Project

May 28, 2019

[1]:
```
%matplotlib inline

import numpy as np
import pandas as pd

from matplotlib import pyplot as plt
import seaborn as sns
import networkx as nx
from operator import itemgetter
from collections import Counter

from pylab import rcParams

plt.style.use('ggplot')
rcParams['figure.figsize'] = 10, 8
sns.set(font_scale=1)
cmap = sns.diverging_palette(220, 10, as_cmap=True)


from IPython.display import HTML

HTML('''<script>
code_show=true;
function code_toggle() {
 if (code_show){
 $('div.input').hide();
 } else {
 $('div.input').show();
 }
 code_show = !code_show
}
$( document ).ready(code_toggle);
</script>
<form action="javascript:code_toggle()"><input type="submit" value="Click here␣
 ↪to toggle on/off the raw code."></form>''')
```

[1]:
```
<IPython.core.display.HTML object>
```

1 Data Analysis

[8]:
```
data = pd.read_csv("My Uber Drives - 2016.csv")
data = data[:-1]
data.head(5)
```

[8]:
```
      START_DATE*       END_DATE* CATEGORY*       START*            STOP*  \
0  1/1/2016 21:11  1/1/2016 21:17  Business  Fort Pierce      Fort Pierce
1   1/2/2016 1:25   1/2/2016 1:37  Business  Fort Pierce      Fort Pierce
2  1/2/2016 20:25  1/2/2016 20:38  Business  Fort Pierce      Fort Pierce
3  1/5/2016 17:31  1/5/2016 17:45  Business  Fort Pierce      Fort Pierce
4  1/6/2016 14:42  1/6/2016 15:49  Business  Fort Pierce  West Palm Beach

   MILES*         PURPOSE*
0     5.1   Meal/Entertain
1     5.0              NaN
2     4.8  Errand/Supplies
3     4.7          Meeting
4    63.7   Customer Visit
```

[9]:
```
data.describe(include=['O']).transpose()
```

[9]:
```
             count unique              top  freq
START_DATE*   1155   1154  6/28/2016 23:34     2
END_DATE*     1155   1154  6/28/2016 23:59     2
CATEGORY*     1155      2         Business  1078
START*        1155    177             Cary   201
STOP*         1155    188             Cary   203
PURPOSE*       653     10          Meeting   187
```

[10]:
```
data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1155 entries, 0 to 1154
Data columns (total 7 columns):
START_DATE*    1155 non-null object
END_DATE*      1155 non-null object
CATEGORY*      1155 non-null object
START*         1155 non-null object
STOP*          1155 non-null object
MILES*         1155 non-null float64
PURPOSE*       653 non-null object
dtypes: float64(1), object(6)
memory usage: 63.2+ KB
```

[11]:
```
data.isnull().any()
```

[11]:
```
START_DATE*    False
END_DATE*      False
CATEGORY*      False
```

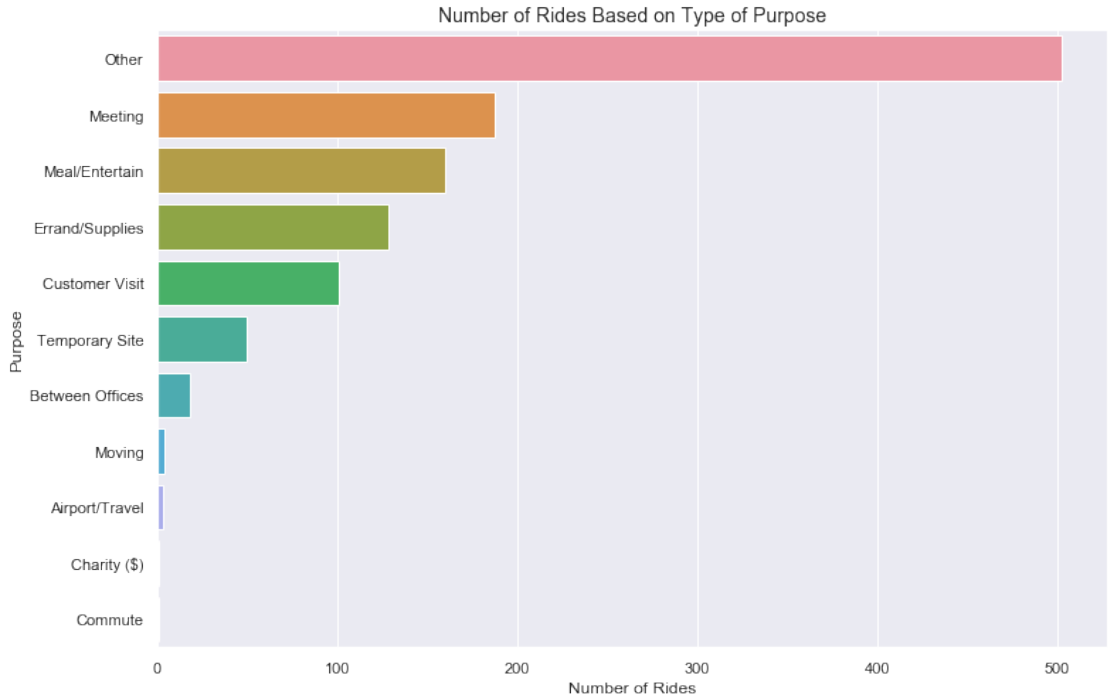
```
START*          False
STOP*           False
MILES*          False
PURPOSE*         True
dtype: bool
```

[12]:
```
data = data.rename(columns = {'START_DATE*': 'StartDate', 'END_DATE*':␣
↪'EndDate', 'CATEGORY*': 'Category', 'START*': 'Start', 'STOP*': 'Stop',␣
↪'MILES*': 'Miles', 'PURPOSE*': 'Purpose'})
```

[13]:
```
data['Purpose'].replace(np.nan, 'Other', inplace=True)
```

1.1 Number of Rides Based on Type of Purpose

[14]:
```
rcParams['figure.figsize'] = 12, 8
data_grouped = data.groupby('Purpose').size().reset_index(name="Frequency")
ax = sns.barplot(x='Frequency',y='Purpose', data=data_grouped.
↪sort_values(by='Frequency', ascending=0))
ax.set(xlabel='Number of Rides', ylabel='Purpose')
plt.title("Number of Rides Based on Type of Purpose", fontsize='14')
plt.show()
```

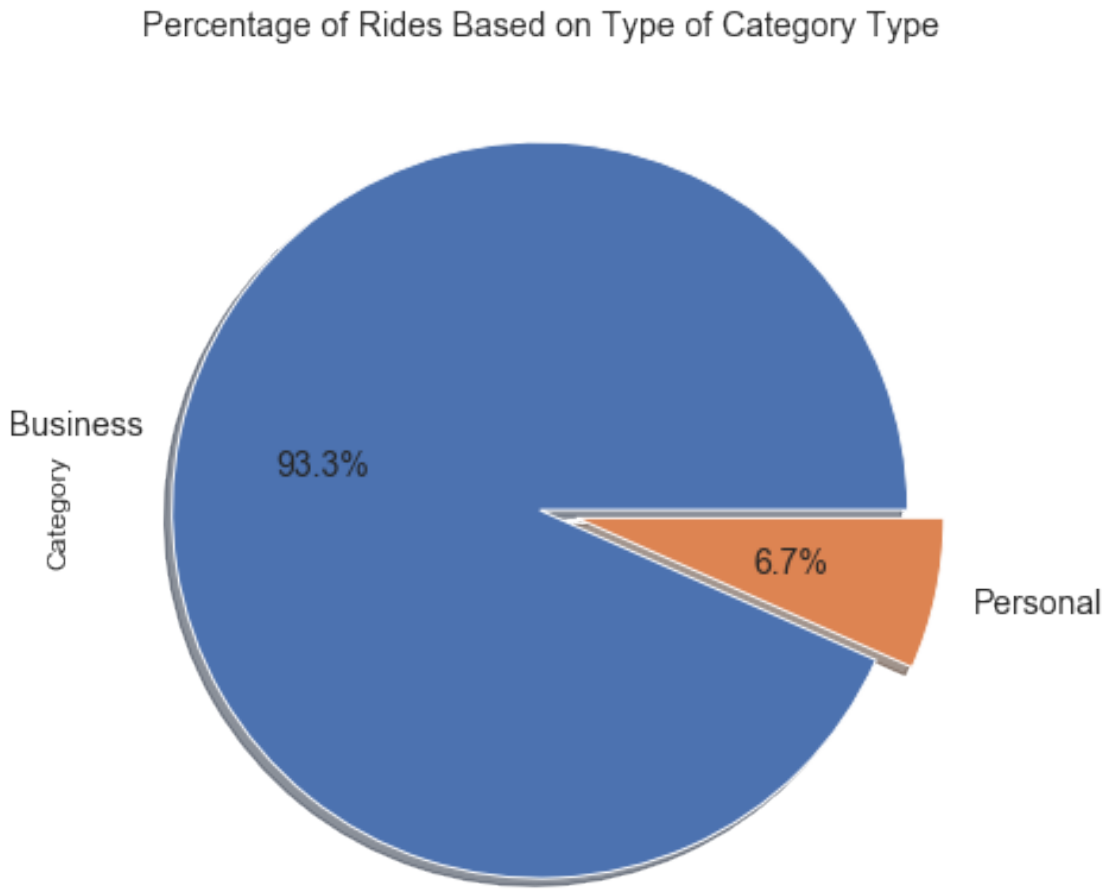


[15]:
```
print(data.groupby('Purpose').size().sort_values(ascending=False), '\n')
```

```
Purpose
Other               502
Meeting             187
Meal/Entertain      160
Errand/Supplies     128
Customer Visit      101
Temporary Site       50
Between Offices      18
Moving                4
Airport/Travel        3
Commute               1
Charity ($)           1
dtype: int64
```

1.2 Percentage of Rides Based on Type of Category Type

[16]:
```
data['Category'].value_counts().plot.pie(explode=[0, 0.1], autopct='%1.
↪1f%%',shadow=True, figsize=(8,6), fontsize=14)
plt.title("Percentage of Rides Based on Type of Category Type", fontsize=14)
plt.tight_layout()
plt.show()
```



[17]:
```
print(data.groupby('Category').size().sort_values(ascending=False), '\n')
```

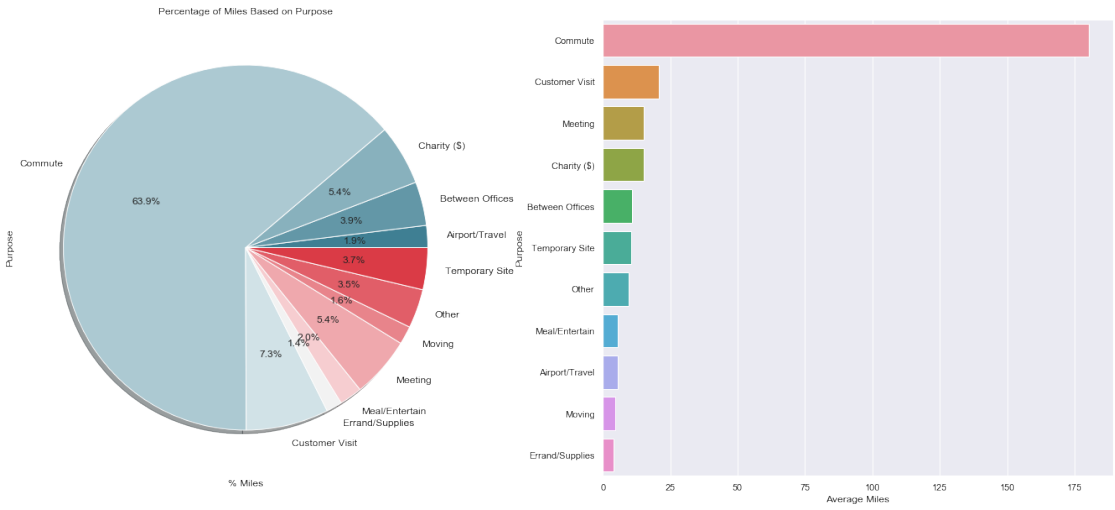
```
Category
Business    1078
Personal      77
dtype: int64
```

1.3 Ride Summary - Miles Based on Purpose

[18]:
```
data_grouped = data.groupby(['Purpose'])['Miles'].mean().reset_index()
data_grouped.set_index('Purpose', inplace=True)
data_grouped.reset_index(inplace= True)
```

[19]:
```
f, ax = plt.subplots(1, 2, figsize=(24,10))
```

```
data_grouped.set_index('Purpose')['Miles'].plot.pie(autopct='%1.1f%%',␣
 ↪ax=ax[0], cmap= cmap, shadow=True, fontsize=12, title='Percentage of Miles␣
 ↪Based on Purpose')
ax[0].set(xlabel='% Miles', ylabel='Purpose')
sns.barplot(x='Miles',y='Purpose', data=data_grouped.sort_values(by='Miles',␣
 ↪ascending=0),ax=ax[1])
ax[1].set(xlabel='Average Miles', ylabel='Purpose')
plt.show()
```



[20]:
```
df = data.copy()

df['StartDate'] = pd.to_datetime(df['StartDate'])
df['EndDate'] = pd.to_datetime(df['EndDate'])

df['StartTime'] = df['StartDate'].dt.time
df['StartDate'] =  pd.to_datetime(df['StartDate'].dt.date)
df['EndTime'] = df['EndDate'].dt.time
df['EndDate'] =  pd.to_datetime(df['EndDate'].dt.date)

df.tail(5)
```

[20]:

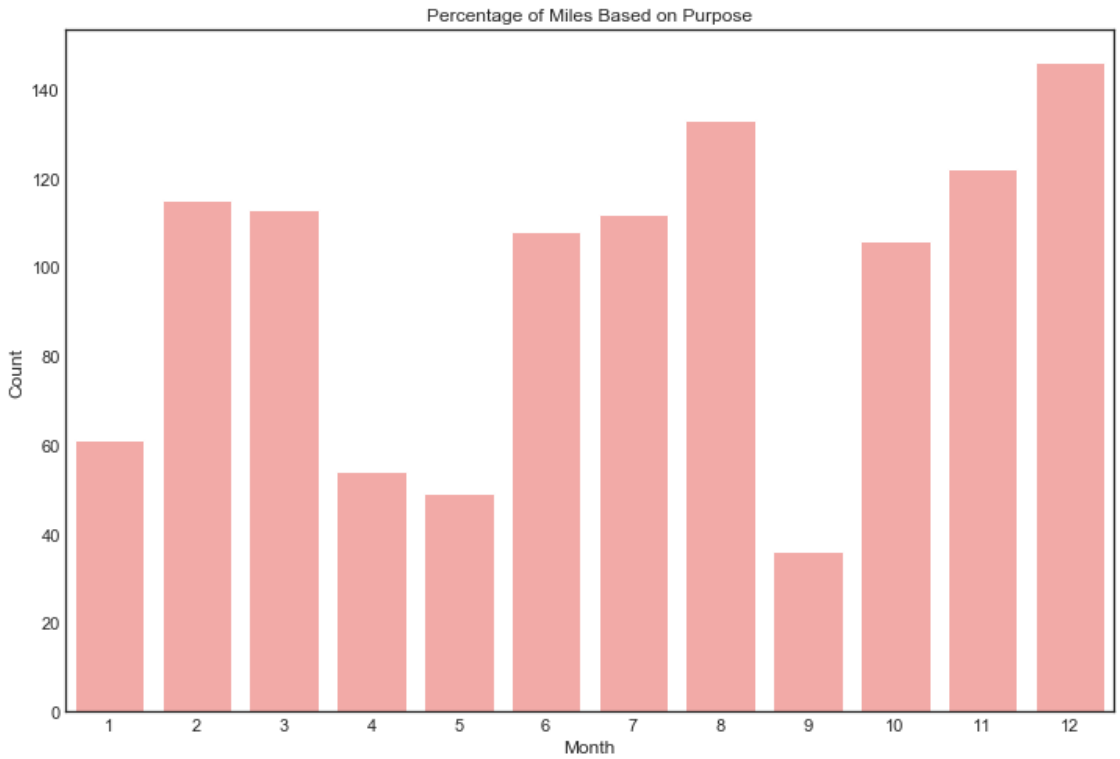
	StartDate	EndDate	Category	Start	Stop	Miles	Purpose	StartTime	EndTime
1150	2016-12-31	2016-12-31	Business	Kar?chi	Kar?chi	0.7	Meeting	01:07:00	01:14:00
1151	2016-12-31	2016-12-31	Business	Kar?chi	Unknown Location	3.9	Temporary Site	13:24:00	13:42:00
1152	2016-12-31	2016-12-31	Business	Unknown Location	Unknown Location				
1153	2016-12-31	2016-12-31	Business	Katunayake	Gampaha				
1154	2016-12-31	2016-12-31	Business	Gampaha	Ilukwatta				

```
1152   16.2          Meeting  15:03:00  15:38:00
1153    6.4  Temporary Site  21:32:00  21:50:00
1154   48.2  Temporary Site  22:08:00  23:51:00
```

1.4 Number of Rides Based on Months

[21]:
```
df_per_month = df.groupby(df.StartDate.dt.month).size().
 ↪reset_index(name="Count")
df_per_month.columns = ['Month', 'Count']
```

[22]:
```
plt.style.use('seaborn-white')
rcParams['figure.figsize'] = 12, 8
ax = sns.barplot(x='Month',y='Count', data=df_per_month, color='#FF9F9A')
ax.set(title='Percentage of Miles Based on Purpose')
ax.set(xlabel='Month', ylabel='Count')
plt.show()
```



2 Network Analysis

2.1 Graph Creation

[23]:
```
G = nx.Graph()
G = nx.from_pandas_edgelist(df, source='Start',target='Stop',
                            edge_attr=['StartDate',␣
 ↪'StartTime','EndDate','EndTime','Category','Miles','Purpose'])
print(nx.info(G))
#FG = nx.from_pandas_edgelist(data, source='Start', target='Stop',␣
 ↪edge_attr=True,)
```

```
Name:
Type: Graph
Number of nodes: 209
Number of edges: 280
Average degree:   2.6794
```

The graph has 209 nodes and 280 edges so the size of the network is 209.
On average the degree is 2.67

[24]:
```
print(list(G.nodes())[:20])
```

```
['Fort Pierce', 'West Palm Beach', 'Palm Beach', 'Cary', 'Morrisville',
'Jamaica', 'New York', 'Queens', 'Elmhurst', 'Midtown', 'East Harlem', 'NoMad',
'Flatiron District', 'Midtown East', 'Hudson Square', 'Lower Manhattan', "Hell's
Kitchen", 'Queens County', 'Downtown', 'Gulfton']
```

[25]:
```
print(list(G.edges())[:20])
```

```
[('Fort Pierce', 'Fort Pierce'), ('Fort Pierce', 'West Palm Beach'), ('West Palm
Beach', 'West Palm Beach'), ('West Palm Beach', 'Palm Beach'), ('Cary', 'Cary'),
('Cary', 'Morrisville'), ('Cary', 'Durham'), ('Cary', 'Raleigh'), ('Cary',
'Apex'), ('Cary', 'Chapel Hill'), ('Cary', 'Latta'), ('Cary', 'Florence'),
('Cary', 'Holly Springs'), ('Cary', 'Boone'), ('Cary', 'Wake Forest'), ('Cary',
'Eagle Rock'), ('Cary', 'Winston Salem'), ('Cary', 'Mebane'), ('Cary', 'Unknown
Location'), ('Cary', 'Wake Co.')]
```

2.2 Components and Subgraphs

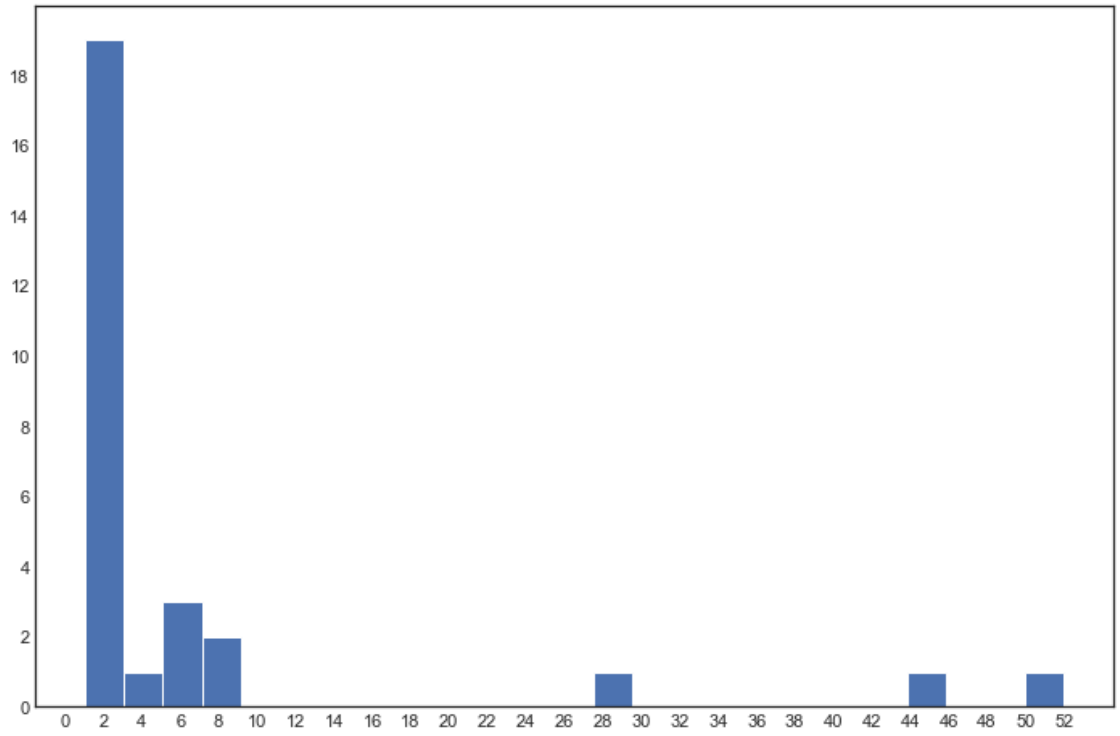
[26]:
```
subgraphsLst = list(nx.connected_component_subgraphs(G))
len(subgraphsLst)
```

[26]: 28

Uber Rides Network contains 209 nodes, but the network is split into over 28 component subgraphs.

2.2.1 Network Component Distribution

[27]:
```
components =[len(c) for c in subgraphsLst]
plt.hist(components, bins = 25)
plt.xticks(range(0,54,2), rotation="horizontal")
plt.yticks(range(0,20,2), rotation="horizontal")
plt.show()
```



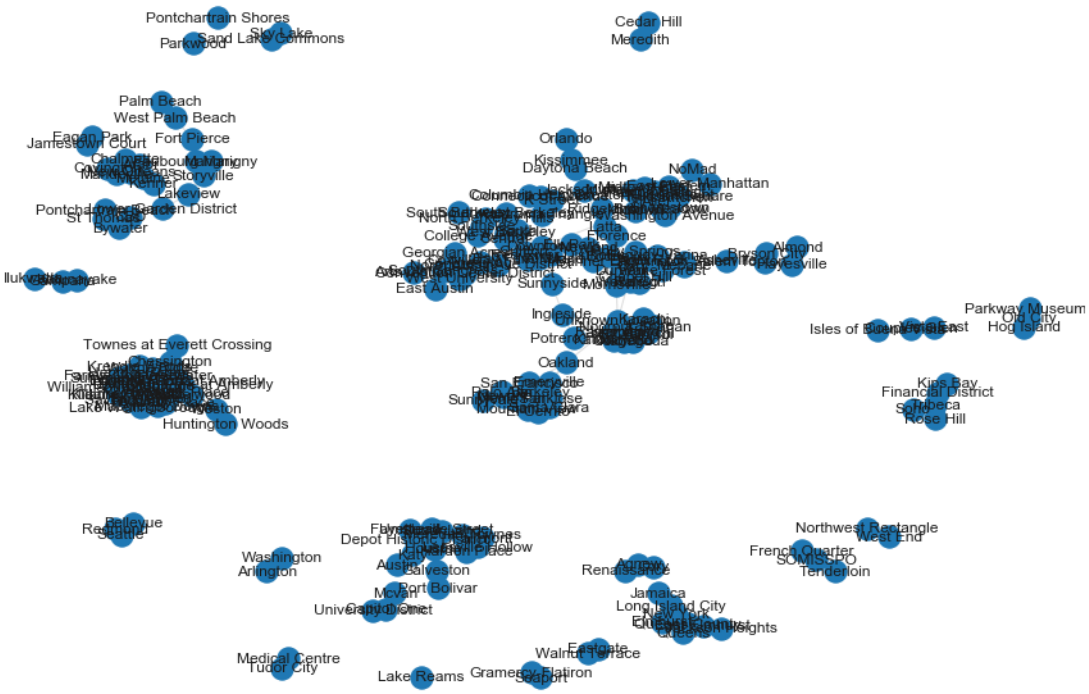
[28]:
```
total_counts = [[x, components.count(x)] for x in set(components)]
comp_df = pd.DataFrame(total_counts, columns=['Component', 'Count'])
comp_df.set_index('Component', inplace=True)
comp_df.style.background_gradient(cmap=cmap)
```

[28]:
```
<pandas.io.formats.style.Styler at 0x1fbf71e7dd8>
```

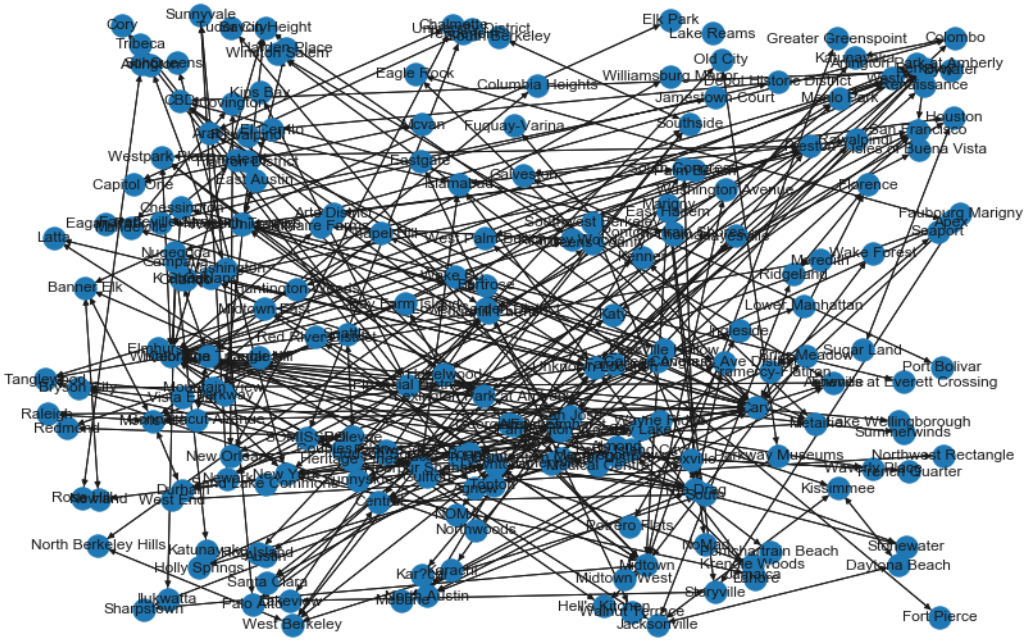
Component subgraphs (or simply components) are portions of the network that are disconnected from each other. Of 28 components, 3 are of size 1 -these are called "isolates" and should be removed from the network-.There are 8 components of size 2 and 3. And the biggest subgraph is contains 52 nodes of a network.

3 Visualization of Uber Traffic Flow Network

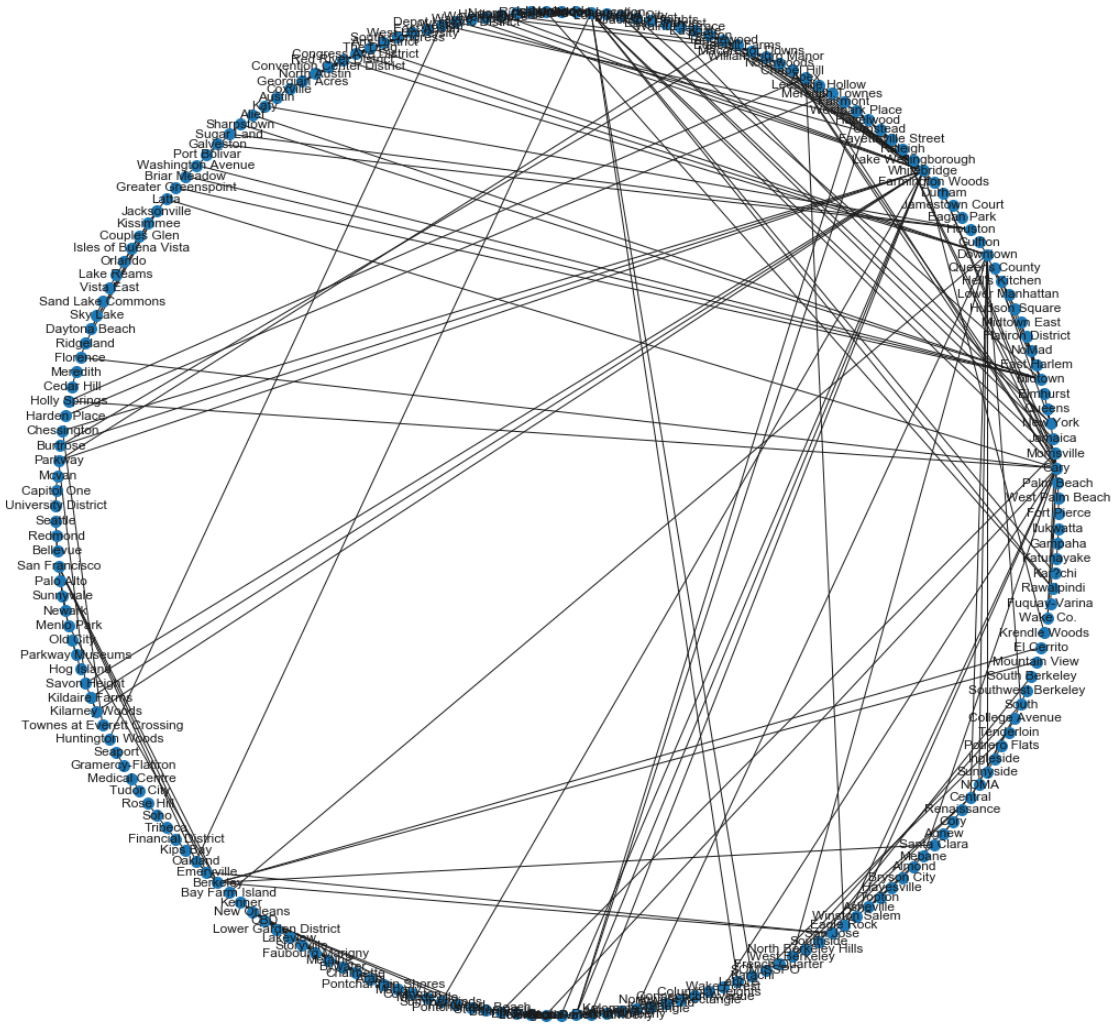
[29]:
```
nx.draw_spring(G, edge_color='#dddddd', with_labels=True)
plt.show()
```



[30]:
```
#nx.draw_spring(G, with_labels=True)
nx.draw_random(G.to_directed(), with_labels=True)
plt.show()
```



[31]:
```
# Plot it
plt.figure(figsize=(14,14))
nx.draw_circular(G, with_labels=True,node_size=100)
plt.show()
```



3.1 Analysis of Nodes

[56]:
```
degree_dict = dict(G.degree(G.nodes()))
sorted_degree = sorted(degree_dict.items(), key=itemgetter(1), reverse=True)

print("Top 20 nodes by degree:")

degree_dist = pd.DataFrame(sorted_degree, columns=['Location','Degree'])
degree_dist.sort_values(by='Degree',ascending=False).head(20).style.
 ↪background_gradient(cmap=cmap)
```

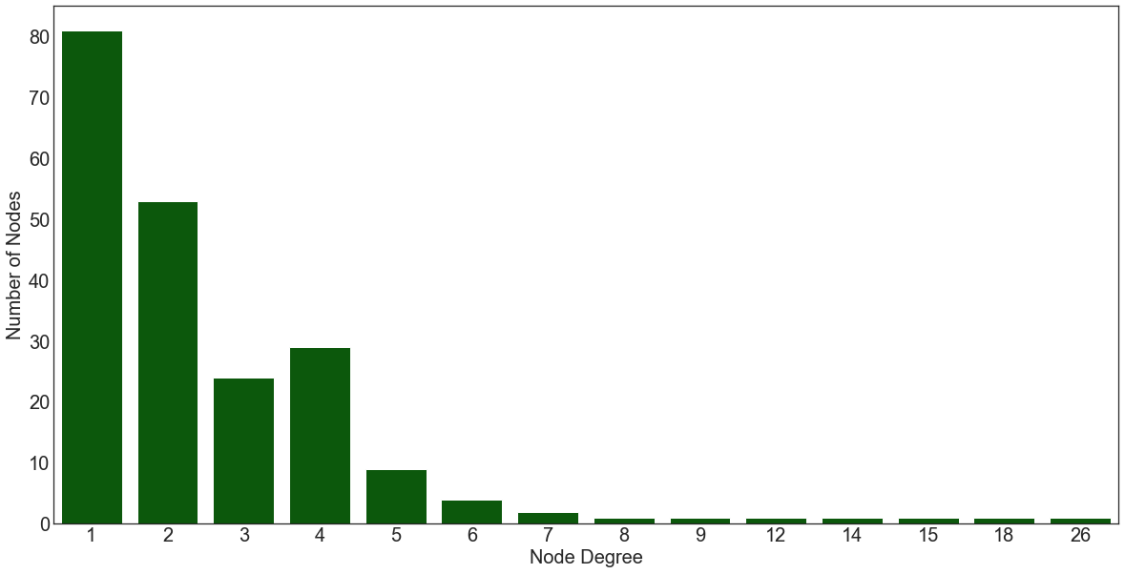
```
Top 20 nodes by degree:
```

[56]: `<pandas.io.formats.style.Styler at 0x1fbf83f7470>`

The results identifies which location is being visited more frequently. Here it can be seen that Whitebridge and Cary are the places taht are visited mostly.

3.1.1 Distribution of the node degrees

[33]:
```
degree_dic = Counter(dict(G.degree()).values())
degree_hist = pd.DataFrame({"degree": list(degree_dic.values()),
                            "Number of Nodes": list(degree_dic.keys())})
plt.figure(figsize=(20,10))
sns.barplot(y = 'degree', x = 'Number of Nodes', data = degree_hist, color =␣
 ↪'darkgreen')
plt.xlabel('Node Degree', fontsize=20)
plt.ylabel('Number of Nodes', fontsize=20)
plt.tick_params(axis='both', which='major', labelsize=20)
plt.show()
```



Most of the nodes tend to have a degree of 1 or 2 and 4.

3.1.2 Network Density

[34]:
```
density = nx.density(G)
print("Network density:", density)
```

```
Network density: 0.012881854987118146
```

The density of our network is approximately 0.0129. On a scale of 0 to 1, not a very dense network, which comports with what you can see in the visualization. A 0 would mean that there

are no connections at all, and a 1 would indicate that all possible edges are present (a perfectly connected network): This Uber network is on the lower end of that scale, but still far from 0.

3.2 Centrality

Centrality aims to find the most important nodes in a network.

3.2.1 Degree Centrality

[35]:
```
degree_centrality = nx.algorithms.degree_centrality(G)
sorted_degree_centrality = sorted(degree_centrality.items(), key=itemgetter(1),␣
 ↪reverse=True)
sorted_degree_centrality[:10]
```

[35]:
```
[('Whitebridge', 0.125),
 ('Cary', 0.08653846153846154),
 ('Unknown Location', 0.07211538461538462),
 ('Midtown', 0.06730769230769232),
 ('Downtown', 0.057692307692307696),
 ('Morrisville', 0.04326923076923077),
 ('Berkeley', 0.038461538461538464),
 ('The Drag', 0.03365384615384616),
 ('Central', 0.03365384615384616),
 ('New York', 0.028846153846153848)]
```

3.2.2 Eigenvector Centrality

Eigenvector centrality is a kind of extension of degree—centrality. It looks at a combination of a node's edges and the edges of that node's neighbors. Eigenvector centrality cares if you are a hub, but it also cares how many hubs you are connected to.

[38]:
```
eigenvector_centrality = nx.algorithms.eigenvector_centrality(G, max_iter=500)␣
 ↪# Notice the 3 airports from which all of our 100 rows of data originates
sorted_eigenvector_centrality = sorted(eigenvector_centrality.items(),␣
 ↪key=itemgetter(1), reverse=True)
sorted_eigenvector_centrality[:10]
```

[38]:
```
[('Whitebridge', 0.6646598425612025),
 ('Preston', 0.2258961119723626),
 ('Lexington Park at Amberly', 0.20712910313780167),
 ('Edgehill Farms', 0.2051712166317349),
 ('Westpark Place', 0.20047189476573732),
 ('Tanglewood', 0.19234876125053213),
 ('Hazelwood', 0.17431819214287014),
 ('Northwoods', 0.17066934400969044),
 ('Parkway', 0.15923630129510694),
 ('Savon Height', 0.1533529382511316)]
```

3.2.3 Katz Centrality

[37]:
```
katz_centrality = nx.algorithms.katz_centrality(G, max_iter=500) # Notice the 3␣
 ↪airports from which all of our 100 rows of data originates
sorted_katz_centrality = sorted(katz_centrality.items(), key=itemgetter(1),␣
 ↪reverse=True)
sorted_katz_centrality[:10]
```

[37]:
```
[('Whitebridge', 0.2719384341254852),
 ('Cary', 0.1951184803643446),
 ('Unknown Location', 0.17465046022598132),
 ('Midtown', 0.13451560365297247),
 ('Downtown', 0.13322538808045487),
 ('Morrisville', 0.13251870013513256),
 ('Preston', 0.10870972414143357),
 ('Lexington Park at Amberly', 0.105085109926472),
 ('Edgehill Farms', 0.10424685821946111),
 ('Westpark Place', 0.10043500585941184)]
```

3.3 Detecting Cliques

[39]:
```
clique_lst = list(nx.find_cliques(G))
print(len(clique_lst))
clique_lst[:10]
```

```
173
```

[39]:
```
[['Tenderloin', 'SOMISSPO'],
 ['Mountain View', 'Berkeley'],
 ['Lower Garden District', 'CBD'],
 ['Lower Garden District', 'Lakeview'],
 ['Fuquay-Varina', 'Cary'],
 ['Bellevue', 'Redmond', 'Seattle'],
 ['Rose Hill', 'Soho'],
 ['K Street', 'Kalorama Triangle'],
 ['Lakeview', 'Storyville'],
 ['St Thomas', 'CBD']]
```

A clique is defined as a maximal complete subgraph of a given graph.

3.4 Density of Network

[40]:
```
nx.density(G) # Average edge density of the Graphs
```

[40]:
```
0.012881854987118146
```

Density measures how many links from all possible links within the network are realized.

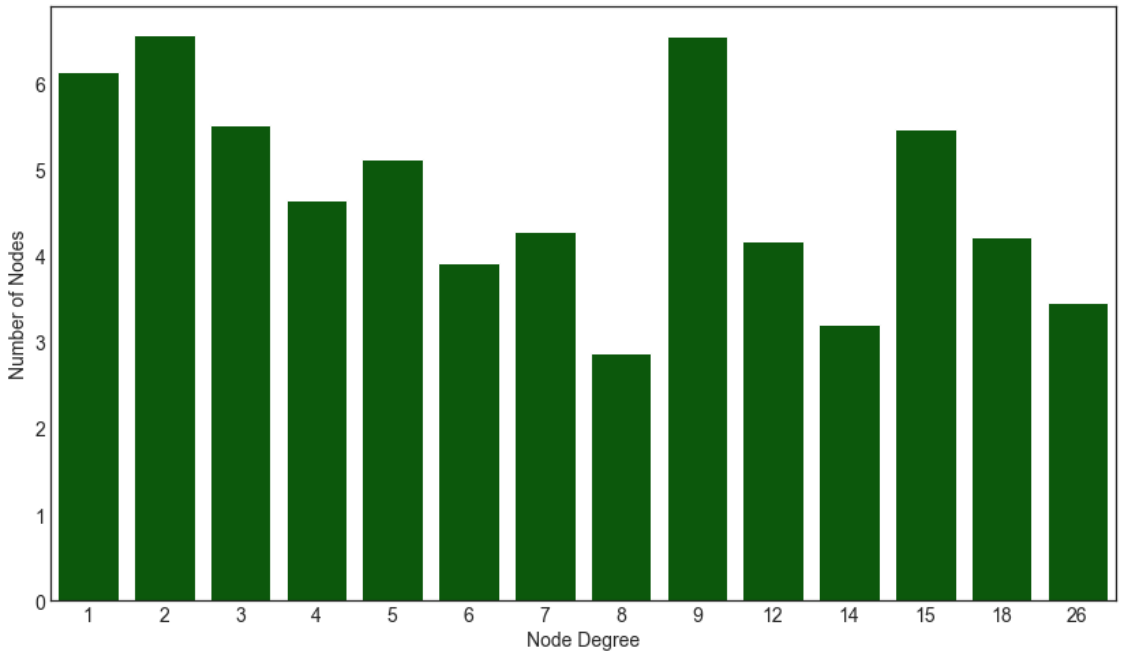
3.5 Average Degree Connectivity

[57]:
```
#  # For a node of degree k - What is the average of its neighbours' degree?

average_degree_connectivity = dict(nx.average_degree_connectivity(G))
df_avg_degree_connectivity = pd.DataFrame(average_degree_connectivity,␣
 ↪index=[0]).T
df_avg_degree_connectivity.columns = ['Avg Degree of Neighbors']
df_avg_degree_connectivity.style.background_gradient(cmap=cmap)
```

[57]:
```
<pandas.io.formats.style.Styler at 0x1fbf83f7828>
```

[63]:
```
average_degree_connectivity_hist = pd.DataFrame({"degree":␣
 ↪list(average_degree_connectivity.values()),
                            "Number of Nodes": list(degree_dic.keys())})
plt.figure(figsize=(14,8))
sns.barplot(y = 'degree', x = 'Number of Nodes', data =␣
 ↪average_degree_connectivity_hist, color = 'darkgreen')
plt.xlabel('Node Degree', fontsize=14)
plt.ylabel('Number of Nodes', fontsize=14)
plt.tick_params(axis='both', which='major', labelsize=14)
plt.show()
```



4 Path Analysis

4.0.1 All available paths from San Francisco to Palo Alto

[47]:
```
for path in nx.all_simple_paths(G, source='San Francisco', target='Palo Alto'):
    print(path)
```

```
['San Francisco', 'Palo Alto']
['San Francisco', 'Newark', 'Sunnyvale', 'Palo Alto']
['San Francisco', 'Newark', 'Menlo Park', 'Palo Alto']
['San Francisco', 'Emeryville', 'Oakland', 'Berkeley', 'Menlo Park', 'Newark',
'Sunnyvale', 'Palo Alto']
['San Francisco', 'Emeryville', 'Oakland', 'Berkeley', 'Menlo Park', 'Palo
Alto']
['San Francisco', 'Emeryville', 'Berkeley', 'Menlo Park', 'Newark', 'Sunnyvale',
'Palo Alto']
['San Francisco', 'Emeryville', 'Berkeley', 'Menlo Park', 'Palo Alto']
['San Francisco', 'Emeryville', 'San Jose', 'Berkeley', 'Menlo Park', 'Newark',
'Sunnyvale', 'Palo Alto']
['San Francisco', 'Emeryville', 'San Jose', 'Berkeley', 'Menlo Park', 'Palo
Alto']
['San Francisco', 'Emeryville', 'San Jose', 'Santa Clara', 'Berkeley', 'Menlo
Park', 'Newark', 'Sunnyvale', 'Palo Alto']
['San Francisco', 'Emeryville', 'San Jose', 'Santa Clara', 'Berkeley', 'Menlo
Park', 'Palo Alto']
['San Francisco', 'Oakland', 'Emeryville', 'Berkeley', 'Menlo Park', 'Newark',
'Sunnyvale', 'Palo Alto']
['San Francisco', 'Oakland', 'Emeryville', 'Berkeley', 'Menlo Park', 'Palo
Alto']
['San Francisco', 'Oakland', 'Emeryville', 'San Jose', 'Berkeley', 'Menlo Park',
'Newark', 'Sunnyvale', 'Palo Alto']
['San Francisco', 'Oakland', 'Emeryville', 'San Jose', 'Berkeley', 'Menlo Park',
'Palo Alto']
['San Francisco', 'Oakland', 'Emeryville', 'San Jose', 'Santa Clara',
'Berkeley', 'Menlo Park', 'Newark', 'Sunnyvale', 'Palo Alto']
['San Francisco', 'Oakland', 'Emeryville', 'San Jose', 'Santa Clara',
'Berkeley', 'Menlo Park', 'Palo Alto']
['San Francisco', 'Oakland', 'Berkeley', 'Menlo Park', 'Newark', 'Sunnyvale',
'Palo Alto']
['San Francisco', 'Oakland', 'Berkeley', 'Menlo Park', 'Palo Alto']
['San Francisco', 'Berkeley', 'Menlo Park', 'Newark', 'Sunnyvale', 'Palo Alto']
['San Francisco', 'Berkeley', 'Menlo Park', 'Palo Alto']
```

4.0.2 All available paths from Oakland to Newark

[48]:
```
# Let us find all the paths available
for path in nx.all_simple_paths(G, source='Oakland', target='Newark'):
    print(path)
```

```
['Oakland', 'Emeryville', 'Berkeley', 'San Francisco', 'Palo Alto', 'Sunnyvale',
'Newark']
['Oakland', 'Emeryville', 'Berkeley', 'San Francisco', 'Palo Alto', 'Menlo
Park', 'Newark']
['Oakland', 'Emeryville', 'Berkeley', 'San Francisco', 'Newark']
['Oakland', 'Emeryville', 'Berkeley', 'Menlo Park', 'Newark']
['Oakland', 'Emeryville', 'Berkeley', 'Menlo Park', 'Palo Alto', 'San
Francisco', 'Newark']
['Oakland', 'Emeryville', 'Berkeley', 'Menlo Park', 'Palo Alto', 'Sunnyvale',
'Newark']
['Oakland', 'Emeryville', 'San Francisco', 'Palo Alto', 'Sunnyvale', 'Newark']
['Oakland', 'Emeryville', 'San Francisco', 'Palo Alto', 'Menlo Park', 'Newark']
['Oakland', 'Emeryville', 'San Francisco', 'Newark']
['Oakland', 'Emeryville', 'San Francisco', 'Berkeley', 'Menlo Park', 'Newark']
['Oakland', 'Emeryville', 'San Francisco', 'Berkeley', 'Menlo Park', 'Palo
Alto', 'Sunnyvale', 'Newark']
['Oakland', 'Emeryville', 'San Jose', 'Berkeley', 'San Francisco', 'Palo Alto',
'Sunnyvale', 'Newark']
['Oakland', 'Emeryville', 'San Jose', 'Berkeley', 'San Francisco', 'Palo Alto',
'Menlo Park', 'Newark']
['Oakland', 'Emeryville', 'San Jose', 'Berkeley', 'San Francisco', 'Newark']
['Oakland', 'Emeryville', 'San Jose', 'Berkeley', 'Menlo Park', 'Newark']
['Oakland', 'Emeryville', 'San Jose', 'Berkeley', 'Menlo Park', 'Palo Alto',
'San Francisco', 'Newark']
['Oakland', 'Emeryville', 'San Jose', 'Berkeley', 'Menlo Park', 'Palo Alto',
'Sunnyvale', 'Newark']
['Oakland', 'Emeryville', 'San Jose', 'Santa Clara', 'Berkeley', 'San
Francisco', 'Palo Alto', 'Sunnyvale', 'Newark']
['Oakland', 'Emeryville', 'San Jose', 'Santa Clara', 'Berkeley', 'San
Francisco', 'Palo Alto', 'Menlo Park', 'Newark']
['Oakland', 'Emeryville', 'San Jose', 'Santa Clara', 'Berkeley', 'San
Francisco', 'Newark']
['Oakland', 'Emeryville', 'San Jose', 'Santa Clara', 'Berkeley', 'Menlo Park',
'Newark']
['Oakland', 'Emeryville', 'San Jose', 'Santa Clara', 'Berkeley', 'Menlo Park',
'Palo Alto', 'San Francisco', 'Newark']
['Oakland', 'Emeryville', 'San Jose', 'Santa Clara', 'Berkeley', 'Menlo Park',
'Palo Alto', 'Sunnyvale', 'Newark']
['Oakland', 'Berkeley', 'Emeryville', 'San Francisco', 'Palo Alto', 'Sunnyvale',
'Newark']
['Oakland', 'Berkeley', 'Emeryville', 'San Francisco', 'Palo Alto', 'Menlo
Park', 'Newark']
```

```
['Oakland', 'Berkeley', 'Emeryville', 'San Francisco', 'Newark']
['Oakland', 'Berkeley', 'San Francisco', 'Palo Alto', 'Sunnyvale', 'Newark']
['Oakland', 'Berkeley', 'San Francisco', 'Palo Alto', 'Menlo Park', 'Newark']
['Oakland', 'Berkeley', 'San Francisco', 'Newark']
['Oakland', 'Berkeley', 'San Jose', 'Emeryville', 'San Francisco', 'Palo Alto',
'Sunnyvale', 'Newark']
['Oakland', 'Berkeley', 'San Jose', 'Emeryville', 'San Francisco', 'Palo Alto',
'Menlo Park', 'Newark']
['Oakland', 'Berkeley', 'San Jose', 'Emeryville', 'San Francisco', 'Newark']
['Oakland', 'Berkeley', 'Santa Clara', 'San Jose', 'Emeryville', 'San
Francisco', 'Palo Alto', 'Sunnyvale', 'Newark']
['Oakland', 'Berkeley', 'Santa Clara', 'San Jose', 'Emeryville', 'San
Francisco', 'Palo Alto', 'Menlo Park', 'Newark']
['Oakland', 'Berkeley', 'Santa Clara', 'San Jose', 'Emeryville', 'San
Francisco', 'Newark']
['Oakland', 'Berkeley', 'Menlo Park', 'Newark']
['Oakland', 'Berkeley', 'Menlo Park', 'Palo Alto', 'San Francisco', 'Newark']
['Oakland', 'Berkeley', 'Menlo Park', 'Palo Alto', 'Sunnyvale', 'Newark']
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'Newark']
['Oakland', 'San Francisco', 'Emeryville', 'San Jose', 'Berkeley', 'Menlo Park',
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['Oakland', 'San Francisco', 'Emeryville', 'San Jose', 'Santa Clara',
'Berkeley', 'Menlo Park', 'Newark']
['Oakland', 'San Francisco', 'Emeryville', 'San Jose', 'Santa Clara',
'Berkeley', 'Menlo Park', 'Palo Alto', 'Sunnyvale', 'Newark']
['Oakland', 'San Francisco', 'Berkeley', 'Menlo Park', 'Newark']
['Oakland', 'San Francisco', 'Berkeley', 'Menlo Park', 'Palo Alto', 'Sunnyvale',
'Newark']
```

4.0.3 Shortest path from Oakland to Newark

[65]:
```
dijpath = nx.dijkstra_path(G, source='Oakland', target='Newark')
dijpath
```

[65]:
```
['Oakland', 'San Francisco', 'Newark']
```

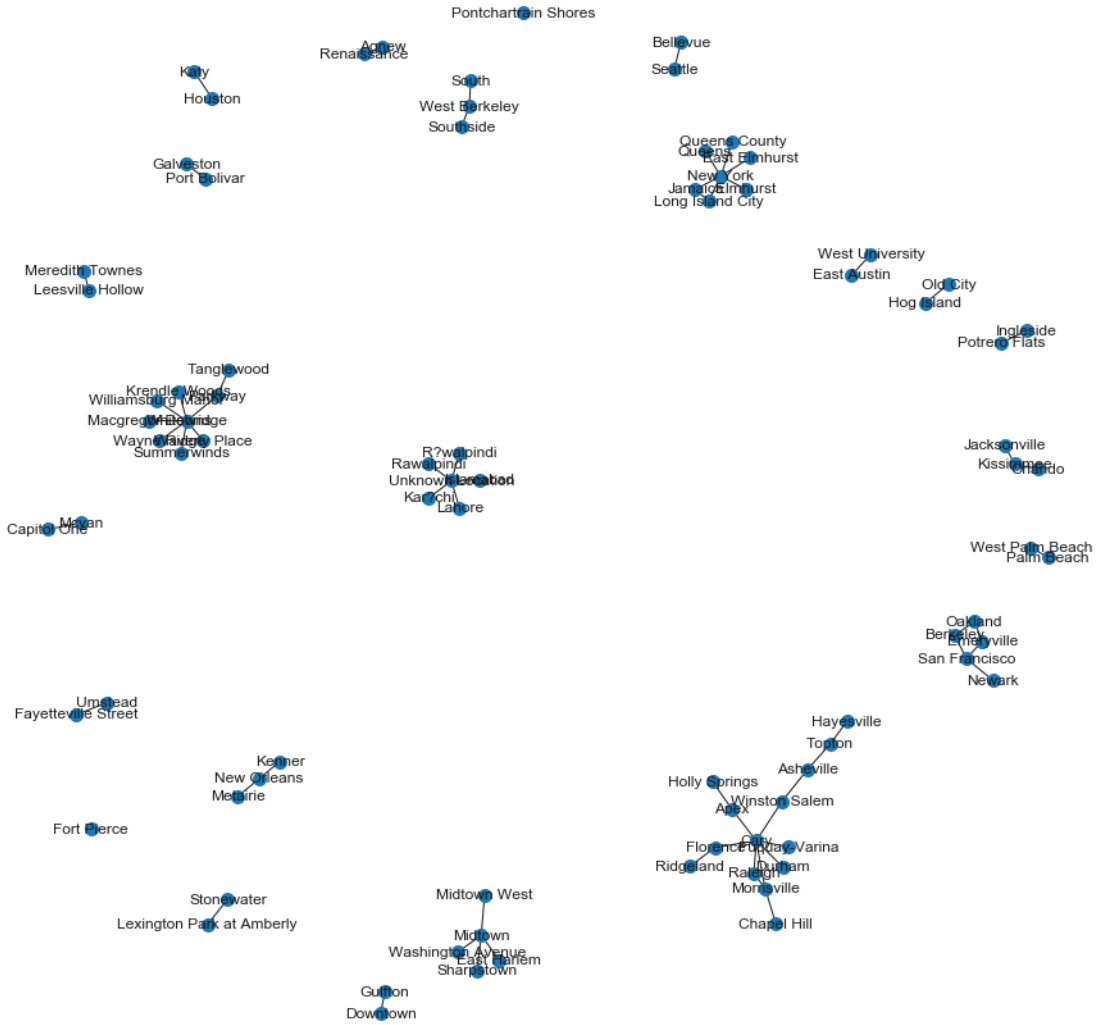
5 Visalization of Network of Rides Based on Meeting Purpose

[66]:
```
g_meeting = nx.Graph()
g_meeting = nx.
 ↪from_pandas_edgelist(df[df['Purpose']=='Meeting'],source='Start',target='Stop')
```

The highest number of rides is for meeting purpose.

[74]:
```
print (nx.info(g_meeting))
plt.figure(figsize=(12,12))
nx.draw_spring(g_meeting, with_labels=True, node_size=100)
plt.show()
```

```
Name:
Type: Graph
Number of nodes: 83
Number of edges: 71
Average degree:   1.7108
```



[68]:
```
degree_dict = dict(g_meeting.degree(g_meeting.nodes()))
sorted_degree = sorted(degree_dict.items(), key=itemgetter(1), reverse=True)

print("Top 20 nodes by degree:")

degree_dist = pd.DataFrame(sorted_degree, columns=['Location','Degree'])
degree_dist.sort_values(by='Degree',ascending=False).head(20).style.
 ↪background_gradient(cmap=cmap)
```

```
Top 20 nodes by degree:
```

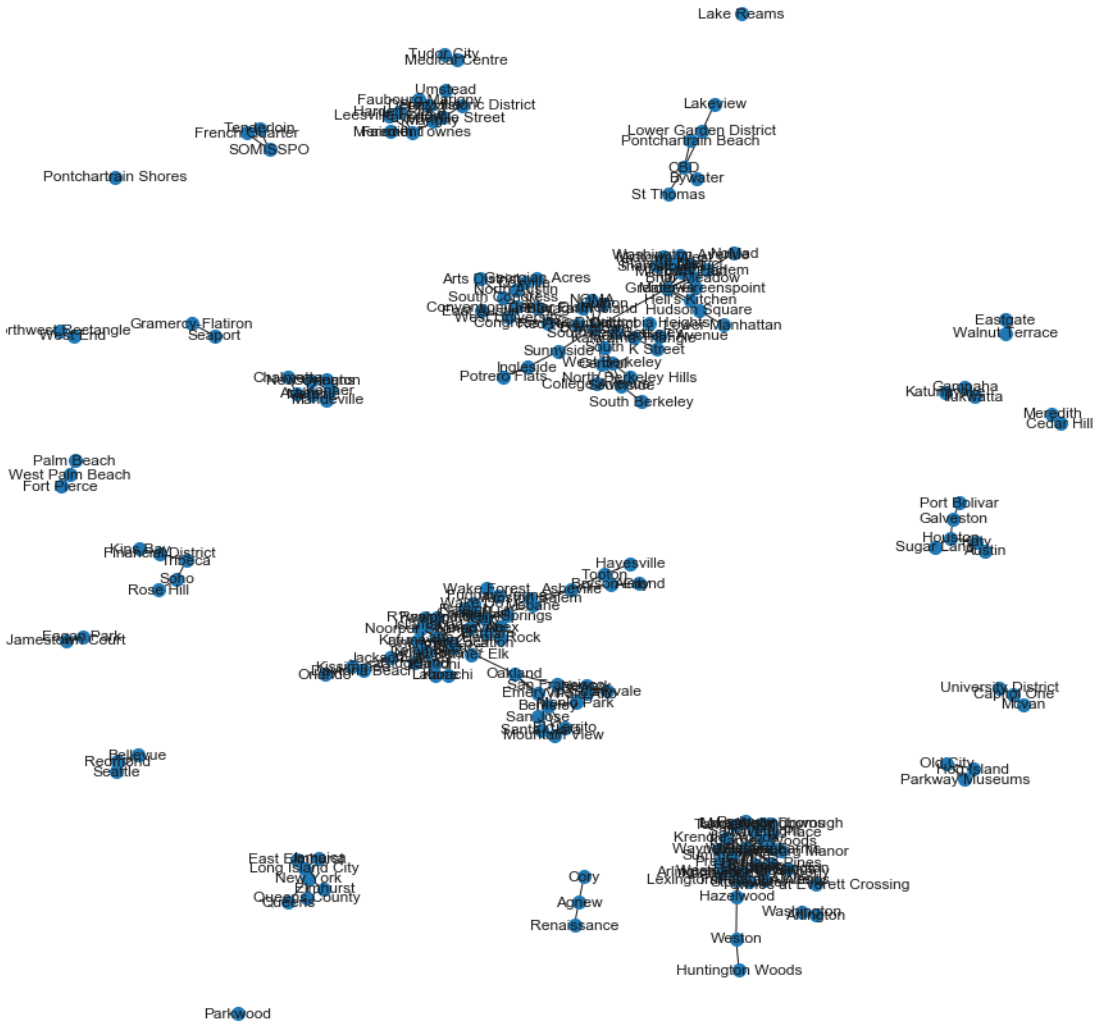
[68]: <pandas.io.formats.style.Styler at 0x1fbf74817b8>

6 Visalization of Network of Rides Based on Business Category Type

[75]:
```
g_business = nx.Graph()
g_business = nx.
 ↪from_pandas_edgelist(df[df['Category']=='Business'],source='Start',target='Stop')
```

[76]:
```
print (nx.info(g_business))
plt.figure(figsize=(12,12))
nx.draw_spring(g_business, with_labels=True, node_size=100)
plt.show()
```

```
Name:
Type: Graph
Number of nodes: 200
Number of edges: 262
Average degree:   2.6200
```



[77]:
```
degree_dict = dict(g_business.degree(g_business.nodes()))
sorted_degree = sorted(degree_dict.items(), key=itemgetter(1), reverse=True)

print("Top 20 nodes by degree:")

degree_dist = pd.DataFrame(sorted_degree, columns=['Location','Degree'])
degree_dist.sort_values(by='Degree',ascending=False).head(20).style.
 ↪background_gradient(cmap=cmap)
```

```
Top 20 nodes by degree:
```

[77]:
```
<pandas.io.formats.style.Styler at 0x1fbf93ed0b8>
```

[ ]:

[ ]:

[ ]: