ProjectNotebook

June 19, 2023

Importing All necessary Libraries

[1]:
```
import numpy as np
import networkx as nx
import matplotlib.pyplot as plt
```

1 Calculation of centralities

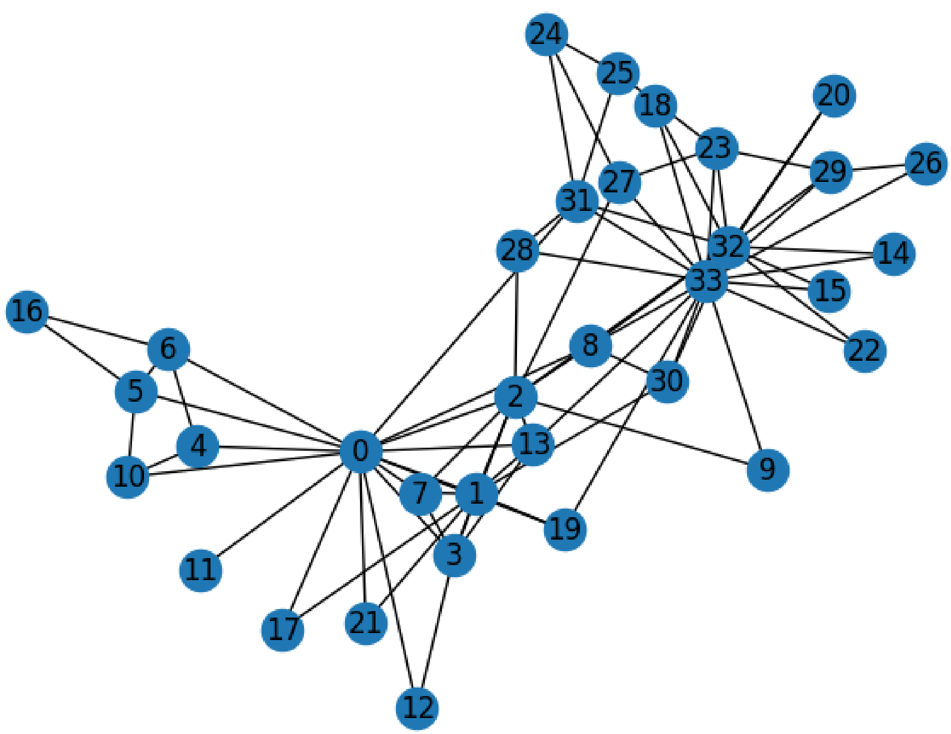
1.1 Calculation of Degree Centrality

1.1.1 Calculation of Degree Centrality using Linear Algebra

[2]:
```
def compute_degree_centrality(adj_matrix):
    num_nodes = adj_matrix.shape[0]

    degree_centrality = np.sum(adj_matrix, axis=1)

    normalization_factor = num_nodes - 1

    degree_centrality = degree_centrality.astype(float) / normalization_factor

    return dict(enumerate(degree_centrality))


G = nx.karate_club_graph()

weighted_adjacency_matrix = nx.to_numpy_array(G)

unweighted_adjacency_matrix = (weighted_adjacency_matrix > 0).astype(int)

print(f"No of Nodes in the Graph is {unweighted_adjacency_matrix.shape[0]}")
print("The Adjacency Matrix corresponding to the graph is:")
print(unweighted_adjacency_matrix)


print("The Graph is")
nx.draw(G,with_labels=True)
plt.show()
```

```python
degree_centrality_LA = compute_degree_centrality(unweighted_adjacency_matrix)

print("Degree Centrality using LA:")
print(degree_centrality_LA)
```

```
No of Nodes in the Graph is 34
The Adjacency Matrix corresponding to the graph is:
[[0 1 1 … 1 0 0]
 [1 0 1 … 0 0 0]
 [1 1 0 … 0 1 0]
 …
 [1 0 0 … 0 1 1]
 [0 0 1 … 1 0 1]
 [0 0 0 … 1 1 0]]
The Graph is
```




```
Degree Centrality using LA:
{0: 0.48484848484848486, 1: 0.2727272727272727, 2: 0.30303030303030304, 3:
0.18181818181818182, 4: 0.09090909090909091, 5: 0.12121212121212122, 6:
0.12121212121212122, 7: 0.12121212121212122, 8: 0.15151515151515152, 9:
```

```
0.06060606060606061, 10: 0.09090909090909091, 11: 0.030303030303030304, 12:
0.06060606060606061, 13: 0.15151515151515152, 14: 0.06060606060606061, 15:
0.06060606060606061, 16: 0.06060606060606061, 17: 0.06060606060606061, 18:
0.06060606060606061, 19: 0.09090909090909091, 20: 0.06060606060606061, 21:
0.06060606060606061, 22: 0.06060606060606061, 23: 0.15151515151515152, 24:
0.09090909090909091, 25: 0.09090909090909091, 26: 0.06060606060606061, 27:
0.12121212121212122, 28: 0.09090909090909091, 29: 0.12121212121212122, 30:
0.12121212121212122, 31: 0.18181818181818182, 32: 0.36363636363636365, 33:
0.5151515151515151}
```

1.1.2 Calculation of Degree Centrality Using In-Built Function

[3]:
```python
degree_centrality_inBuilt = nx.degree_centrality(G)
print("Degree Centrality InBuilt:")
print(degree_centrality_inBuilt)
```

```
Degree Centrality InBuilt:
{0: 0.48484848484848486, 1: 0.2727272727272727, 2: 0.30303030303030304, 3:
0.18181818181818182, 4: 0.09090909090909091, 5: 0.12121212121212122, 6:
0.12121212121212122, 7: 0.12121212121212122, 8: 0.15151515151515152, 9:
0.06060606060606061, 10: 0.09090909090909091, 11: 0.030303030303030304, 12:
0.06060606060606061, 13: 0.15151515151515152, 14: 0.06060606060606061, 15:
0.06060606060606061, 16: 0.06060606060606061, 17: 0.06060606060606061, 18:
0.06060606060606061, 19: 0.09090909090909091, 20: 0.06060606060606061, 21:
0.06060606060606061, 22: 0.06060606060606061, 23: 0.15151515151515152, 24:
0.09090909090909091, 25: 0.09090909090909091, 26: 0.06060606060606061, 27:
0.12121212121212122, 28: 0.09090909090909091, 29: 0.12121212121212122, 30:
0.12121212121212122, 31: 0.18181818181818182, 32: 0.36363636363636365, 33:
0.5151515151515151}
```

Function for comparison of two dictionaries based on some precision

[4]:
```python
def compare_dictionaries(dict1, dict2, precision):
    for key in dict1.keys():
        if key not in dict2:
            return False
        value1 = dict1[key]
        value2 = dict2[key]
        if (round(value1, precision) != round(value2, precision)):
            return False
    return True
```

1.1.3 Comparison of the Degree Centrality Obtained by calculation using Linear Algebra and using Inbuilt function of networkx

[5]:
```python
DecimalPlaces = 15
```

```
if␣
↪compare_dictionaries(degree_centrality_inBuilt,degree_centrality_LA,DecimalPlaces):
↪
    print("The both dictionaries are equal")
else:
    print("The both dictionaries are not equal")
```

```
The both dictionaries are equal
```

1.2 Calculation of Betweenness Centrality

1.2.1 Calculation of Betweenness Centrality using LA

[6]:
```
def compute_betweenness_centrality(graph):
    nodes = graph.nodes()
    betweenness_centrality = {node: 0.0 for node in nodes}

    for source in nodes:
        betweenness = {node: 0.0 for node in nodes}
        stack = []
        distance = {node: -1 for node in nodes}
        sigma = {node: 0 for node in nodes}
        distance[source] = 0
        sigma[source] = 1
        queue = [source]

        while queue:
            node = queue.pop(0)
            stack.append(node)

            for neighbor in graph.neighbors(node):
                if distance[neighbor] == -1:
                    queue.append(neighbor)
                    distance[neighbor] = distance[node] + 1

                if distance[neighbor] == distance[node] + 1:
                    sigma[neighbor] += sigma[node]

        dependency = {node: 0.0 for node in nodes}
        while stack:
            node = stack.pop()
            for predecessor in graph.neighbors(node):
                if distance[predecessor] == distance[node] - 1:
                    dependency[predecessor] += (1 + dependency[node]) *␣
↪sigma[predecessor] / sigma[node]

            if node != source:
                betweenness[node] += dependency[node]
```

```
        for node in nodes:
            if node != source:
                betweenness_centrality[node] += betweenness[node]

    num_nodes = len(nodes)
    normalization_factor = ((num_nodes - 1) * (num_nodes - 2))

    for node in nodes:
        betweenness_centrality[node] /= normalization_factor

    return betweenness_centrality


G = nx.karate_club_graph()

weighted_adjacency_matrix = nx.to_numpy_array(G)

print(f"The Weighted Adjacency matrix is\n{weighted_adjacency_matrix}")

betweenness_centrality_LA = compute_betweenness_centrality(G)

print("Betweenness Centrality computed using brandes algorithm")
print(betweenness_centrality_LA)
```

```
The Weighted Adjacency matrix is
[[0. 4. 5. … 2. 0. 0.]
 [4. 0. 6. … 0. 0. 0.]
 [5. 6. 0. … 0. 2. 0.]
 …
 [2. 0. 0. … 0. 4. 4.]
 [0. 0. 2. … 4. 0. 5.]
 [0. 0. 0. … 4. 5. 0.]]
Betweenness Centrality computed using brandes algorithm
{0: 0.43763528138528146, 1: 0.053936688311688304, 2: 0.14365680615680618, 3:
0.011909271284271283, 4: 0.0006313131313131313, 5: 0.02998737373737374, 6:
0.029987373737373736, 7: 0.0, 8: 0.055926827801827804, 9: 0.0008477633477633478,
10: 0.0006313131313131313, 11: 0.0, 12: 0.0, 13: 0.04586339586339586, 14: 0.0,
15: 0.0, 16: 0.0, 17: 0.0, 18: 0.0, 19: 0.0324750481000481, 20: 0.0, 21: 0.0,
22: 0.0, 23: 0.017613636363636363, 24: 0.0022095959595959595, 25:
0.0038404882154882154, 26: 0.0, 27: 0.022333453583453577, 28:
0.0017947330447330447, 29: 0.0029220779220779218, 30: 0.014411976911976912, 31:
0.13827561327561322, 32: 0.14524711399711399, 33: 0.30407497594997559}
```

1.2.2 Calculation of Betweenness Centrality using In-Built function

[7]:
```
betweenness_centrality_inBuilt= nx.betweenness_centrality(G)
print("Betweenness Centrality computed using inBuilt function of networkx:")
print(betweenness_centrality_inBuilt)
```

```
Betweenness Centrality computed using inBuilt function of networkx:
{0: 0.43763528138528146, 1: 0.053936688311688304, 2: 0.14365680615680618, 3:
0.011909271284271283, 4: 0.0006313131313131313, 5: 0.02998737373737374, 6:
0.029987373737373736, 7: 0.0, 8: 0.05592682780182781, 9: 0.0008477633477633478,
10: 0.0006313131313131313, 11: 0.0, 12: 0.0, 13: 0.04586339586339586, 14: 0.0,
15: 0.0, 16: 0.0, 17: 0.0, 18: 0.0, 19: 0.03247504810004811, 20: 0.0, 21: 0.0,
22: 0.0, 23: 0.017613636363636363, 24: 0.0022095959595959595, 25:
0.0038404882154882154, 26: 0.0, 27: 0.02233345358345358, 28:
0.0017947330447330447, 29: 0.0029220779220779218, 30: 0.014411976911976909, 31:
0.13827561327561325, 32: 0.145247113997114, 33: 0.30407497594997596}
```

1.2.3 Comparison of the Betweenness Centrality Obtained by calculation using Linear Algebra and using Inbuilt function of networkx

[8]:
```
if␣
↪compare_dictionaries(betweenness_centrality_LA,betweenness_centrality_inBuilt,DecimalPlaces
↪
    print("Both the dictionaries are equal")
else:
    print("Both the dictionaries are not equal")
```

```
Both the dictionaries are equal
```

1.3 Calculation of Closeness Centrality

1.3.1 Calculation of Closeness Centrality using LA

[9]:
```
def compute_closeness_centrality(graph):
    num_nodes = graph.number_of_nodes()

    closeness_scores = {}

    for node in graph.nodes():
        shortest_paths = nx.shortest_path_length(graph, source=node)

        total_distance = sum(shortest_paths.values())

        closeness_centrality = (num_nodes - 1) / total_distance

        closeness_scores[node] = closeness_centrality

    return closeness_scores
```

```
closeness_centrality_LA = compute_closeness_centrality(G)


print("Closeness Centrality computed using LA:")
print(closeness_centrality_LA)
```

```
Closeness Centrality computed using LA:
{0: 0.5689655172413793, 1: 0.4852941176470588, 2: 0.559322033898305, 3:
0.4647887323943662, 4: 0.3793103448275862, 5: 0.38372093023255816, 6:
0.38372093023255816, 7: 0.44, 8: 0.515625, 9: 0.4342105263157895, 10:
0.3793103448275862, 11: 0.36666666666666664, 12: 0.3707865168539326, 13:
0.515625, 14: 0.3707865168539326, 15: 0.3707865168539326, 16:
0.28448275862068967, 17: 0.375, 18: 0.3707865168539326, 19: 0.5, 20:
0.3707865168539326, 21: 0.375, 22: 0.3707865168539326, 23: 0.39285714285714285,
24: 0.375, 25: 0.375, 26: 0.3626373626373626, 27: 0.4583333333333333, 28:
0.4520547945205479, 29: 0.38372093023255816, 30: 0.4583333333333333, 31:
0.5409836065573771, 32: 0.515625, 33: 0.55}
```

1.3.2 Calculation of Closeness Centrality using In-Built function

[10]:
```
closeness_centrality_inBuilt = nx.closeness_centrality(G)
print("Closeness Centrality using InBuilt function:")
print(closeness_centrality_inBuilt)
```

```
Closeness Centrality using InBuilt function:
{0: 0.5689655172413793, 1: 0.4852941176470588, 2: 0.559322033898305, 3:
0.4647887323943662, 4: 0.3793103448275862, 5: 0.38372093023255816, 6:
0.38372093023255816, 7: 0.44, 8: 0.515625, 9: 0.4342105263157895, 10:
0.3793103448275862, 11: 0.36666666666666664, 12: 0.3707865168539326, 13:
0.515625, 14: 0.3707865168539326, 15: 0.3707865168539326, 16:
0.28448275862068967, 17: 0.375, 18: 0.3707865168539326, 19: 0.5, 20:
0.3707865168539326, 21: 0.375, 22: 0.3707865168539326, 23: 0.39285714285714285,
24: 0.375, 25: 0.375, 26: 0.3626373626373626, 27: 0.4583333333333333, 28:
0.4520547945205479, 29: 0.38372093023255816, 30: 0.4583333333333333, 31:
0.5409836065573771, 32: 0.515625, 33: 0.55}
```

1.3.3 Comparison of the Closeness Centrality Obtained by calculation using Linear Algebra and using Inbuilt function of networkx

[11]:
```
if compare_dictionaries(closeness_centrality_LA ,closeness_centrality_inBuilt,␣
 ↪DecimalPlaces):
    print("Both the dictionaries are equal")
else:
    print("Both the dictionaries are not equal")
```

```
Both the dictionaries are equal
```

1.4 Calculation of EigenVector Centrality

1.4.1 Calculation of Eigenvector Centrality using LA

[12]:
```
def eigenvector_centrality(adjacency_matrix, max_iterations=1000):
    A = np.array(adjacency_matrix)
    arr = np.ones(adjacency_matrix.shape[0])
    arr = arr.T
    for i in range(max_iterations):
        arr = A @ arr
        arr = arr/np.linalg.norm(arr)

    centrality_scores = dict(enumerate(arr))
    return centrality_scores


G = nx.karate_club_graph()

weighted_adjacency_matrix = nx.to_numpy_array(G)

unweighted_adjacency_matrix = (weighted_adjacency_matrix > 0).astype(int)

eigenvector_centrality_LA = eigenvector_centrality(unweighted_adjacency_matrix)
print("Eigenvector Centrality Computed Using LA:")
print(eigenvector_centrality_LA)
```

```
Eigenvector Centrality Computed Using LA:
{0: 0.35549144452456655, 1: 0.26595991955249165, 2: 0.31719250448643155, 3:
0.21117972037789023, 4: 0.07596881818306894, 5: 0.07948304511709947, 6:
0.07948304511709947, 7: 0.17095974804479633, 8: 0.22740390712540018, 9:
0.10267425072358623, 10: 0.07596881818306894, 11: 0.05285569749352132, 12:
0.08425462871671373, 13: 0.22647272014248127, 14: 0.10140326218952461, 15:
0.10140326218952461, 16: 0.023635628104591376, 17: 0.09239953819570258, 18:
0.10140326218952461, 19: 0.1479125102933875, 20: 0.10140326218952461, 21:
0.09239953819570258, 22: 0.10140326218952461, 23: 0.15011857186115288, 24:
0.05705244054116565, 25: 0.05920647491677849, 26: 0.07557941348827213, 27:
0.13347715338024013, 28: 0.13107782298371085, 29: 0.13496081926232786, 30:
0.17475830231435285, 31: 0.19103384140654378, 32: 0.30864421979104717, 33:
0.37336347029148315}
```

1.4.2 Calculation of Eigenvector Centrality using In-Built function

[13]:
```
eigenvector_centrality_inBuilt = nx.eigenvector_centrality(G)
print("Eigenvector Centrality using InBuilt function:")
print(eigenvector_centrality_inBuilt)
```

```
Eigenvector Centrality using InBuilt function:
{0: 0.35548349418519426, 1: 0.2659538704545024, 2: 0.3171893899684447, 3:
0.21117407832057056, 4: 0.0759664588165738, 5: 0.07948057788594245, 6:
```

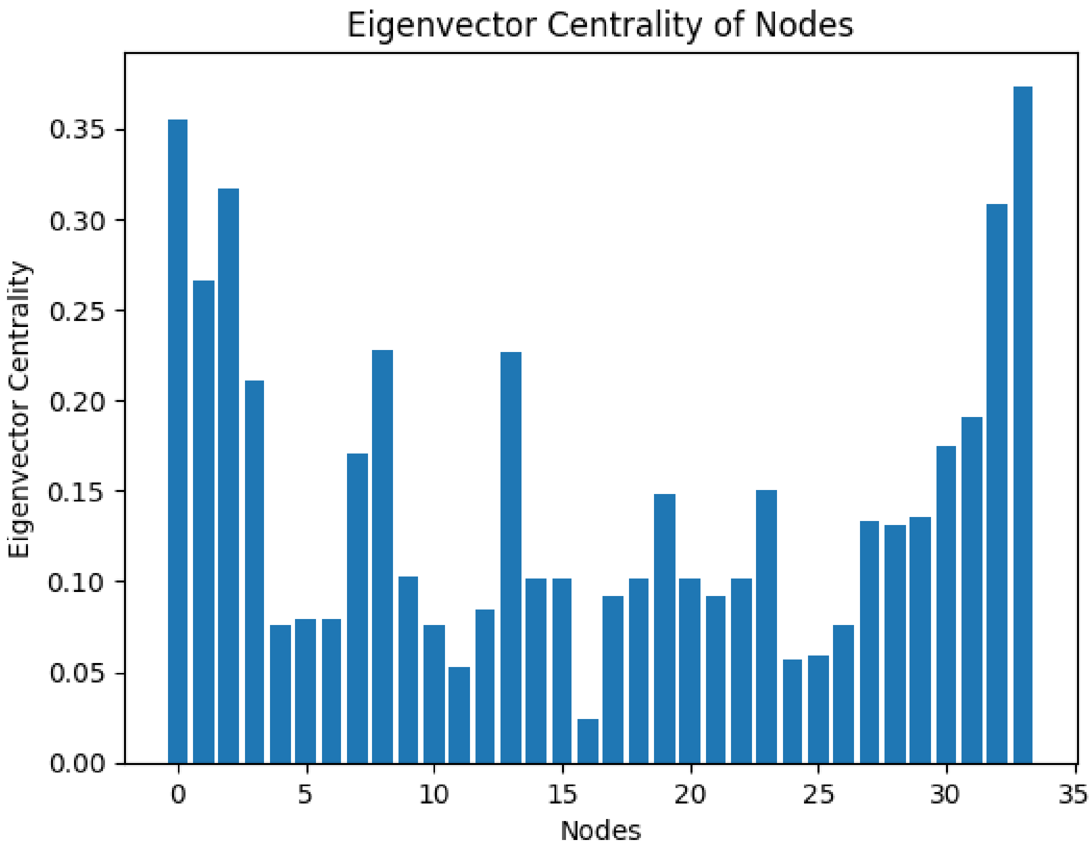
```
0.07948057788594245, 7: 0.1709551149803543, 8: 0.22740509147166046, 9:
0.10267519030637756, 10: 0.0759664588165738, 11: 0.05285416945233646, 12:
0.08425192086558085, 13: 0.22646969838808145, 14: 0.10140627846270832, 15:
0.10140627846270832, 16: 0.02363479426059687, 17: 0.0923967566684595, 18:
0.10140627846270832, 19: 0.14791134007618667, 20: 0.10140627846270832, 21:
0.0923967566684595, 22: 0.10140627846270832, 23: 0.15012328691726787, 24:
0.057053735638028055, 25: 0.0592082025027901, 26: 0.07558192219009324, 27:
0.13347932684333308, 28: 0.13107925627221215, 29: 0.13496528673866567, 30:
0.17476027834493088, 31: 0.191036269797917, 32: 0.3086510477336959, 33:
0.37337121301323506}
```

1.4.3 Comparison of the Eigenvector Centrality Obtained by calculation using Linear Algebra and using Inbuilt function of networkx

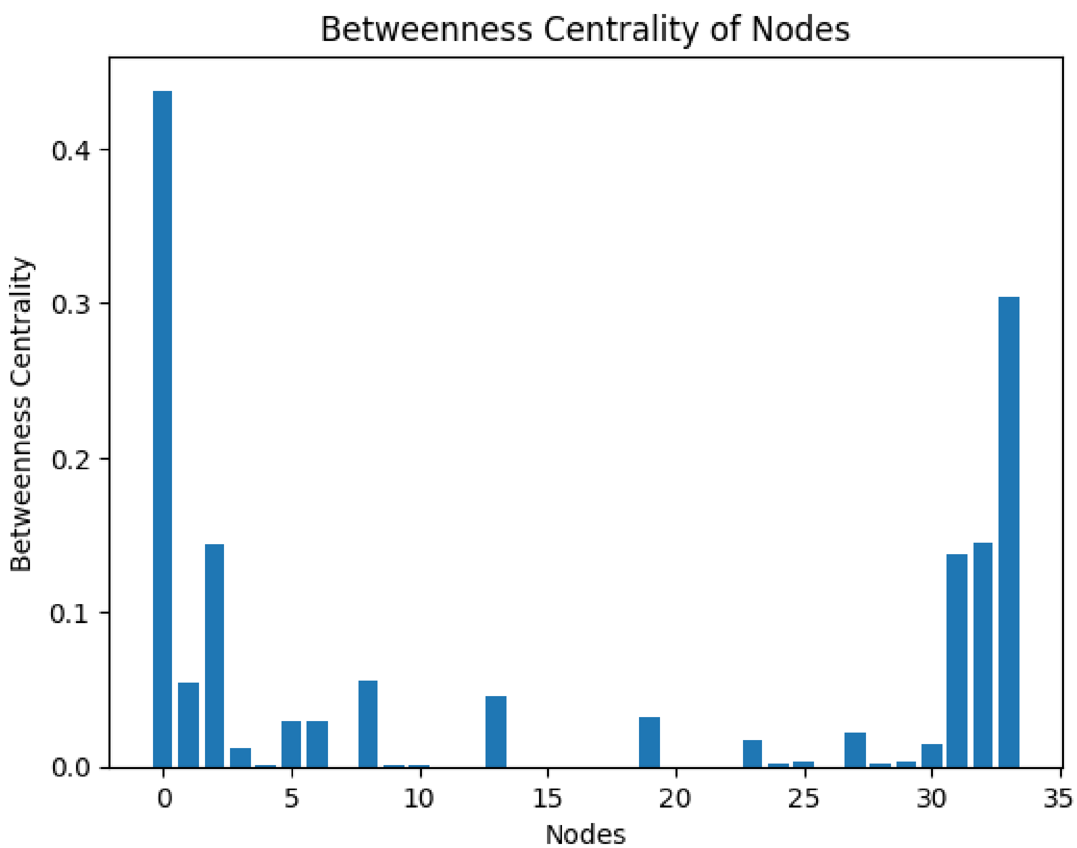
[14]:
```
if compare_dictionaries(eigenvector_centrality_inBuilt␣
 ↪,eigenvector_centrality_inBuilt, 4):
    print("Both the dictionaries are equal")
else:
    print("Both the dictionaries are not equal")
```

```
Both the dictionaries are equal
```

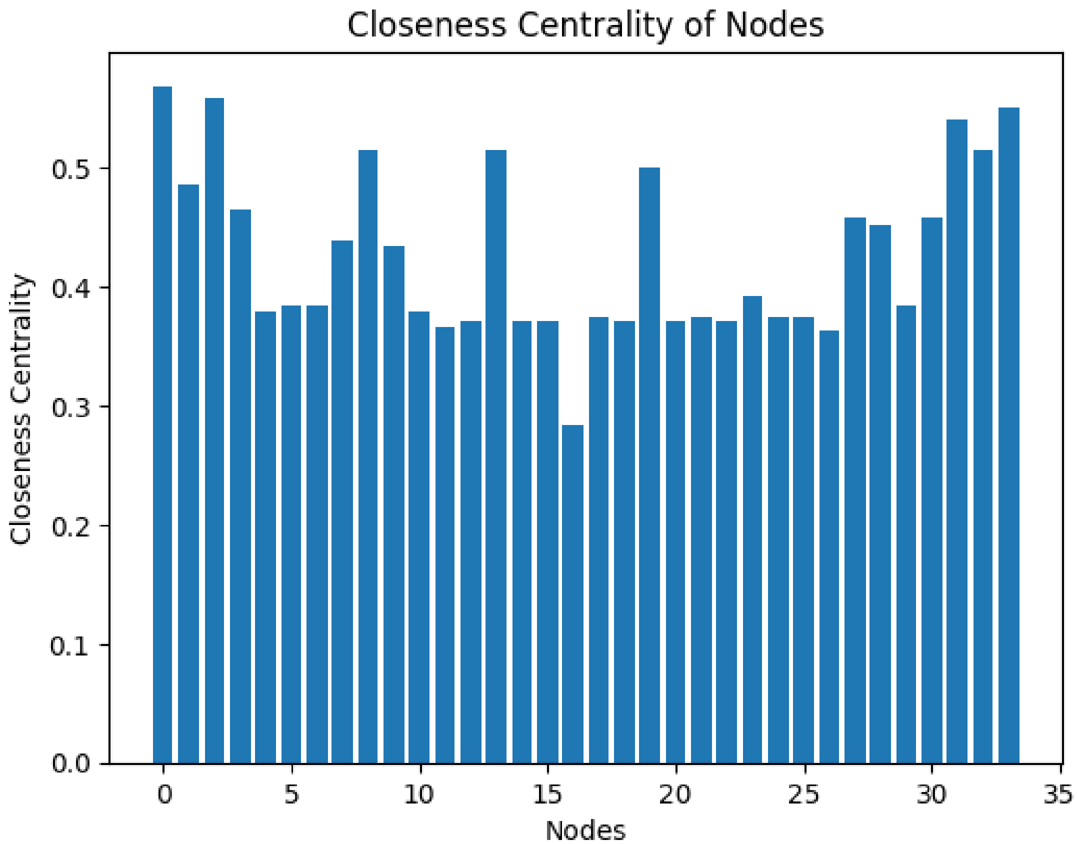
[23]:
```
x = eigenvector_centrality_inBuilt.keys()
y = eigenvector_centrality_inBuilt.values()

plt.bar(x,y)
plt.title("Eigenvector Centrality of Nodes")
plt.xlabel("Nodes")
plt.ylabel("Eigenvector Centrality")
plt.show()
```



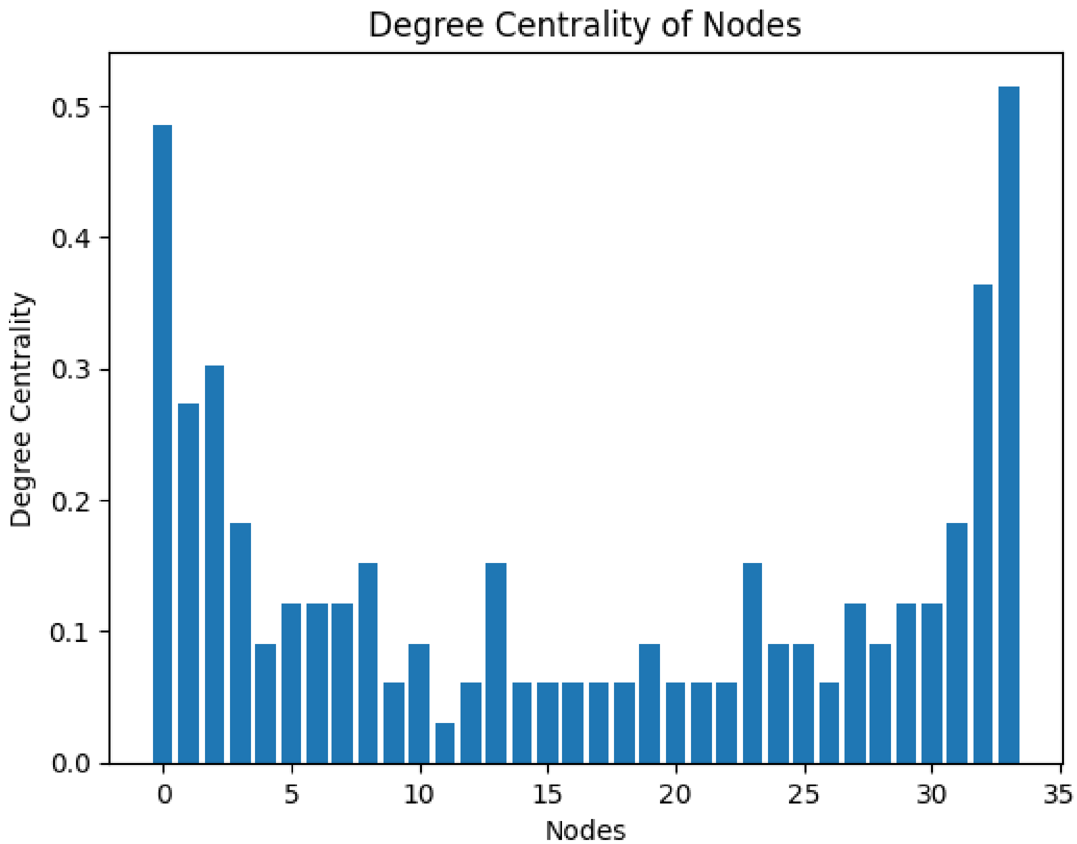
[24]:
```
x = betweenness_centrality_inBuilt.keys()
y = betweenness_centrality_inBuilt.values()

plt.bar(x,y)
plt.title("Betweenness Centrality of Nodes")
plt.xlabel("Nodes")
plt.ylabel("Betweenness Centrality")
plt.show()
```



[25]:
```
x = closeness_centrality_inBuilt.keys()
y = closeness_centrality_inBuilt.values()

plt.bar(x,y)
plt.title("Closeness Centrality of Nodes")
plt.xlabel("Nodes")
plt.ylabel("Closeness Centrality")
plt.show()
```



[26]:
```
x = degree_centrality_inBuilt.keys()
y = degree_centrality_inBuilt.values()

plt.bar(x,y)
plt.title("Degree Centrality of Nodes")
plt.xlabel("Nodes")
plt.ylabel("Degree Centrality")
plt.show()
```



2 Finding All Centralities of Facebook Data

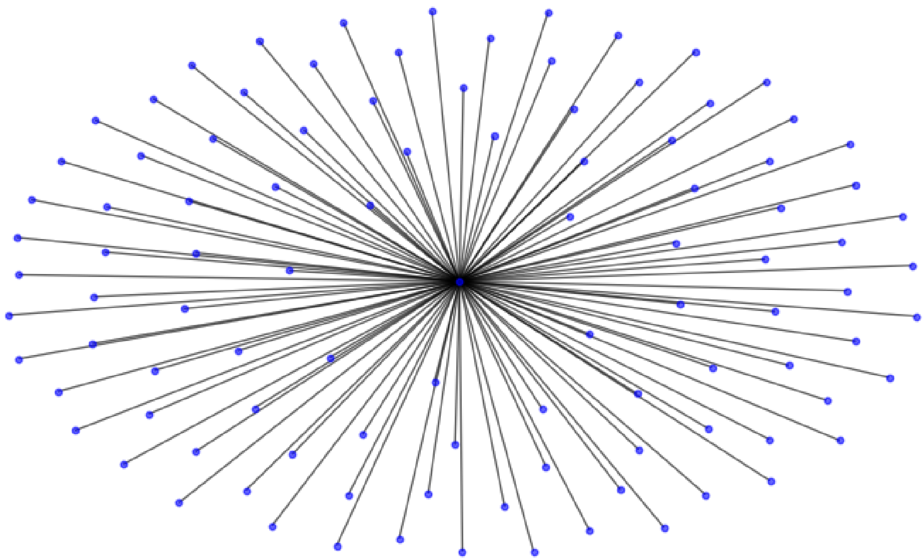
2.1 Taking 100 Edges

[15]:
```
G = nx.Graph()

NumberofNodes = 100

with open("data.txt","r") as f:
    for i in range(NumberofNodes):
        data = f.readline()
        node1,node2 = data.strip().split(' ')
        G.add_edge(node1,node2)



degree_centrality = nx.degree_centrality(G)
betweenness_centrality = nx.betweenness_centrality(G)
closeness_centrality = nx.closeness_centrality(G)
```

```
eigenvector_centrality = nx.eigenvector_centrality(G)

max_degree_centrality = max(degree_centrality,key=degree_centrality.get)
max_betweenness_centrality =␣
 ↪max(betweenness_centrality,key=betweenness_centrality.get)
max_closeness_centrality = max(closeness_centrality,key=closeness_centrality.
 ↪get)
max_eigenvector_centrality =␣
 ↪max(eigenvector_centrality,key=eigenvector_centrality.get)


print(f"Max Degree Centrality Node:{max_degree_centrality} and It's Centrality:
 ↪{degree_centrality[max_degree_centrality]}")
print(f"Max Betweenness Centrality Node:{max_betweenness_centrality} and It's␣
 ↪Centrality:{betweenness_centrality[max_betweenness_centrality]}")
print(f"Max Closeness Centrality Node:{max_closeness_centrality} and It's␣
 ↪Centrality:{closeness_centrality[max_closeness_centrality]}")
print(f"Max Eigenvector Centrality Node:{max_eigenvector_centrality} and It's␣
 ↪Centrality:{eigenvector_centrality[max_eigenvector_centrality]}")
print()


import matplotlib.pyplot as plt
plt.figure(figsize=(10, 6))
pos = nx.spring_layout(G, seed=42)
nx.draw_networkx(G, pos, with_labels=False, node_size=10, node_color='blue',␣
 ↪alpha=0.6)
plt.title("Facebook Social Circles Graph")
plt.axis("off")
plt.show()
```

```
Max Degree Centrality Node:0 and It's Centrality:1.0
Max Betweenness Centrality Node:0 and It's Centrality:1.0
Max Closeness Centrality Node:0 and It's Centrality:1.0
Max Eigenvector Centrality Node:0 and It's Centrality:0.7071033667005829
```

Facebook Social Circles Graph

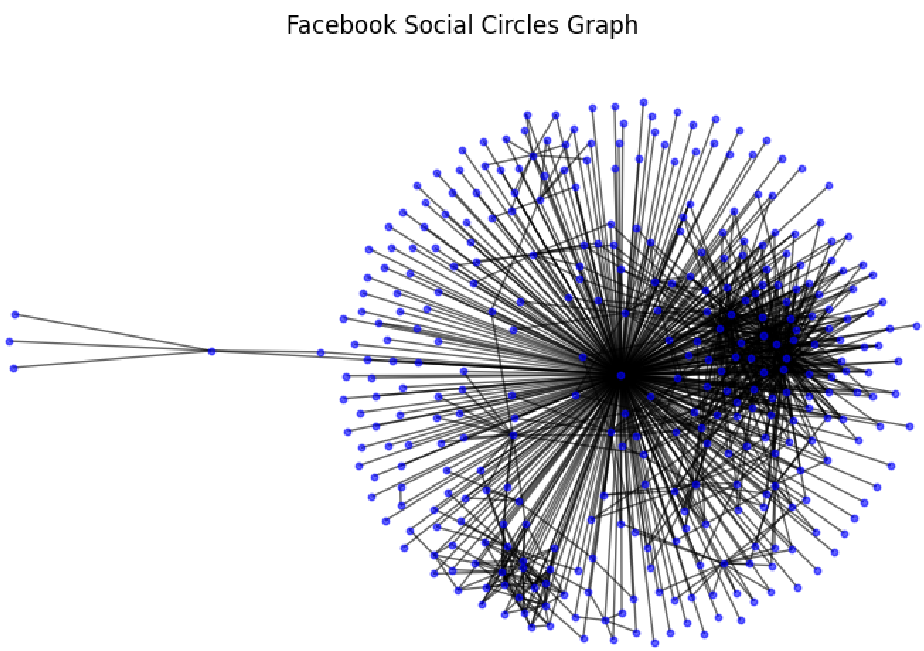


2.2 Taking 1000 Edges

[16]:
```
G = nx.Graph()

NumberofNodes = 1000

with open("data.txt","r") as f:
    for i in range(NumberofNodes):
        data = f.readline()
        node1,node2 = data.strip().split(' ')
        G.add_edge(node1,node2)




degree_centrality = nx.degree_centrality(G)
betweenness_centrality = nx.betweenness_centrality(G)
closeness_centrality = nx.closeness_centrality(G)
eigenvector_centrality = nx.eigenvector_centrality(G)

max_degree_centrality = max(degree_centrality,key=degree_centrality.get)
max_betweenness_centrality =␣
 ↪max(betweenness_centrality,key=betweenness_centrality.get)
max_closeness_centrality = max(closeness_centrality,key=closeness_centrality.
 ↪get)
```

```
max_eigenvector_centrality = 
 ↪max(eigenvector_centrality,key=eigenvector_centrality.get)


print(f"Max Degree Centrality Node:{max_degree_centrality} and It's Centrality:
 ↪{degree_centrality[max_degree_centrality]}")
print(f"Max Betweenness Centrality Node:{max_betweenness_centrality} and It's 
 ↪Centrality:{betweenness_centrality[max_betweenness_centrality]}")
print(f"Max Closeness Centrality Node:{max_closeness_centrality} and It's 
 ↪Centrality:{closeness_centrality[max_closeness_centrality]}")
print(f"Max Eigenvector Centrality Node:{max_eigenvector_centrality} and It's 
 ↪Centrality:{eigenvector_centrality[max_eigenvector_centrality]}")
print()


import matplotlib.pyplot as plt
plt.figure(figsize=(10, 6))
pos = nx.spring_layout(G, seed=42)
nx.draw_networkx(G, pos, with_labels=False, node_size=10, node_color='blue', 
 ↪alpha=0.6)
plt.title("Facebook Social Circles Graph")
plt.axis("off")
plt.show()
```

```
Max Degree Centrality Node:0 and It's Centrality:0.9914285714285714
Max Betweenness Centrality Node:0 and It's Centrality:0.927374266793833
Max Closeness Centrality Node:0 and It's Centrality:0.9915014164305949
Max Eigenvector Centrality Node:0 and It's Centrality:0.559416676755645
```

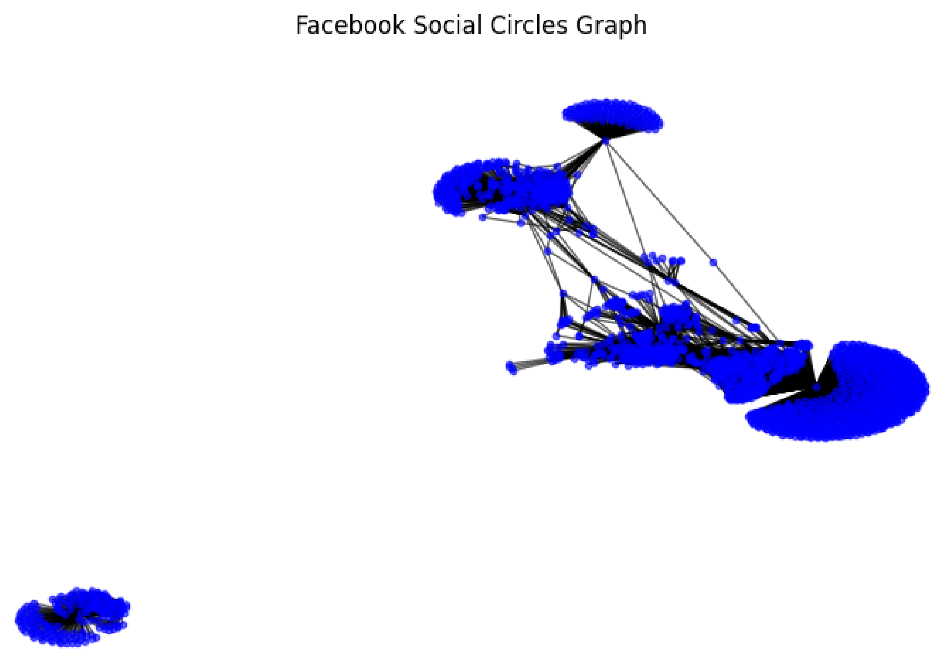


2.3 Taking 10000 Edges

[17]:
```
G = nx.Graph()

NumberofNodes = 10000

with open("data.txt","r") as f:
    for i in range(NumberofNodes):
        data = f.readline()
        node1,node2 = data.strip().split(' ')
        G.add_edge(node1,node2)



degree_centrality = nx.degree_centrality(G)
betweenness_centrality = nx.betweenness_centrality(G)
closeness_centrality = nx.closeness_centrality(G)
eigenvector_centrality = nx.eigenvector_centrality(G)

max_degree_centrality = max(degree_centrality,key=degree_centrality.get)
max_betweenness_centrality =␣
 ↪max(betweenness_centrality,key=betweenness_centrality.get)
max_closeness_centrality = max(closeness_centrality,key=closeness_centrality.
 ↪get)
```

```
max_eigenvector_centrality = 
  ↪max(eigenvector_centrality,key=eigenvector_centrality.get)


print(f"Max Degree Centrality Node:{max_degree_centrality} and It's Centrality:
  ↪{degree_centrality[max_degree_centrality]}")
print(f"Max Betweenness Centrality Node:{max_betweenness_centrality} and It's 
  ↪Centrality:{betweenness_centrality[max_betweenness_centrality]}")
print(f"Max Closeness Centrality Node:{max_closeness_centrality} and It's 
  ↪Centrality:{closeness_centrality[max_closeness_centrality]}")
print(f"Max Eigenvector Centrality Node:{max_eigenvector_centrality} and It's 
  ↪Centrality:{eigenvector_centrality[max_eigenvector_centrality]}")
print()


import matplotlib.pyplot as plt
plt.figure(figsize=(10, 6))
pos = nx.spring_layout(G, seed=42)
nx.draw_networkx(G, pos, with_labels=False, node_size=10, node_color='blue', 
  ↪alpha=0.6)
plt.title("Facebook Social Circles Graph")
plt.axis("off")
plt.show()
```

```
Max Degree Centrality Node:107 and It's Centrality:0.5222388805597201
Max Betweenness Centrality Node:107 and It's Centrality:0.6663327965109708
Max Closeness Centrality Node:107 and It's Centrality:0.6121482053413674
Max Eigenvector Centrality Node:348 and It's Centrality:0.1837055147302193
```



2.4 Taking all Edges

[18]:
```
G = nx.Graph()

NumberofNodes = 88234

with open("data.txt","r") as f:
    for i in range(NumberofNodes):
        data = f.readline()
        node1,node2 = data.strip().split(' ')
        G.add_edge(node1,node2)


degree_centrality = nx.degree_centrality(G)
betweenness_centrality = nx.betweenness_centrality(G)
closeness_centrality = nx.closeness_centrality(G)
eigenvector_centrality = nx.eigenvector_centrality(G)

max_degree_centrality = max(degree_centrality,key=degree_centrality.get)
max_betweenness_centrality =␣
 ↪max(betweenness_centrality,key=betweenness_centrality.get)
max_closeness_centrality = max(closeness_centrality,key=closeness_centrality.
 ↪get)
```

```
max_eigenvector_centrality = max(eigenvector_centrality,key=eigenvector_centrality.get)


print(f"Max Degree Centrality Node:{max_degree_centrality} and It's Centrality:{degree_centrality[max_degree_centrality]}")
print(f"Max Betweenness Centrality Node:{max_betweenness_centrality} and It's Centrality:{betweenness_centrality[max_betweenness_centrality]}")
print(f"Max Closeness Centrality Node:{max_closeness_centrality} and It's Centrality:{closeness_centrality[max_closeness_centrality]}")
print(f"Max Eigenvector Centrality Node:{max_eigenvector_centrality} and It's Centrality:{eigenvector_centrality[max_eigenvector_centrality]}")
print()

import matplotlib.pyplot as plt
plt.figure(figsize=(10, 6))
pos = nx.spring_layout(G, seed=42)
nx.draw_networkx(G, pos, with_labels=False, node_size=10, node_color='blue', alpha=0.6)
plt.title("Facebook Social Circles Graph")
plt.axis("off")
plt.show()
```

```
Max Degree Centrality Node:107 and It's Centrality:0.258791480931154
Max Betweenness Centrality Node:107 and It's Centrality:0.4805180785560152
Max Closeness Centrality Node:107 and It's Centrality:0.45969945355191255
Max Eigenvector Centrality Node:1912 and It's Centrality:0.09540696149067629
```

Facebook Social Circles Graph