4. Page Ranking Algorithm

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```
In [1]: import pandas as pd
        import matplotlib.pyplot as plt
        %matplotlib inline
        import seaborn as sb
        import networkx as nx
```

```
/anaconda3/lib/python3.6/importlib/_bootstrap.py:219: RuntimeWarning: numpy.dtype size changed
  return f(*args, **kwds)
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/anaconda3/lib/python3.6/importlib/_bootstrap.py:219: RuntimeWarning: numpy.dtype size changed
  return f(*args, **kwds)
```
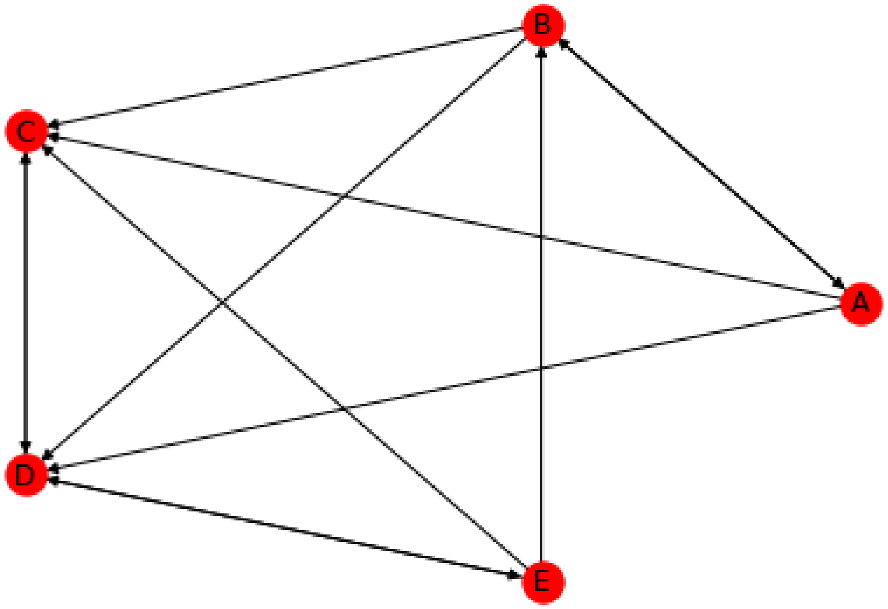

```
In [2]: # Defining the outlink matrix for given question

        matrix = [[0,1,1,1,0],
                  [1,0,1,1,0],
                  [0,0,0,1,0],
                  [0,0,1,0,1],
                  [0,1,1,1,0]]

        nnodes = len(matrix)

        # Returns the inlinks of a node
        def getInlinks(node):
            return [row for row in range(nnodes) if matrix[row][node]==1]

        # Returns the outlinks of a node
        def getOutlinks(node):
            return [i for i in range(nnodes) if matrix[node][i]==1 ]

        # Returns the weightin(v, u)
        def getWeightIn(v, u):
            rv = getInlinks(v)
            ip = [len(getInlinks(p)) for p in rv]
            win = len(getInlinks(u))/sum(ip)
            return win

        # Returns the weightout(v, u)
        def getWeightOut(v, u):
            rv = getInlinks(v)
            ip = [len(getOutlinks(p)) for p in rv]
            wout = len(getOutlinks(u))/sum(ip)
            return wout

        # Returns the page ranks over n iterations
        def pageRank(d, n):
            mat = []
            pr = [1 for i in range(nnodes)]
            for _ in range(n):
                mat.append(pr)
                prtemp = [0 for i in range(nnodes)]
                for u in range(nnodes):
                    summation = 0
                    for v in getInlinks(u):
                        summation += pr[v] / len(getOutlinks(v))
                    prtemp[u] = (1-d) + d*summation
                    prtemp[u] = round(prtemp[u],5)
                pr = prtemp
            df = pd.DataFrame(mat, columns=['A', 'B', 'C', 'D', 'E'])
            return df

        # Returns the weighted page ranks over n iterations
        def weightedPR(d, n):
            mat = []
            pr = [1 for i in range(nnodes)]
            for _ in range(n):
                mat.append(pr)
                prtemp = [0 for i in range(nnodes)]
                for u in range(nnodes):
                    summation = 0
                    for v in getInlinks(u):
                        summation += pr[v] * getWeightIn(v, u) * getWeightOut(v,u)
                    prtemp[u] = (1-d) + d*summation
                    prtemp[u] = round(prtemp[u],5)
                pr = prtemp
            df = pd.DataFrame(mat, columns=['A', 'B', 'C', 'D', 'E'])
            return df
```

```
In [16]: #Plotting the network graph for pages
```

```
G = nx.DiGraph()
nodes = ['A', 'B', 'C', 'D', 'E']
G.add_nodes_from(nodes)
for i in range(nnodes):
    for j in range(nnodes):
        if matrix[i][j]==1:
            G.add_edge(nodes[i], nodes[j])
nx.draw_shell(G, with_labels=True, arrows=True)
```



```
In [3]: # Results of normal page rank algorithm
        print('Normal page rank')
        npr = pageRank(0.5, 10)
        npr.head(10)
```

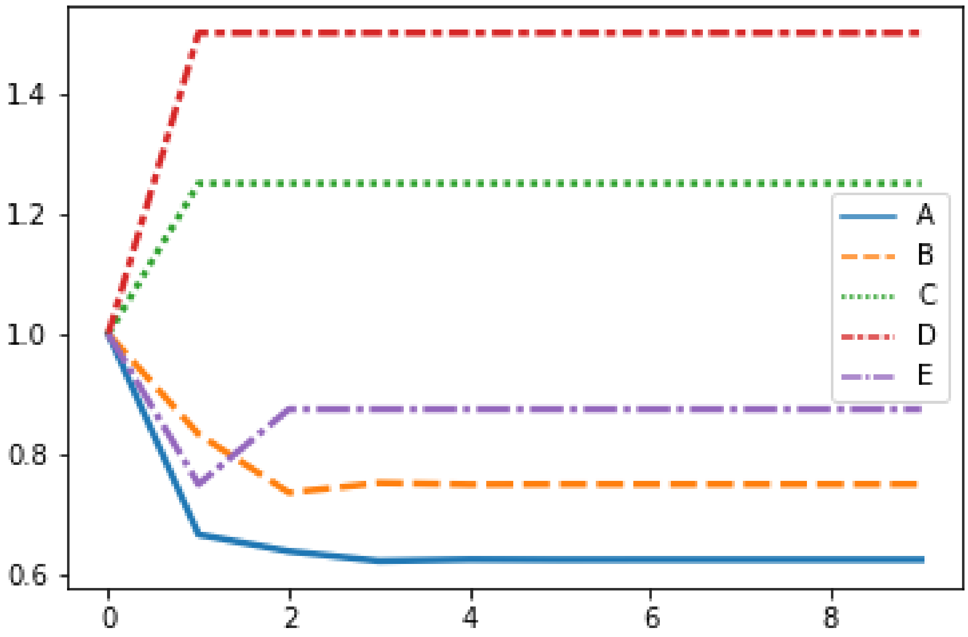
```
Normal page rank
```

```
Out[3]:          A        B     C    D      E
        0  1.00000  1.00000  1.00  1.0  1.000
        1  0.66667  0.83333  1.25  1.5  0.750
        2  0.63889  0.73611  1.25  1.5  0.875
        3  0.62269  0.75232  1.25  1.5  0.875
        4  0.62539  0.74962  1.25  1.5  0.875
```

```
5  0.62494  0.75006  1.25  1.5  0.875
6  0.62501  0.74999  1.25  1.5  0.875
7  0.62500  0.75000  1.25  1.5  0.875
8  0.62500  0.75000  1.25  1.5  0.875
9  0.62500  0.75000  1.25  1.5  0.875
```

```
In [4]: # Plot of normal page ranks across iterations
        sb.lineplot(data=npr, linewidth=2.5)
```

```
Out[4]: <matplotlib.axes._subplots.AxesSubplot at 0x1a1b859748>
```



```
In [5]: # Results of weighted page rank algorithm
        print('Weighted page rank')
        wpr = weightedPR(0.5, 10)
        wpr.head(10)
```

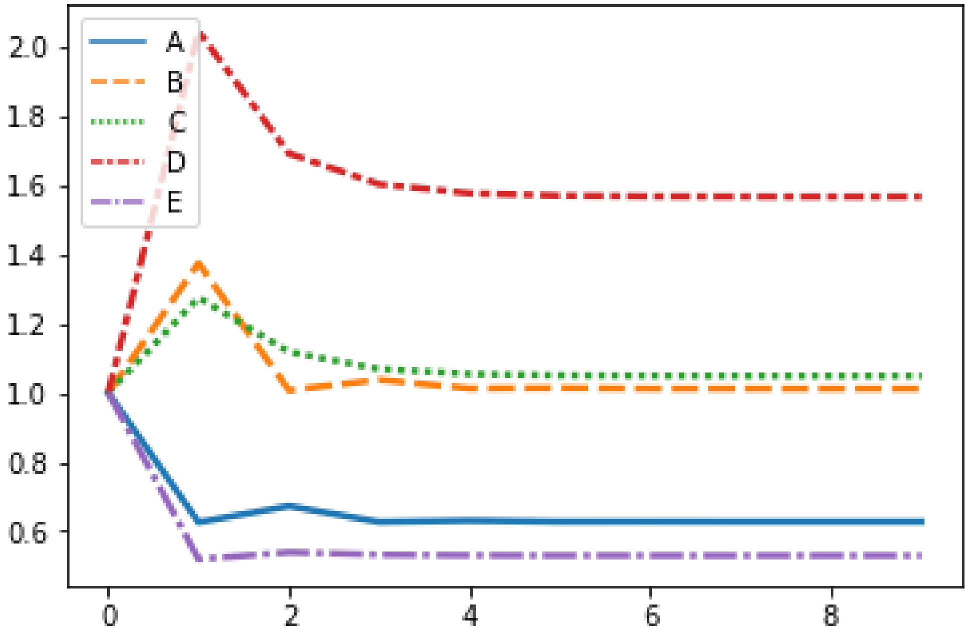
```
Weighted page rank
```

```
Out[5]:        A        B        C        D        E
        0  1.00000  1.00000  1.00000  1.00000  1.00000
        1  0.62500  1.37500  1.27500  2.04545  0.51875
        2  0.67188  1.00703  1.11832  1.69233  0.53835
        3  0.62588  1.03782  1.06869  1.60360  0.53173
        4  0.62973  1.01234  1.05462  1.57764  0.53007
        5  0.62654  1.01364  1.05059  1.57024  0.52958
```

```
6  0.62671  1.01186  1.04944  1.56812  0.52944
7  0.62648  1.01189  1.04911  1.56752  0.52940
8  0.62649  1.01177  1.04901  1.56734  0.52939
9  0.62647  1.01177  1.04899  1.56729  0.52939
```

```
In [6]: # Plot of weighted page ranks across iterations
        sb.lineplot(data=wpr, linewidth=2.5)
```

```
Out[6]: <matplotlib.axes._subplots.AxesSubplot at 0x1a1d957748>
```


A
B
C
D
E
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0
2
4
6
8