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 **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
3. Choose the number of clusters for which you have maximum score of $Cost1*Cost2$
4. Cost1 =
$$\frac{1}{N}\sum_{\text{each cluster i}}\frac{(\text{number of nodes in the largest connected component in the graph with the actor nodes and its}}{(\text{total number of nodes in that cluster i})}$$
where N= number of clusters (Write your code in def cost1())
5. Cost2 =
$$\frac{1}{N}\sum_{\text{each cluster i}}\frac{(\text{sum of degress of actor nodes in the graph with the actor nodes and its movie neighbours in c}}{(\text{number of unique movie nodes in the graph with the actor nodes and its movie neighbours in}}$$
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 =
   $$\frac{1}{N}\sum_{\text{each cluster i}}\frac{\text{(number of nodes in the largest connected component in the graph with the movie nodes and it}}{\text{(total number of nodes in that cluster i)}}$$
   where N= number of clusters (Write your code in def cost1())

3. Cost2 =
   $$\frac{1}{N}\sum_{\text{each cluster i}}\frac{\text{(sum of degress of movie nodes in the graph with the movie nodes and its actor neighbours in}}{\text{(number of unique actor nodes in the graph with the movie nodes and its actor neighbours in c}}$$
   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 actor
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
graphs)
    (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(graph3) # 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
</pre>
```

```
#!pip install networkx==2.3
```

```
#! pip install stellargraph
```

```
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")
```

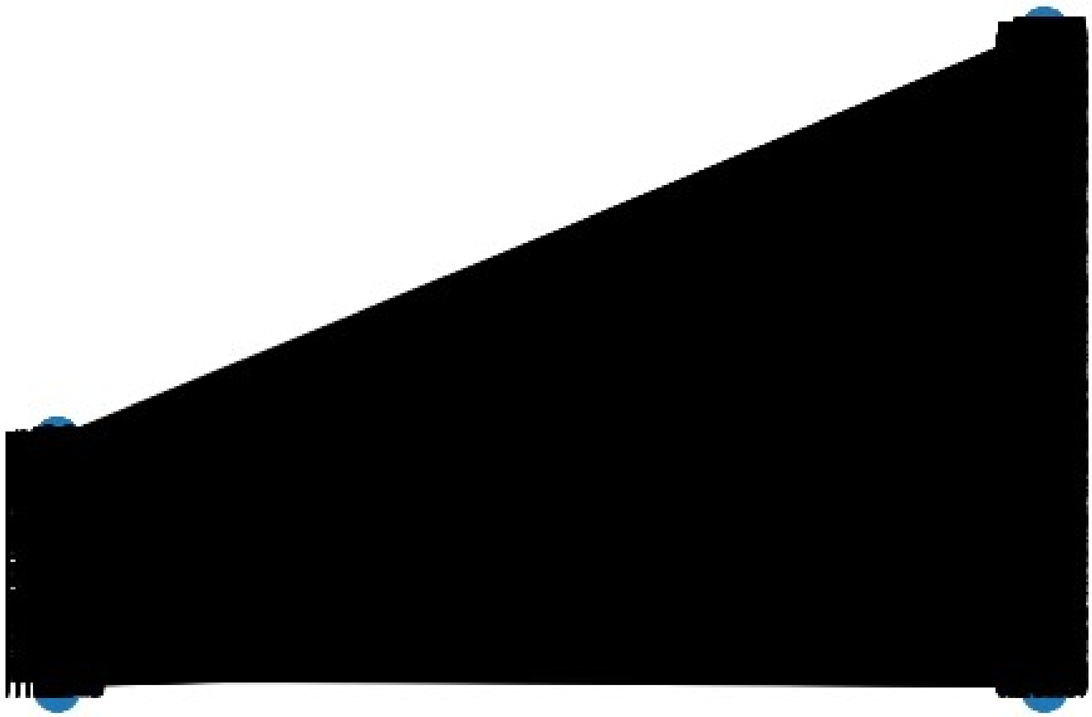
```python
import pandas as pd
# you need to have tensorflow
from stellargraph.data import UniformRandomMetaPathWalk
from stellargraph import StellarGraph

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

```
Mounted at /content/drive
```

```python
data=pd.read_csv('/content/drive/MyDrive/Advanced_Machine_Learning/
Clustering/Clustering_Assignment/movie_actor_network.csv',
index_col=False, names=['movie','actor'])

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

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())
```

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

```python
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()
```



```python
movies = []
actors = []
for i in A.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
```

```python
# Create the random walker
rw = UniformRandomMetaPathWalk(StellarGraph(A))

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

walks = rw.run(nodes=list(A.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
```

```
from gensim.models import Word2Vec
model = Word2Vec(walks, size=128, window=5)
```

```
model.wv.vectors.shape  # 128-dimensional vector for each node in the
graph
```

```
(4703, 128)
```

```
# Retrieve node embeddings and corresponding subjects
node_ids = model.wv.index2word  # list of node IDs
node_embeddings = model.wv.vectors  # numpy.ndarray of size number of
nodes times embeddings dimensionality
node_targets = [ A.node[node_id]['label'] for node_id in node_ids]
```

```
print(node_ids[:15], end='')
```

```
['a973', 'a967', 'a964', 'a1731', 'a969', 'a970', 'a1028', 'a1057', 'a965', 'a1003', 'm1094', 'a966', 'm67', 'a988', 'm1111']
```

```
print(node_targets[:15],end='')
```

```
['actor', 'actor', 'actor', 'actor', 'actor', 'actor', 'actor', 'actor', 'actor', 'actor', 'movie', 'actor', 'movie', 'actor', 'movie']
```

```
def data_split(node_ids,node_targets,node_embeddings):
    '''In this function, we will split the node embeddings into
actor_embeddings , movie_embeddings '''
    actor_nodes,movie_nodes=[],[]
    actor_embeddings,movie_embeddings=[],[]
    # split the node_embeddings into actor_embeddings,movie_embeddings
based on node_ids
    # By using node_embedding and node_targets, we can extract
actor_embedding and movie embedding
    # By using node_ids and node_targets, we can extract actor_nodes
and movie nodes
    actor_nodes = list(np.array(node_ids)
[np.where(np.array(node_targets) == 'actor')[0]])
    movie_nodes = list(np.array(node_ids)
[np.where(np.array(node_targets) == 'movie')[0]])
    actor_embeddings = list(np.array(node_embeddings)
[np.where(np.array(node_targets) == 'actor')[0]])
    movie_embeddings = list(np.array(node_embeddings)
[np.where(np.array(node_targets) == 'movie')[0]])
    return actor_nodes,movie_nodes,actor_embeddings,movie_embeddings
actor_nodes,movie_nodes,actor_embeddings,movie_embeddings =
data_split(node_ids,node_targets,node_embeddings)
```

Grader function - 1

```
def grader_actors(data):
    assert(len(data)==3411)
    return True
grader_actors(actor_nodes)
```

```
True
```

Grader function - 2

```
def grader_movies(data):
    assert(len(data)==1292)
    return True
grader_movies(movie_nodes)
```

```
True
```

Calculating cost1

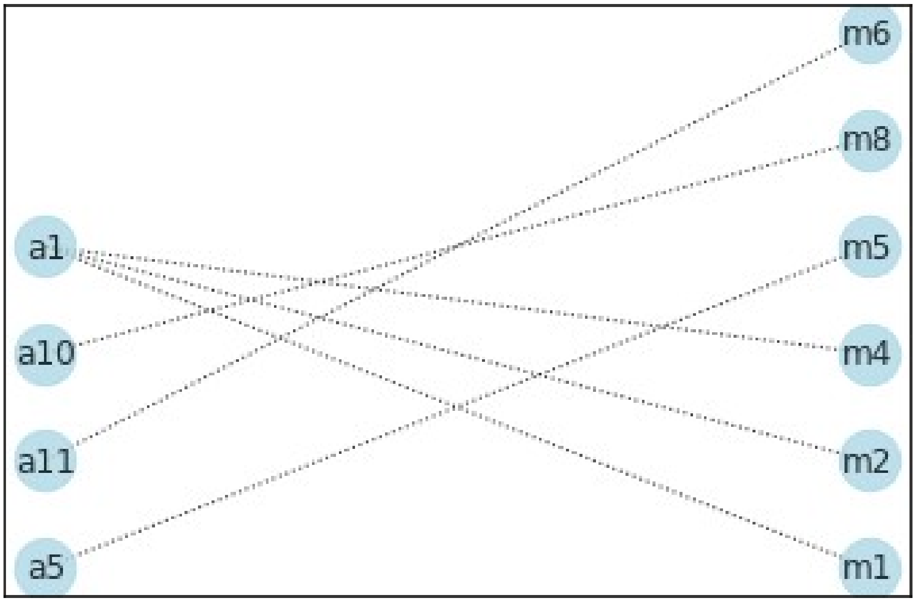
Cost1 =

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

where N= number of clusters

```
def cost1(graph,number_of_clusters):
    '''In this function, we will calculate cost1'''
    #cost1=  calculate cost1
    cost1= (1/number_of_clusters) *
((max(nx.connected_component_subgraphs(graph),
key=len).number_of_nodes()/graph.number_of_nodes()))
    return cost1
```

```
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 node attribute "bipartite"
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'),('a5','m5'),('a10','m8')])
l={'a1','a5','a10','a11'};r={'m1','m2','m4','m6','m5','m8'}
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_networkx(graded_graph, pos=pos,
with_labels=True,node_color='lightblue',alpha=0.8,style='dotted',node_
size=500)
```



Grader function - 3

```
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)
```

```
True
```

Calculating cost2

Cost2 =
$$\frac{1}{N}\sum_{\text{each cluster i}}\frac{(\text{sum of degress of actor nodes in the graph with the actor nodes and its movie neighbours in cluster i})}{(\text{number of unique movie nodes in the graph with the actor nodes and its movie neighbours in cluster}}$$
where N= number of clusters

```
def cost2(graph,number_of_clusters):
    '''In this function, we will calculate cost1'''
    #cost2= calculate cost1
    degree=graph.degree()
    actor_degree_sum=0 # to store sum of all  degree of actor nodes
    unique_mov_nodes=0  #to store sum of all unique movie nodes
    for i in degree:
      if "a" in i[0]:
        actor_degree_sum=actor_degree_sum+i[1]
      else:
        unique_mov_nodes=unique_mov_nodes+1
    cost2=((1/number_of_clusters)*(actor_degree_sum/unique_mov_nodes))
    return cost2
```

Grader function - 4

```
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)
```

```
True
```

Grouping similar actors

```
cost_value={}
for number_of_clusters in [3, 5, 10, 30, 50, 100, 200, 500]:
  cost1_val = 0
  cost2_val = 0
  algo = KMeans(n_clusters=number_of_clusters)
  algo.fit(actor_embeddings)
  actor_labels = algo.labels_
  for graphnum in range(number_of_clusters):
    cluster_graph = nx.Graph()
    k = [index for index, value in enumerate(actor_labels) if value ==
graphnum]
    actor_nodes_of_graphnum=[actor_nodes[l] for l in k]
    for actor in actor_nodes_of_graphnum:
      sub_graph1=nx.ego_graph(B,actor)
      cluster_graph.add_nodes_from(sub_graph1.nodes) # adding nodes
      cluster_graph.add_edges_from(sub_graph1.edges()) # adding edges
      cst1=cost1(cluster_graph,number_of_clusters)
      cost1_val=cost1_val+cst1 # calculating cost functions
      cst2=cost2(cluster_graph,number_of_clusters)
      cost2_val=cost2_val+cst2
    metric_cost = cost1_val*cost2_val
    cost_value[number_of_clusters]=metric_cost

optimal_cluster_number = max(cost_value, key=cost_value.get)
print("optimal cluster number = ",optimal_cluster_number)
```

```
optimal cluster number =  3
```

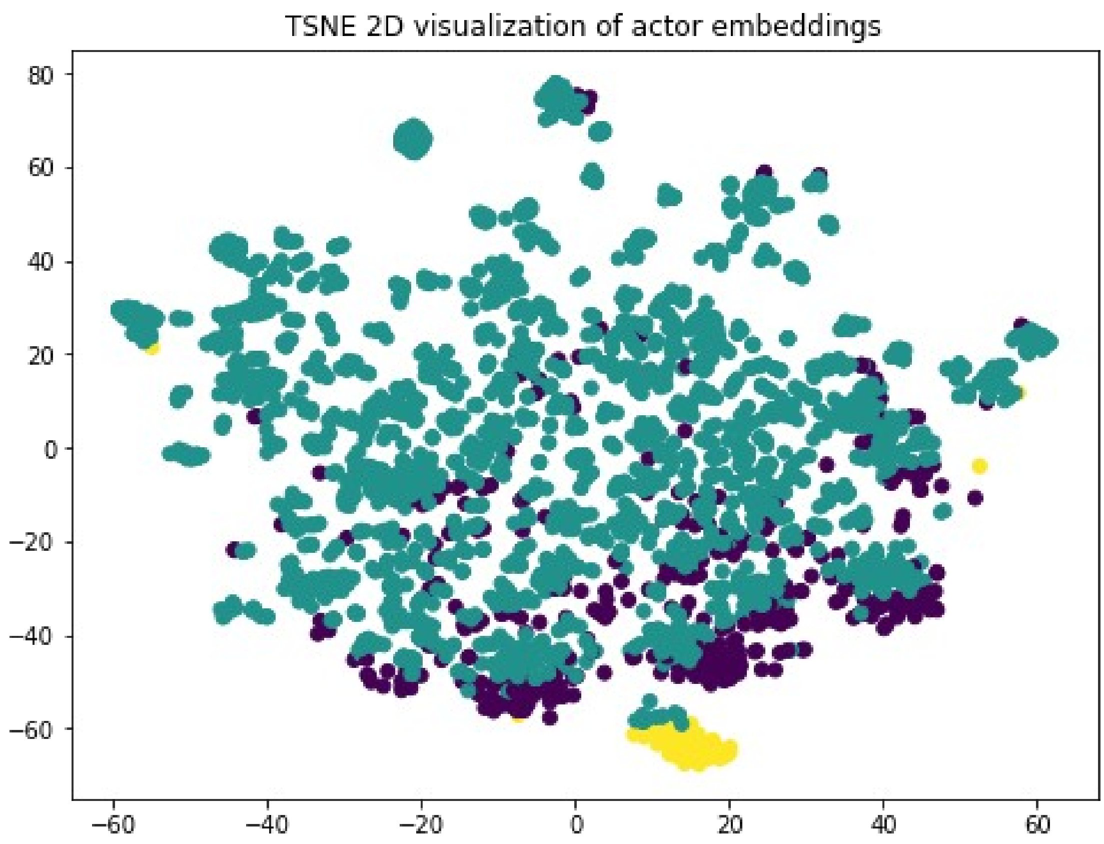
Displaying similar actor clusters

```
model= KMeans(n_clusters=optimal_cluster_number)
model.fit(actor_embeddings)
label=model.labels_
node_cluster={}
for graphnum in range(optimal_cluster_number):
  k=[index for index, value in enumerate(label) if value == i]  #
getting the cluster number for each node
  label_divi=[ actor_nodes[l] for l in k]
  for node in label_divi:
    node_cluster[node]=i
    k = [index for index, value in enumerate(actor_labels) if value ==
graphnum]
```

```
    actor_nodes_of_graphnum=[actor_nodes[l] for l in k]
    for actor in actor_nodes_of_graphnum:
      node_cluster[actor]=graphnum
```

```
from sklearn.manifold import TSNE
transform = TSNE #PCA
trans = transform(n_components=2,perplexity = 40.0)
actor_embeddings_2d = trans.fit_transform(actor_embeddings)
plt.figure(figsize=(8, 6))
#https://stackoverflow.com/questions/28227340/kmeans-scatter-plot-plot-different-colors-per-cluster
plt.scatter(actor_embeddings_2d[:,0], actor_embeddings_2d[:,1], c=model.labels_.astype(float))
plt.title('TSNE 2D visualization of actor embeddings')
```

```
Text(0.5, 1.0, 'TSNE 2D visualization of actor embeddings')
```



Grouping similar movies

```
cost_value={}
for number_of_clusters in [3, 5, 10, 30, 50, 100, 200, 500]:
  cost1_val = 0
  cost2_val = 0
  algo = KMeans(n_clusters=number_of_clusters)
  algo.fit(movie_embeddings)
```

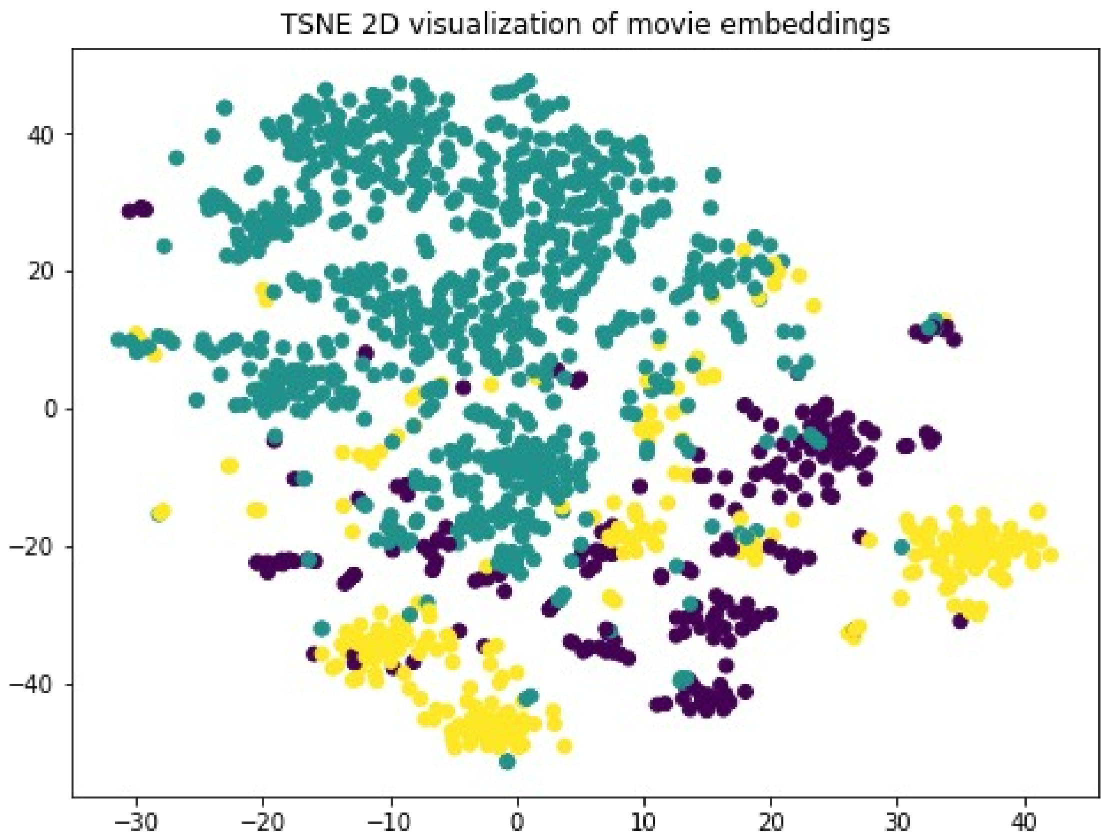
```
  movie_labels = algo.labels_
  for graphnum in range(number_of_clusters):
    cluster_graph = nx.Graph()
    k = [index for index, value in enumerate(movie_labels) if value == graphnum]
    movie_nodes_of_graphnum=[movie_nodes[l] for l in k]
    for movie in movie_nodes_of_graphnum:
      sub_graph1=nx.ego_graph(B,movie)
      cluster_graph.add_nodes_from(sub_graph1.nodes) # adding nodes
      cluster_graph.add_edges_from(sub_graph1.edges()) # adding edges
      cst1=cost1(cluster_graph,number_of_clusters)
      cost1_val=cost1_val+cst1 # calculating cost functions
      cst2=cost2(cluster_graph,number_of_clusters)
      cost2_val=cost2_val+cst2
    metric_cost = cost1_val*cost2_val
    cost_value[number_of_clusters]=metric_cost

optimal_cluster_number = max(cost_value, key=cost_value.get)
print("optimal cluster number = ",optimal_cluster_number)
```

```
optimal cluster number =  3
```

Displaying similar movie clusters

```
model= KMeans(n_clusters=optimal_cluster_number)
model.fit(movie_embeddings)
label=model.labels_
node_cluster={}
for graphnum in range(optimal_cluster_number):
  k=[index for index, value in enumerate(label) if value == i]  # getting the cluster number for each node
  label_divi=[movie_nodes[l] for l in k]
  for node in label_divi:
    node_cluster[node]=i
    k = [index for index, value in enumerate(movie_labels) if value == graphnum]
    movie_nodes_of_graphnum=[movie_nodes[l] for l in k]
    for movie in movie_nodes_of_graphnum:
      node_cluster[movie]=graphnum

transform = TSNE #PCA
trans = transform(n_components=2,perplexity = 30.0)
movie_embeddings_2d = trans.fit_transform(movie_embeddings)
plt.figure(figsize=(8, 6))
#https://stackoverflow.com/questions/28227340/kmeans-scatter-plot-plot-different-colors-per-cluster
plt.scatter(movie_embeddings_2d[:,0], movie_embeddings_2d[:,1], c=model.labels_.astype(float))
plt.title('TSNE 2D visualization of movie embeddings')
```

```
Text(0.5, 1.0, 'TSNE 2D visualization of movie embeddings')
```


TSNE 2D visualization of movie embeddings
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