rawDf = df[df["tweet"].str.lower().str.contains("#iremember", na=False)].copy()
rawDf = rawDf.sample(frac=0.5, replace=True, random_state=42)


# filter out those tweets not mentioning anyone
tagDf = rawDf[rawDf['tweet'].str.contains("@")]
# drop those tweets that @ follows by a space which in most case does not mean mentioning
tagDf = tagDf[~tagDf['tweet'].str.contains("@ ")]
```

Q2. Build a Mention Graph

(a)

```
def addMentionedColumn(df):

    def mentionsList(txt):
        allWords = [word.strip(""" ,.:'\";""").lower() for word in txt.split()]
        allNames = [word.strip("@") for word in allWords if word.startswith("@")]
        uniqueNames = list(set(allNames))
        return allNames

    df["mentioned"] = df["tweet"].apply(mentionsList)


addMentionedColumn(tagDf)


tagDf
```

	date	user	tweet	mentioned
2704910	2009-06-14 05:04:00	missbfabulous	@saundraaa the #iremember is the top trend rig...	[saundraaa]
2409503	2009-06-13 22:47:42	mikachu02	Haaaa! Who u tellin! RT @datboybroadway #ireme...	[datboybroadway]
2484444	2009-06-14 00:28:53	kitlewis	RT @OneHalfMokha: #iremember when I didn't hav...	[onehalfmokha]
2458508	2009-06-13 23:58:47	deauxboi	#iremember wen if u could touch the net n 3rd ...	[coopwood, jazzysoul]
2040237	2009-06-13 14:33:09	rashaunwilliams	RT @freshoneblade: #iremember British Knights,...	[freshoneblade]
...	...	...	...	...
	2009-06-		@MsAddikted2Fame RT	[msaddikted2fame

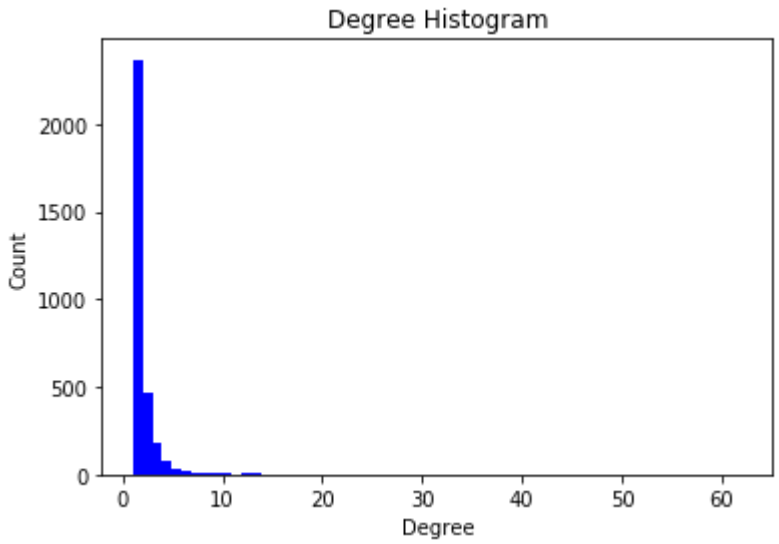
```
def mentionGraph(df):
    g = nx.Graph()

    for (index, date, user, tweet, mentionedUsers) in df.itertuples():
        for mentionedUser in mentionedUsers:
            if (user in g) and (mentionedUser in g[user]):
                g[user][mentionedUser]["numberMentions"] += 1
            else:
                g.add_edge(user, mentionedUser, numberMentions=1)

    return g

tagGraph = mentionGraph(tagDf)

print("# nodes:", len(tagGraph.nodes()))
print("# edges:", len(tagGraph.edges()))
```

```
# nodes: 3199
# edges: 2531
```

(b)

```
degrees=nx.degree(tagGraph)
```

```
degree_sequence = sorted([d for n, d in tagGraph.degree()], reverse=True)  # degree sequer

# plot histogram
plt.hist(degree_sequence, bins=500, width=1, color='b')

plt.title("Degree Histogram")
plt.ylabel("Count")
plt.xlabel("Degree")


plt.show()
```



Most of nodes' degree crowed in the left side, in another word, they are most low node degrees. So mo by) with a few users on twitter.

(c)

```
sorted(tagGraph.edges(data=True),key=lambda x: x[2]['numberMentions'],reverse=True)[:5]
```

```
[('javilovespizza', 'twitter', {'numberMentions': 16}),
 ('savedbarbie', 'naykidd', {'numberMentions': 10}),
 ('wakkaoaka1337', 'maryfarnsworth', {'numberMentions': 9}),
 ('mileycyrus', 'vonnieee', {'numberMentions': 9}),
 ('chasencashe', 'drunkenrandom', {'numberMentions': 8})]
```

(d)

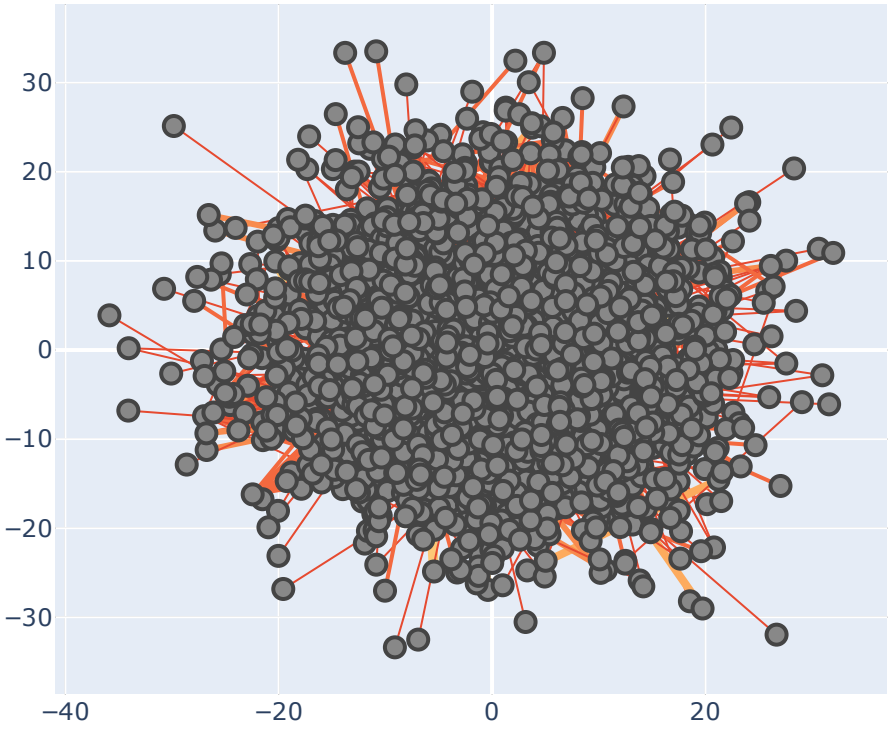
```
def addRandomPositions(graph):
    posDict = dict((node,(random.gauss(0,10),random.gauss(0,10))) for node in graph.nodes
    nx.set_node_attributes(graph, name="pos", values=posDict)

addRandomPositions(tagGraph)
```

```
addRandomPositions(tagGraph)
def configure_plotly_browser_state():
  import IPython
  display(IPython.core.display.HTML('''
        <script src="/static/components/requirejs/require.js"></script>
        <script>
          requirejs.config({
            paths: {
              base: '/static/base',
              plotly: 'https://cdn.plot.ly/plotly-latest.min.js?noext',
            },
          });
        </script>
        '''))


import colorlover as cl
from IPython.display import HTML
rdyibu = cl.scales['9']['div']['RdYlBu']
rdyibu300 = cl.interp(rdyibu, 17)
HTML(cl.to_html(rdyibu300))
```



```
def plotNetworkWidthColor(graph):
    scatters=[]

    for (node1, node2) in graph.edges():
        x0, y0 = graph.nodes[node1]['pos']
        x1, y1 = graph.nodes[node2]['pos']
        edgeWidth = graph[node1][node2]['numberMentions']
        s = Scatter(
                x=[x0, x1],
                y=[y0, y1],
                hoverinfo='none',
                mode='lines',
                line=scatter.Line(width=edgeWidth ,color=rdyibu300[edgeWidth]))
        scatters.append(s)



    for node in graph.nodes():
        xPos, yPos = graph.nodes[node]['pos']
        s = Scatter(
                x=[xPos],
                y=[yPos],
                hoverinfo='none',
                mode='markers',
                marker=dict(
                    color="#888",
                    size=10,
                    line=dict(width=2)))
```

```
            scatters.append(s)

        layout = Layout(showlegend=False)
        fig = Figure(data=scatters, layout=layout)
        iplot(fig, show_link=True)


configure_plotly_browser_state()
plotNetworkWidthColor(tagGraph)
```



Export to plot.ly »

Q3. Content Analysis

```
def getTopK(df, k, column='tweet'):
    stop = set(stopwords.words('english'))
    #Add possible Stop Words for tweets
    stop.add('RT')
    stop.add('lol')
    stop.add('iremember')
    stop.add('http')
    stop.add('2009')
    stop.add('com')
```

```
        stop.add('lmao')
        stop.add('tinyurl')
        stop.add('twitpic')
        stop.add('twitter')
        counter = Counter()
        for tweet in df[column]:
            counter.update([word
                            for word
                            in re.findall(r'\w+', tweet)
                            if word.lower() not in stop and len(word) > 2])
        topk = counter.most_common(k)
        return topk


pd.DataFrame(getTopK(tagDf,500)).head(50)
```

	0	1
0	used	181
1	like	167
2	get	154
3	got	121
4	one	120
5	bit	119
6	remember	114
7	back	109
8	could	108
9	first	107
10	use	105
11	shit	102
12	still	96
13	would	93
14	time	92
15	school	88
16	people	81
17	TheRealJordin	78
18	day	76
19	good	76
20	days	76
21	thought	72
22	came	67
23	show	63
24	know	62
25	wen	61
26	never	60
27	damn	59
28	actually	59
29	really	58

30	make	57
31	love	56
32	game	56
33	ass	55
34	phone	55
35	ChaseNCashe	54
36	life	54
37	right	51
38	going	50
39	girls	49
40	smh	49
41	wit	49
42	black	49
43	play	49
44	everyone	48
45	haha	48
46	thing	48
47	song	47
48	music	45
49	see	45

The hastag #iremember main theme could be looking back to some old times. Some are good and so enjoy looking back at those memories. When looking closer to some tweets, some are about the chan different from the past.

There are two user got mentioned very frequently, TheRealJordin and ChaseNCashe. Jordin Spark rose season of American Idol, hence the tweeter account TheRealJordin she was using has a lot of followe Same goes for ChaseNCashe, a rapper.

```
tagDf[tagDf['tweet'].str.contains('TheRealJordin')]
```

	date	user	tweet	mentioned
3091525	2009-06-14 16:00:35	chelsyarchuleta	@TheRealJordin #iremember boy bands, and good ...	[therealjordin]
3080745	2009-06-14 15:45:53	gusherettes	@TheRealJordin #iremember when einnA17 sang NO...	[therealjordin]
3267108	2009-06-14 20:06:45	lavalamplv	RT @TheRealJordin: #Iremember playing Barbies ...	[therealjordin]
3171014	2009-06-14 17:55:27	apclayton	RT @TheRealJordin: #iremember Scholastic order...	[therealjordin]
3263764	2009-06-14 19:59:04	mandaplz	Truth!RT @TheRealJordin #iremember FRUIT STRIP...	[therealjordin]
...	...	...	...	...
2999864	2009-06-14 13:45:54	mercybeltran	RT @TheRealJordin: #iremember MTV being MUSIC ...	[therealjordin]

```
tagDf[tagDf['tweet'].str.contains('ChaseNCashe')]
```

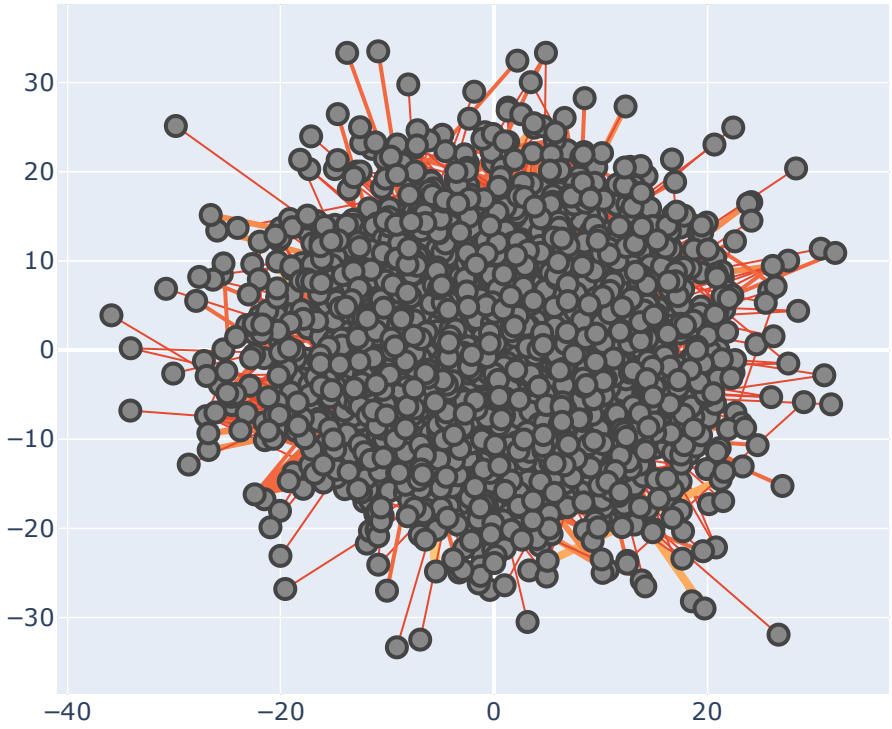
	date	user	tweet	mentioned
1784037	2009-06-13 07:20:25	chinichole	RT @lonestarrmuzik: @ChaseNCashe #iRemember po...	[lonestarrmuzik, chasencashe]
1817608	2009-06-13 08:09:20	onthajon	@ChaseNCashe #iRemember when jezzy's rap name ...	[chasencashe]
1798326	2009-06-13 07:40:23	drunkenrandom	RT @ChaseNCashe #iRemember when Lil Wayne didn...	[chasencashe]
2737306	2009-06-14 05:48:49	kitlewis	RT @ChaseNCashe: #iRemember hearing the baby i...	[chasencashe]
2493399	2009-06-14 00:40:18	asdavis10	RT @JdotRose: RT @ChaseNCashe #iRemember when ...	[jdotrose, chasencashe]
1735108	2009-06-13 05:59:23	drunkenrandom	RT @ChaseNCashe #IRemember Citas World. |Damn,...	[chasencashe]
3408198	2009-06-14 23:16:52	djfu	RT @ChaseNCashe: #iRemember when I used to kno...	[chasencashe]
2468060	2009-06-14 00:09:12	sincere11	RT: @ChaseNCashe #iRemember when shorties used...	[chasencashe]
1801675	2009-06-13 07:46:28	velmadaria	RT @ChaseNCashe Ok so officially I AM LEGEND. ...	[chasencashe, chasencashe]
1745937	2009-06-13 06:15:05	skmusic	RT @ChaseNCashe: #IRemember when they first st...	[chasencashe]
1782378	2009-06-13 07:18:00	acebillionaire	RT @ChaseNCashe: #iRemember Surge Soda. No one...	[chasencashe]
1736685	2009-06-13 06:01:17	louie206	RT @ChaseNCashe #IRemember when they first sta...	[chasencashe]
1745937	2009-06-13 06:15:05	skmusic	RT @ChaseNCashe: #IRemember when they first st...	[chasencashe]
1828218	2009-06-13 08:27:38	youngsafe	yeah the first bars of the beats lol RT @Chase...	[chasencashe]
1851742	2009-06-13	trytobnice	RT @ChaseNCashe: #iRemember Biker Mice	[chasencashe]

1851742	13 09:10:25	trytobnice	#IRemember Biker Mice from Ma...	[chasencashe]
2808962	2009-06-14 07:51:10	youngchu	RT @ChaseNCashe #iRemember when cassettes fuck...	[chasencashe]
3104438	2009-06-14 16:21:57	chasencashe	RT @velmadaria: @ChaseNCashe is a legend for s...	[velmadaria, chasencashe]
2269160	2009-06-13 19:37:01	imkelz	RT @@ChaseNCashe #IRemember when Video Music B...	[chasencashe]
1798327	2009-06-13 07:40:23	drunkenrandom	RT @ChaseNCashe #iRemember when Lil Wayne didn...	[chasencashe]
1813411	2009-06-13 08:02:44	rachdro	RT @ChaseNCashe: #iRemember when White People ...	[chasencashe]
3222961	2009-06-14 19:06:45	lovablebeauty	RT @ChaseNCashe #iRemember doing a project on ...	[chasencashe]
1750402	2009-06-13 06:22:09	freekittweekit	RT @ChaseNCashe #iRemember fried baloney sandw...	[chasencashe]
3410197	2009-06-14 23:19:37	youngry	RT @ChaseNCashe #iRemember when I used to know...	[chasencashe]
1745937	2009-06-13 06:15:05	skmusic	RT @ChaseNCashe: #IRemember when they first st...	[chasencashe]
1798327	2009-06-13 07:40:23	drunkenrandom	RT @ChaseNCashe #iRemember when Lil Wayne didn...	[chasencashe]
	2009-06-		RT @ChaseNCashe	

(b)

```
def plotNetworkHover(graph):

    scatters=[]

    for (node1, node2) in graph.edges():
        x0, y0 = graph.nodes[node1]['pos']
        x1, y1 = graph.nodes[node2]['pos']
        edgeWidth = graph[node1][node2]['numberMentions']
        s = Scatter(
```

```
            s = Scatter(
                    x=[x0, x1],
                    y=[y0, y1],
                    text="%s\nand%s\nhave %i\nconnections" % (node1, node2, edgeWidth),
                    hoverinfo='text',
                    mode='lines',
                    line=scatter.Line(width=edgeWidth ,color=rdyibu300[edgeWidth]))
            scatters.append(s)



        for node in graph.nodes():
            nodeDf=tagDf[tagDf['user']==node]

            xPos, yPos = graph.nodes[node]['pos']
            s = Scatter(
                    x=[xPos],
                    y=[yPos],
                    text="User: %s\nhas 3 most common words: %s" % (node, getTopK(nodeDf,3)),
                    hoverinfo='text',
                    mode='markers',
                    marker=dict(
                        color='#888',
                        size=10,
                        line=dict(width=2)))
            scatters.append(s)

        layout = Layout(showlegend=False)
        fig = Figure(data=scatters, layout=layout)
        iplot(fig, show_link=False)

    configure_plotly_browser_state()
    plotNetworkHover(tagGraph)
```



The node with empyty top words are the ones that has been mentioned, but does not have tweets ass

Q4. Centrality Analysis

(a)

```
btwCentr = nx.betweenness_centrality(tagGraph)
maxCentrBtw = max(btwCentr.values())
minCentrBtw = min(btwCentr.values())

closeness = nx.closeness_centrality(tagGraph)
maxCentrCl = max(closeness.values())
minCentrCl = min(closeness.values())
```

Node degree, Betweeness and Closeness are chosen as the centrality measure in a social network.

Node degree reflects the amount of user it either has mentioned or has been mentioned. It can be assc in the other centrality measures.

High betweeness means the node is close to the center of the net and a lot of connections go through the user is close to the center of the chosen hastag of the topic.

Closeness measures the averaged distance of shortest paths from nodes reachable by the objective n network, high closeness means the user is closer to all the other connectable user on average.

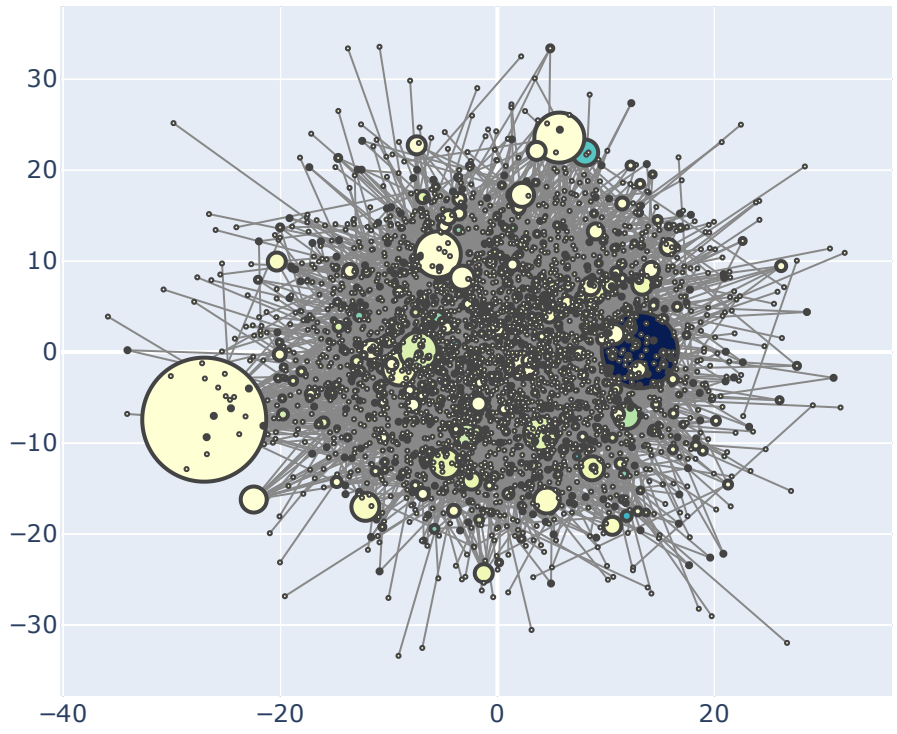
Pagerank is also a good way to represent the centrality but since the graph we have here is undirected graph, this centrality method is not used.

(b)

```
# map color scale to 300 cells
ylgnbu = cl.scales['9']['seq']['YlGnBu']
ylgnbu300 = cl.interp(ylgnbu, 300)
HTML(cl.to_html(ylgnbu300))
```

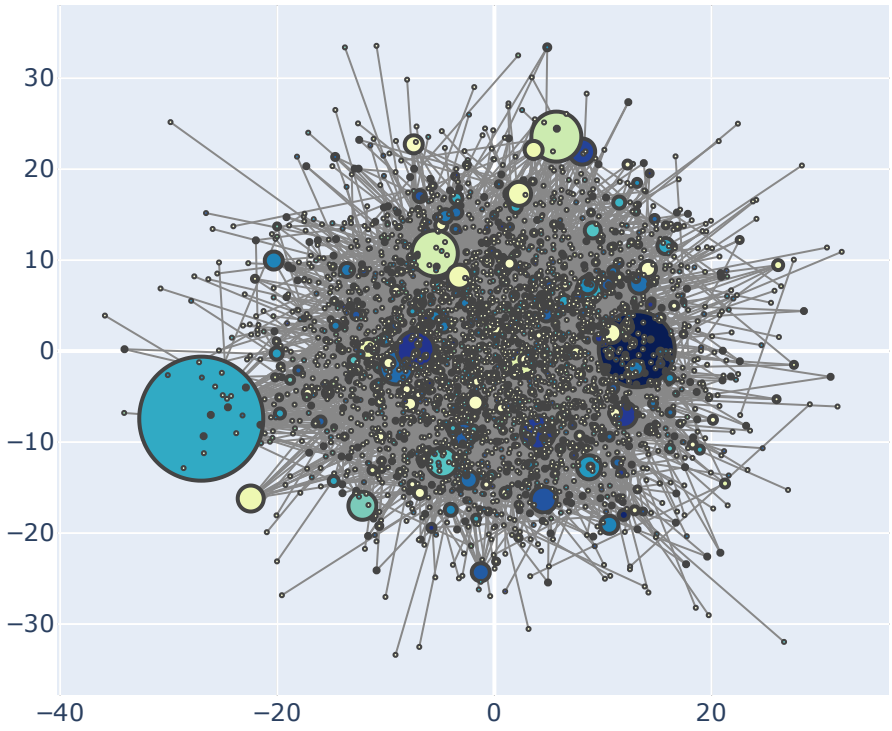
```
def plotNetworkCentr(graph,centrality,maxCentr,minCentr):


    scatters=[]

    for (node1, node2) in graph.edges():
        x0, y0 = graph.nodes[node1]['pos']
        x1, y1 = graph.nodes[node2]['pos']
        edgeWidth = graph[node1][node2]['numberMentions']
        s = Scatter(
                x=[x0, x1],
                y=[y0, y1],
                hoverinfo='none',
                mode='lines',
                line=scatter.Line(width=1 ,color='#888'))
        scatters.append(s)



    for node in graph.nodes():
        nodeCentr = centrality[node]
```

```
            nodeColor = int(299*(nodeCentr-minCentr)/(maxCentr-minCentr))
            xPos, yPos = graph.nodes[node]['pos']
            s = Scatter(
                    x=[xPos],
                    y=[yPos],
                    text="User: %s\nCentrality: %.3f" % (node, nodeCentr*100),
                    hoverinfo='text',
                    mode='markers',
                    marker=dict(
                        color=ylgnbu300[nodeColor],
                        size=nx.degree(graph,node),
                        line=dict(width=2)))
            scatters.append(s)

        layout = Layout(showlegend=False)
        fig = Figure(data=scatters, layout=layout)
        iplot(fig, show_link=False)


    configure_plotly_browser_state()
    plotNetworkCentr(tagGraph, btwCentr, maxCentrBtw, minCentrBtw)
```




```
    configure_plotly_browser_state()
```

```
plotNetworkCentr(tagGraph, closeness, maxCentrCl, minCentrCl)
```



(c)

1. Are the results similar or different? Explain what can be the reason for the observed similarity or difference.
2. What centrality measure produced a more meaningful interpretation? Why?

The two similarity measure return a much different result. However, the node chasenchase have the hi

In betweeness centrality, most of the nodes have low centrality rank, which indictes most of the nodes other, so they do not need to go through others to connect with each other.

In closeness centrality, a large amount of nodes have high closeness, which means they are very close tribes.

The reason for the different is how the centrality is measured here, as mentioned in (a), betweeness m GRAPH go through the targeted nodes, while the closeness measures how close the targeted node cor WITH and decreases as the distance(number of nodes) it has to go through. In another words, becaus

with all the rest of the nodes with very short distance, the closeness calculate centrality of each node b penalized close to zero due to long distance, instead of the whlole graph like betweeness.

The result of betweeness bears more meaningful interpretation in this situation as it high betweeness go through it and without the node, most of the connection in the social network will break. But with cl produce very high closeness nodes but they are not that important to the social network.

One thing to be noticed here is the node therealjordin, which has the largest node degree but very low b

Q5. Connectivity Patterns

(a)

```
# Number of maximal cliques for each node
clique = nx.number_of_cliques(tagGraph)
maximalCl = pd.DataFrame(clique.items())
maximalCl.columns=['User', 'MaximalCliques']
maximalCl.sort_values(by=['MaximalCliques'], ascending=False)
```

	User	MaximalCliques
40	therealjordin	60
104	chasencashe	35
759	shyla	25
1985	maxofs2d	23
1821	yungcmusic	19
...	...	...
1354	naykidd	1
1356	kdeezy90	1
1357	shawny08	1
1358	sandrinecharles	1
3198	l0veyou	1

3199 rows × 2 columns

```
# Number of maximal cliques
sum(maximalCl['MaximalCliques'])
```

```
4790
```

```
# The graph's clique number
nx.graph_clique_number(tagGraph)
```

```
3
```

```
# Size of the largest maximal clique containing each given node.
ccn = nx.cliques_containing_node(tagGraph)
ccnDf = pd.DataFrame.from_dict(ccn, orient='index')


for index, row in ccnDf.iterrows():
  ccnDf.loc[index, 'largestMaximalClique'] = row.str.len().max()
maxClDf = pd.DataFrame(ccnDf['largestMaximalClique'].copy())
maxClDf.sort_values(by=['largestMaximalClique'], ascending=False).head(50)
```

	largestMaximalClique
fetti	3.0
rebeccamezzino	3.0
mstoshay	3.0
nessalewinski	3.0
twitter	3.0
javilovespizza	3.0
msbond2u	3.0
mrpeteywheat	3.0
funwugirl	3.0
threedukes	3.0
camashe	3.0
bkrasner	3.0
poison_ivy4	3.0
flapjacks9702	3.0
whitefolkz	3.0
dre1479	3.0
swaggerreelz	3.0
nomim	3.0
brwnskinhoney	3.0
candygurlbx	3.0
gwen86	3.0
donnie7	3.0
yani_babi	3.0
sexyshida	3.0
kellz_bellz	3.0
itsdemyduhh	3.0
ksdflowers	3.0
chasencashe	3.0
cgzee	3.0
liggmo	3.0

shariselw	3.0
bscott26	3.0
misspretty03	3.0
kisshippie13	3.0
jdashvo	3.0
luck_yhgm	3.0
britterhart	3.0
thetruthac310	3.0
stormie__skyy	3.0
totallytee	3.0
mzambitious	3.0
je_nicole	3.0
starkiller99	3.0
asdavis10	3.0
kiannabanks	3.0
jonasbrothers	3.0
djalizay	3.0
seancallanan	3.0
leetmouse	3.0
daklubkilla	3.0

```
len(maxClDf[maxClDf['largestMaximalClique']==3])/len(maxClDf)
```

```
0.030634573304157548
```

(b)

The largest clique has the size of 3 and there are a lot of them. So the situation that a large group of u does not happen.

There are 4790 maximal cliques in the graph with largest to be size of 3, it means all of the maximal c is size of 2 and the network is constructed undirected with mentions, with about 97% of maximal cliqu of the users do not know or interact with most of the users in the network.

The number of maximal clique of each node is also informative as most of cliques has size of 2 and i number of maximal clique are famous, because they have been mentioned by many different users.