Clustering Assignment

There will be some functions that start with the word "grader" ex: grader_actors(), grader_movies(), grader_cost1() etc, you should not change those function definition.

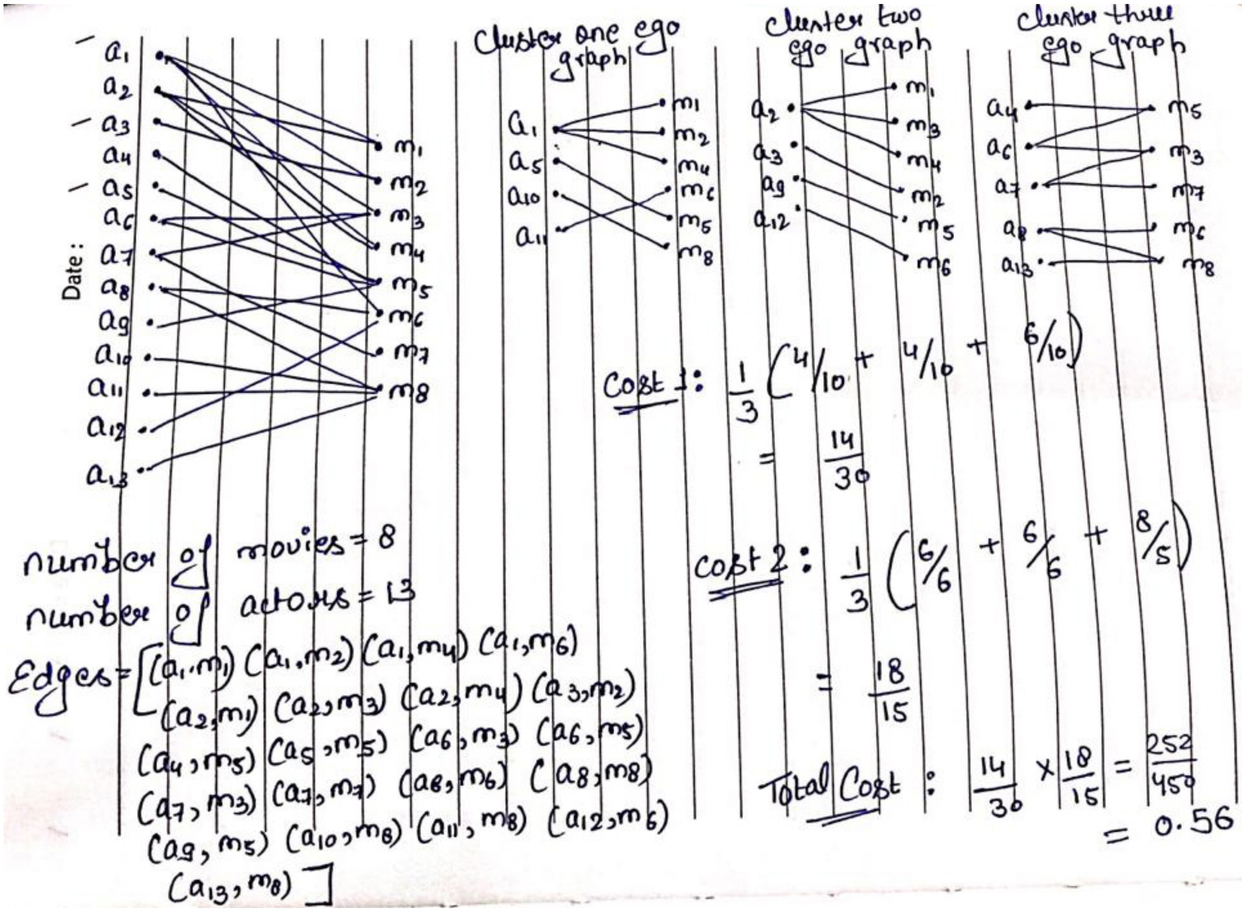
Every Grader function has to return True.

Please check [clustering assignment helper functions (https://drive.google.com/file/d/1V29KhKo3YnckMX32treEgdtH5r90DljU/view?usp=sharing)](https://drive.google.com/file/d/1V29KhKo3YnckMX32treEgdtH5r90DljU/view?usp=sharing) notebook before attempting this assignment.

- Read graph from the given movie_actor_network.csv (note that the graph is bipartite graph.)
- Using stellergaph and gensim packages, get the dense representation(128dimensional vector) of every node in the graph. [Refer Clustering_Assignment_Reference.ipynb]
- Split the dense representation into actor nodes, movies nodes.(Write you code in def data_split())

Task 1 : Apply clustering algorithm to group similar actors

1. For this task consider only the actor nodes
2. Apply any clustering algorithm of your choice
   Refer : [https://scikit-learn.org/stable/modules/clustering.html (https://scikit-learn.org/stable/modules/clustering.html)](https://scikit-learn.org/stable/modules/clustering.html)
3. Choose the number of clusters for which you have maximum score of $Cost1 * Cost2$
4. Cost1 =
   $\frac{1}{N} \sum_{\text{each cluster i}} \frac{\text{(number of nodes in the largest connected component in the graph with the actor nodes and its movie ne}}{\text{(total number of nodes in that cluster i)}}$
   where N= number of clusters
   (Write your code in def cost1())
5. Cost2 =
   $\frac{1}{N} \sum_{\text{each cluster i}} \frac{\text{(sum of degress of actor nodes in the graph with the actor nodes and its movie neighbours in cluster i)}}{\text{(number of unique movie nodes in the graph with the actor nodes and its movie neighbours in cluster i)}}$
   where N= number of clusters
   (Write your code in def cost2())
6. Fit the clustering algorithm with the opimal number_of_clusters and get the cluster number for each node
7. Convert the d-dimensional dense vectors of nodes into 2-dimensional using dimensionality reduction techniques (preferably TSNE)
8. Plot the 2d scatter plot, with the node vectors after step e and give colors to nodes such that same cluster nodes will have same color



Task 2 : Apply clustering algorithm to group similar movies

1. For this task consider only the movie nodes
2. Apply any clustering algorithm of your choice 3.Choose the number of clusters for which you have maximum score of $Cost1 * Cost2$

   Cost1 =
   $\frac{1}{N} \sum_{\text{each cluster i}} \frac{\text{(number of nodes in the largest connected component in the graph with the movie nodes and its actor ne}}{\text{(total number of nodes in that cluster i)}}$
   where N= number of clusters
   (Write your code in def cost1())
3. Cost2 =
   $\frac{1}{N} \sum_{\text{each cluster i}} \frac{\text{(sum of degress of movie nodes in the graph with the movie nodes and its actor neighbours in cluster i)}}{\text{(number of unique actor nodes in the graph with the movie nodes and its actor neighbours in cluster i)}}$
   where N= number of clusters
   (Write your code in def cost2())

Algorithm for actor nodes

```
for number_of_clusters in [3, 5, 10, 30, 50, 100, 200, 500]:
    algo = clustering_algorith(clusters=number_of_clusters)
```

```
        # you will be passing a matrix of size N*d where N number of acto
r nodes and d is dimension from gensim
        algo.fit(the dense vectors of actor nodes)
        You can get the labels for corresponding actor nodes (algo.labels
_)
        Create a graph for every cluster(ie., if n_clusters=3, create 3 g
raphs)
        (You can use ego_graph to create subgraph from the actual graph)
        compute cost1,cost2
           (if n_cluster=3, cost1=cost1(graph1)+cost1(graph2)+cost1(graph
3) # here we are doing summation
            cost2=cost2(graph1)+cost2(graph2)+cost2(graph3)
        computer the metric Cost = Cost1*Cost2
    return number_of_clusters which have maximum Cost
```

In [1]:

```python
import networkx as nx
from networkx.algorithms import bipartite
import matplotlib.pyplot as plt
from sklearn.cluster import KMeans
import numpy as np
import warnings
warnings.filterwarnings("ignore")
import pandas as pd
# you need to have tensorflow
from stellargraph.data import UniformRandomMetaPathWalk
from stellargraph import StellarGraph
from tqdm import tqdm
```

In [2]:

```python
data=pd.read_csv('movie_actor_network.csv', index_col=False, names=['movie','

```

In [3]:

```python
edges = [tuple(x) for x in data.values.tolist()]
```

In [4]:

```python
edges=[(x,y) for (y,x) in edges]
```

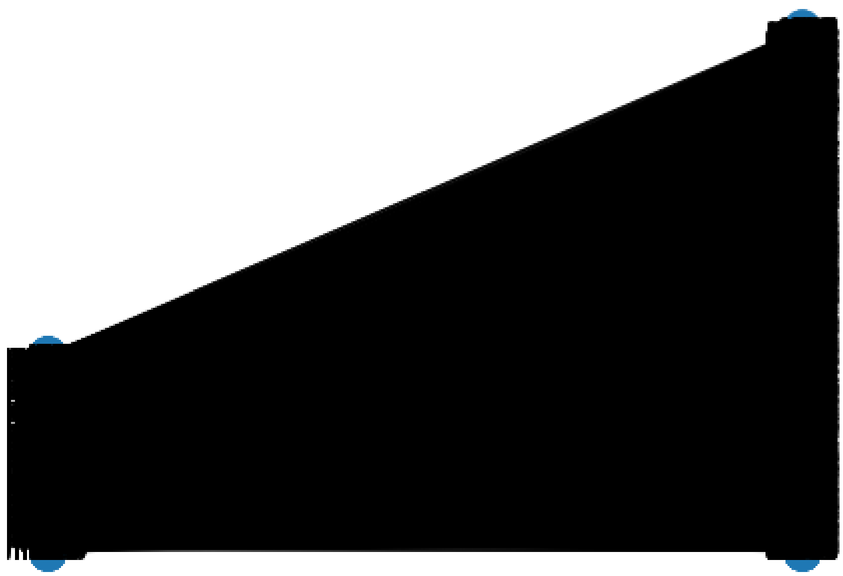
In [5]:

```
B = nx.Graph()
B.add_nodes_from(data['movie'].unique(), bipartite=0, label='movie')
B.add_nodes_from(data['actor'].unique(), bipartite=1, label='actor')
B.add_edges_from(edges, label='acted')
A = list(nx.connected_component_subgraphs(B))[0]
print("number of nodes", A.number_of_nodes())
print("number of edges", A.number_of_edges())
l, r = nx.bipartite.sets(A)
pos = {}

pos.update((node, (1, index)) for index, node in enumerate(l))
pos.update((node, (2, index)) for index, node in enumerate(r))

nx.draw(A, pos=pos, with_labels=True)
plt.show()
```

```
number of nodes 4703
number of edges 9650
```



In [6]:
```
movies = []
actors = []
for i in B.nodes():
    if 'm' in i:
        movies.append(i)
    if 'a' in i:
        actors.append(i)
print('number of movies ', len(movies))
print('number of actors ', len(actors))
```

```
number of movies  1292
number of actors  3411
```

In [7]:
```
# Create the random walker
rw = UniformRandomMetaPathWalk(StellarGraph(B))

# specify the metapaths schemas as a list of lists of node types.
metapaths = [
    ["movie", "actor", "movie"],
    ["actor", "movie", "actor"]

]

walks = rw.run(nodes=list(B.nodes()), # root nodes
               length=100,  # maximum length of a random walk
               n=1,        # number of random walks per root node
               metapaths=metapaths
              )

print("Number of random walks: {}".format(len(walks)))
```

```
Number of random walks: 4703
```

In [8]:
```
from gensim.models import Word2Vec
model = Word2Vec(walks, vector_size=128, window=5)
```

In [9]:
```
model.wv.vectors.shape  # 128-dimensional vector for each node in the graph
```

Out[9]:
```
(4703, 128)
```

In [10]:
```
# Retrieve node embeddings and corresponding subjects
node_ids = model.wv.index_to_key  # list of node IDs
node_embeddings = model.wv.vectors  # numpy.ndarray of size number of nodes t
```

In [11]:
```
actor_nodes=[i for i in node_ids if "a" in i]
movie_nodes=[j for j in node_ids if "m" in j]
len(actor_nodes),len(movie_nodes)
```

Out[11]:
```
(3411, 1292)
```

In [12]:
```
def data_split(node_ids,node_embeddings):
    '''In this function, we will split the node embeddings into actor_embeddi
    '''First we have taken the node_ids from wv embeddings then tried to get 
    Then with the help of these indices we can find the word embeddings of th
    nodes_actor=[]
    nodes_movie=[]
    for actor_movie in node_ids:
        if "a" in actor_movie:
            nodes_actor.append(actor_movie)
        else:
            nodes_movie.append(actor_movie)
    movie_indices=[]
    actor_indices=[]
    for actormovie_indices in node_ids:
        if "m" in actormovie_indices:
            movie_indices.append(node_ids.index(actormovie_indices))
        else:
            actor_indices.append(node_ids.index(actormovie_indices))
    actor_embeddings,movie_embeddings=node_embeddings[actor_indices,:],node_e
    return nodes_actor,nodes_movie,actor_embeddings,movie_embeddings
```

Grader function - 1

In [13]:
```
def grader_actors(data):
    assert(len(data)==3411)
    return True
grader_actors(actor_nodes)
```

Out[13]: True

Grader function - 2

In [14]:
```
def grader_movies(data):
    assert(len(data)==1292)
    return True
grader_movies(movie_nodes)
```

Out[14]: True

Calculating cost1

Cost1 =

$$\frac{1}{N}\sum_{\text{each cluster i}} \frac{\text{(number of nodes in the largest connected component in the graph with the actor nodes and its movie neighbo}}{\text{(total number of nodes in that cluster i)}}$$

where N= number of clusters

In [15]:
```python
def cost1(graph,number_of_clusters):
    '''In this function, we will calculate cost1'''
    max_nodes,total_nodes=len(max(nx.connected_components(graph),key=len)),gr
    cost1= max_nodes/(total_nodes)
    return cost1/number_of_clusters
```

Calculating cost2

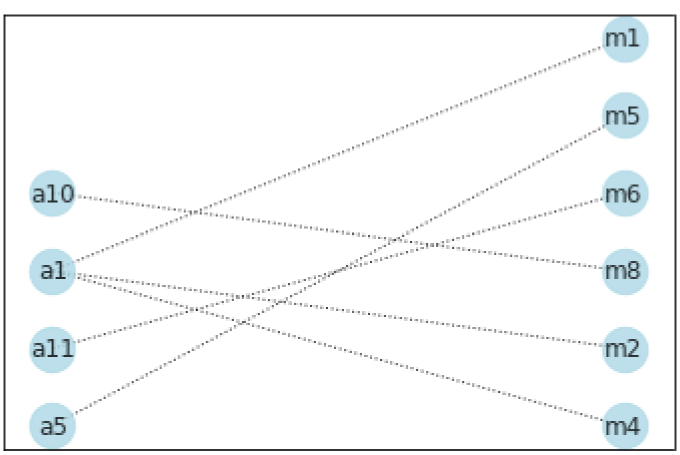
Cost2 =

$$\frac{1}{N}\sum_{\text{each cluster i}}\frac{\text{(sum of degress of actor nodes in the graph with the actor nodes and its movie neighbours in cluster i)}}{\text{(number of unique movie nodes in the graph with the actor nodes and its movie neighbours in cluster i)}}$$

where N= number of clusters

In [16]:
```python
def cost2(graph,number_of_clusters):
    '''In this function, we will calculate cost2'''
    num=0
    den=0
    for i in graph.nodes:
        if "a" in i:
            num+=graph.degree(i)
        else:
            den+=1
    cost2= num/(den)
    return cost2/number_of_clusters
```

In [17]:
```python
import networkx as nx
from networkx.algorithms import bipartite
graded_graph= nx.Graph()
graded_graph.add_nodes_from(['a1','a5','a10','a11'], bipartite=0) # Add the n
graded_graph.add_nodes_from(['m1','m2','m4','m6','m5','m8'], bipartite=1)
graded_graph.add_edges_from([('a1','m1'),('a1','m2'),('a1','m4'),('a11','m6')
l={'a1','a5','a10','a11'};r={'m1','m2','m4','m6','m5','m8'}
pos = {} # it is basically required by the nx.draw to set the position of the
pos.update((node, (1, index)) for index, node in enumerate(l))
pos.update((node, (2, index)) for index, node in enumerate(r))
nx.draw_networkx(graded_graph, pos=pos, with_labels=True,node_color='lightblu
```



Grader function - 3

In [18]:
```
graded_cost1=cost1(graded_graph,3)
def grader_cost1(data):
    assert(data==((1/3)*(4/10))) # 1/3 is number of clusters
    return True
grader_cost1(graded_cost1)
```

Out[18]: True

Grader function - 4

In [19]:
```
graded_cost2=cost2(graded_graph,3)
def grader_cost2(data):
    assert(data==((1/3)*(6/6))) # 1/3 is number of clusters
    return True
grader_cost2(graded_cost2)
```

Out[19]: True

In [20]:
```
def Kmeans_clustering(nodes,list_num_cluster,embeddings):
    all_cost=[]
    #Running loop for different number of cluster values
    for k in (list_num_cluster):
        kmeans = KMeans(n_clusters=k).fit(embeddings)
        currcost1=0
        currcost2=0
        #Finding cost function for each clusters formed from the above fittin
        for i in range(0,k):
            current_nodes=np.array(nodes).reshape(len(nodes),)[kmeans.labels_
            current_graph=nx.Graph()
            #Creating the graph Cluster
            for j in current_nodes:
                current_graph.add_nodes_from(nx.ego_graph(B,j).nodes)
                current_graph.add_edges_from(nx.ego_graph(B,j).edges())
            currcost1=currcost1+cost1(current_graph,k)
            currcost2=currcost2+cost2(current_graph,k)
        all_cost.append(currcost1*currcost2)
    kmax=list_num_cluster[all_cost.index(max(all_cost))]
    return kmax,all_cost
```

In [21]:
```
actor_nodes,movie_nodes,actor_embeddings,movie_embeddings=data_split(node_ids
```

In [22]:
```
list_num_cluster=[3, 5, 10, 30, 50, 100, 200, 500]
kmax_actor,score_actor=Kmeans_clustering(actor_nodes,list_num_cluster,actor_e
for i,j in zip(list_num_cluster,score_actor):
    print("The cost of ",i," number of cluster is ",j)
print("The value of k is ",kmax_actor)
```

```
The cost of  3  number of cluster is  3.725575244657303
The cost of  5  number of cluster is  2.888584960475906
The cost of  10  number of cluster is  2.2689389916515634
The cost of  30  number of cluster is  1.7574169111257325
The cost of  50  number of cluster is  1.5670502480239719
The cost of  100  number of cluster is  1.5592628874662784
The cost of  200  number of cluster is  1.8541525553163092
The cost of  500  number of cluster is  1.8470806873477434
The value of k is  3
```

In [23]:
```
list_num_cluster=[3, 5, 10, 30, 50, 100, 200, 500]
kmax_movie,score_movie=Kmeans_clustering(movie_nodes,list_num_cluster,movie_e
for i,j in zip(list_num_cluster,score_movie):
    print("The cost of ",i," number of cluster is ",j)
print("The value of k is ",kmax_movie)
```

```
The cost of  3  number of cluster is  8.388011950992288
The cost of  5  number of cluster is  8.16310541178454
The cost of  10  number of cluster is  8.964492415785722
The cost of  30  number of cluster is  12.72315556651753
The cost of  50  number of cluster is  14.725889907703424
The cost of  100  number of cluster is  13.99838405964806
The cost of  200  number of cluster is  12.88256578652694
The cost of  500  number of cluster is  10.32299746739229
The value of k is  50
```

In [24]:
```
kmeans = KMeans(n_clusters=kmax_actor, random_state=0).fit(actor_embeddings)
```

In [25]:
```
from sklearn.manifold import TSNE
tsne = TSNE(n_components=2,n_jobs=-1)
actor_tsne_2d = tsne.fit_transform(actor_embeddings)
```

In [26]:

```
#here we are
label_map = { l: i for i, l in enumerate(np.unique(list(kmeans.labels_)))}
node_colours = [ label_map[target] for target in list(kmeans.labels_)]
plt.figure(figsize=(12,12))
plt.axes().set(aspect="equal")
plt.scatter(actor_tsne_2d[:,0],
            actor_tsne_2d[:,1],
            c=node_colours, alpha=1)
plt.title('Tsne visualization of node embeddings')
plt.show()
```

In [27]:

```
kmeans = KMeans(n_clusters=kmax_movie, random_state=0).fit(movie_embeddings)
```

In [28]:

```
from sklearn.manifold import TSNE
tsne = TSNE(n_components=2,n_jobs=-1)
movie_tsne_2d = tsne.fit_transform(movie_embeddings)
```

In [29]:

```
label_map = { l: i for i, l in enumerate(np.unique(list(kmeans.labels_)))}
node_colours = [ label_map[target] for target in list(kmeans.labels_)]
plt.figure(figsize=(12,12))
plt.axes().set(aspect="equal")
plt.scatter(movie_tsne_2d[:,0],
            movie_tsne_2d[:,1],
            c=node_colours, alpha=1)
plt.title('tsne visualization of node embeddings')
plt.show()
```