Clustering Assignment

In [1]:
```python
from google.colab import files
uploaded = files.upload()
```

Choose Files No file chosen Upload widget is only available when the cell has been executed in the current browser session. Please rerun this cell to enable.

```
Saving movie_actor_network.csv to movie_actor_network.csv
```

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

In [ ]:
```python
#!pip install networkx==2.3
#!pip uninstall networkx -y
#!pip install networkx==2.5.1
#!python3 -m pip install networkx
```

```
Python was not found; run without arguments to install from the Microsoft Store, or disable this shortcut from Settings > Manage App Execution Aliases.
```

In [ ]:
```python
!pip install stellargraph
```

In [4]:
```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
```

In [5]:
```python
data=pd.read_csv('movie_actor_network.csv', index_col=False, names=['movie','actor'])
```

In [6]:
```python
edges = [tuple(x) for x in data.values.tolist()]  # Here x is series (ie denoting each row's values in a series format)
```

In [7]:
```python
edges[0]  # (Movie_i, Actor_i) := Movie <-> Actor
```

Out[7]:
```
('m1', 'a1')
```

In [8]:
```python
data.head(2)
```

Out[8]:

	movie	actor
0	m1	a1
1	m2	a1

In [9]:
```python
# Prepare the Bipartite Graph (Movie <-> Actor)
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')
```

In [10]:
```python
# ref :
# https://stackoverflow.com/questions/61154740/attributeerror-module-networkx-has-no-attribute-connected-component-subgraph
# https://networkx.org/documentation/networkx-2.1/reference/algorithms/generated/networkx.algorithms.components.connected_component_subgraphs.html

#A = list(nx.connected_component_subgraphs(B))[0]
subgraphs = [B.subgraph(c) for c in nx.connected_components(B)]
```

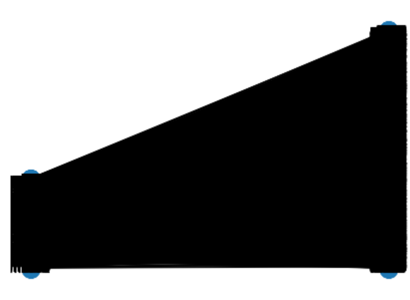
In [11]:
```python
subgraph = subgraphs[0]
print("number of nodes", subgraph.number_of_nodes())
print("number of edges", subgraph.number_of_edges())
```

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

Observations:

As the #nodes < #edges, So we can say that either more movies are associated to an actor or more actors are associated to a movie

In [12]:
```python
l, r = nx.bipartite.sets(subgraph)
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(subgraph, pos=pos, with_labels=True)
plt.show()
```



In [13]:
```python
movies = []
actors = []
# NOTE : This we are checking for only 1 connected sub-component of entire Movie-Actor Bipartite Graph
for i in subgraph.nodes():
    if 'm' in i:
        movies.append(i)
    if 'a' in i:
        actors.append(i)
print('number of movies in current subgraph', len(movies))
print('number of actors in current subgraph', len(actors))
```

```
number of movies in current subgraph 1292
number of actors in current subgraph 3411
```

In [14]:
```python
# For Feature Embedding (Feature Engineering)

# NOTE : Here we are generating walks/paths from only 1 sub-connected-graph from Bipartite(Movie<->Actor)

# Create the random walker
rw = UniformRandomMetaPathWalk(StellarGraph(subgraph))

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

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

Observation :

The path generated = number of nodes in subgraph Thus each node as starting node is considered for path

Feature Embeddings

Each Walk will be represented as 128 size vector

In [16]:
```python
from gensim.models import Word2Vec
model = Word2Vec(walks, size=128, window=5)
```

In [17]:
```python
model.wv.vectors.shape  # 128-dimensional vector for each node in the graph
```

Out[17]:
```
(4703, 128)
```

NOTE: We only need node-id to get information about node in corresponding Graph

In [18]:
```python
# testing (retrieving the node based on id from connected sub-graph)
subgraph.nodes['a973']  # Node with id {a973} belongs to group-1 & labeled{actor}
```

Out[18]:
```
{'bipartite': 1, 'label': 'actor'}
```

In [19]:
```python
# 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

# ref : https://stackoverflow.com/questions/58518554/attributeerror-graph-object-has-no-attribute-node

node_targets = [subgraph.nodes[node_id]['label'] for node_id in node_ids]
```

In [20]:
```python
print(node_ids[:3])
print(node_targets[:3])
```

```
['a973', 'a967', 'a964']
['actor', 'actor', 'actor']
```

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

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

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

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

In [21]:
```python
np.unique(node_targets)
```

Out[21]:
```
array(['actor', 'movie'], dtype='<U5')
```

In [22]:
```python
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
    for lbl, nodeId, vec in zip(node_targets, node_ids, node_embeddings):
      if lbl == 'actor':
        actor_nodes.append(nodeId)
        actor_embeddings.append(vec)
      else:
        movie_nodes.append(nodeId)
        movie_embeddings.append(vec)

    return actor_nodes, movie_nodes, actor_embeddings, movie_embeddings
```

Grader function - 1

In [23]:
```python
actor_nodes, movie_nodes, actor_embeddings, movie_embeddings = data_split(node_ids, node_targets, node_embeddings)
```

In [24]:
```python
def grader_actors(data):
    assert(len(data)==3411)
    return True
grader_actors(actor_nodes)
```

Out[24]:
```
True
```

Grader function - 2

In [25]:
```python
def grader_movies(data):
    assert(len(data)==1292)
    return True
grader_movies(movie_nodes)
```

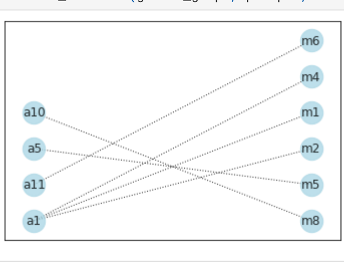
Out[25]:
```
True
```

Calculating cost1

Cost1 = $\frac{1}{N}\sum_{\text{each cluster i}} \frac{\text{(number of nodes in the largest connected component in the graph with the actor nodes and its movie neighbours in cluster i)}}{\text{(total number of nodes in that cluster i)}}$ where N= number of clusters

In [26]:
```python
# ref
# https://networkx.org/documentation/stable/reference/algorithms/generated/networkx.algorithms.components.connected_components.html
# https://stackoverflow.com/questions/64663894/attributeerror-set-object-has-no-attribute-number-of-nodes-working-with-net

def cost1(graph, number_of_clusters):
    '''In this function, we will calculate cost1'''
    # NOTE :- graph := 1 such cluster = cluster_i
    # & this graph is bipartite graph

    total = graph.number_of_nodes()

    # Max Size (ie #nodes) of largest connected components
    largest_cc  = max(nx.connected_components(graph), key=len)
    size = len(largest_cc)

    return (1/number_of_clusters)*(size/total)
```

In [38]:
```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 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)
```



In [39]:
```python
from networkx.algorithms import bipartite
```

In [40]:
```python
# TESTING (PRACTICE)
nx.is_connected(graded_graph)
```

Out[40]:
```
False
```

In [ ]:
```python
# # TESTING (PRACTICE)
# dict(graded_graph.degree)
```

In [ ]:
```python
# # TESTING (PRACTICE)
# # https://networkx.org/documentation/stable/reference/algorithms/bipartite.html
# G = nx.complete_bipartite_graph(3, 2)
# left, right = bipartite.sets(G)
# left, right
```

In [ ]:
```python
# # TESTING (PRACTICE)
# # https://networkx.org/documentation/stable/reference/algorithms/generated/networkx.algorithms.bipartite.basic.degrees.html#networkx.algorithms.bipartite.bas

# degX, degY = bipartite.degrees(G, right)
# print(dict(degX))
# print(dict(degY))
```

In [ ]:
```python
# # TESTING (PRACTICE)
# left = {n for n, d in G.nodes(data=True) if d["bipartite"] == 0}
# right = set(G) - left
# left, right
```

In [ ]:
```python
# # TESTING (PRACTICE)
# d = dict(G.degree)
# print(d)
```

Grader function - 3

In [28]:
```python
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[28]:
```
True
```

Calculating cost2

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

In [65]:
```python
def cost2(graph,number_of_clusters):
    '''In this function, we will calculate cost2'''
    # NOTE : Here {graph} is actually a 1 cluster only & not an entire graph
    # Now this cluster can have many sub connected components
    left = {n for n, d in graph.nodes(data=True) if d["bipartite"] == 0}
    right = set(graph) - left
    degs = sum(map(dict(graph.degree).get, left))
    return (1/number_of_clusters) * (degs/len(right))

# def cost2(graph,number_of_clusters):
#     '''In this function, we will calculate cost1'''
#     # NOTE : Here {graph} is actually a 1 cluster only & not an entire graph
#     # Now this cluster can have many sub connected components
#     left = {n for n, d in graph.nodes(data=True) if d["bipartite"] == 0}
#     right = set(graph) - left
#     degs = sum(map(dict(graph.degree).get, left))
#     return (1/number_of_clusters) * (degs/len(right))
```

Grader function - 4

In [66]:
```python
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[66]:
```
True
```

HELPERS

In [67]:
```python
from sklearn.cluster import KMeans
```

In [74]:
```python
from itertools import compress
from functools import partial
from operator import eq

def decide_k_for_grouping(nodes, mat):
  ''' Hyper Param Tuning for KMeans Clustering
      :nodes: list of nodes id
      :mat: vector representation of those nodes
  '''
  K = [3, 5, 10, 50, 200, 300]  # Hyper-Param
  scores = []
  # 1. Fit
  for k in K:  # k := no. of clusters

    # 1. train
    marker = KMeans(k)
    marker.fit(mat)

    cost_1 = cost_2 = 0

    # 2. Loss/Cost
    for lbl in range(k):      # k clusters
      # lbl := label for current cluster

      # cluster-{lbl}
      G = nx.Graph()  #-> Graph for cluster
      # 2.1. Find node members in cluster-i
      members = compress(nodes, map(partial(eq, lbl), marker.labels_))

      # 2.2 Computing cost for each node
      for actor in members:
        # find all surrounding movies nodes to this {node} as centered
        neigh_movies_graph = nx.ego_graph(B, actor)
        # Add these surrounding movies nodes info to current graph's cluster
        movies = neigh_movies_graph.nodes
        actor_to_movies = neigh_movies_graph.edges()
        G.add_nodes_from([actor], bipartite=0) # adding nodes
        G.add_nodes_from(movies, bipartite=1) # adding nodes
        G.add_edges_from(actor_to_movies) # adding edges

      # 2.3. Find metric for current cluster (ie Cost)
      cost_1 += cost1(G, k)
      cost_2 += cost2(G, k)

    # 3. Score when no. of clusters = k
    score = cost_1 * cost_2
    scores.append(score)

  # Best Score
  i = np.argmax(scores)  # Find best K corresp to best score
  return K[i]
```

In [96]:
```python
from sklearn.manifold import TSNE
import matplotlib.pyplot as plt
import seaborn as sns

def viz_scatter_plot(mat, labels, k):
  ''' Scatter Plot after trasnforming features from d dimen to 2 dimen '''

  # Feature Transformer
  x, y = len(mat), len(mat[0])
  print(f'transforming from {x, y} to {x, 2}')
  transformer = TSNE(n_components=2, verbose=1, perplexity=40, n_iter=300)
  res = transformer.fit_transform(mat)  # converting from (n, k) -> (n, 2)

  col1, col2 = res[:,0], res[:,1]
  plt.figure(figsize=(8, 6))
  # plt.scatter(col1, col2, c=labels)
  plt.title('2D Visualisation')

  # plt.figure(figsize=(16,10))
  sns.scatterplot(
      x=col1,
      y=col2,
      hue=labels,
      palette=sns.color_palette("hls", k),
      legend="full",
      alpha=0.3
  )
  plt.show()
```

Grouping similar actors

In [94]:
```python
bK = decide_k_for_grouping(actor_nodes, actor_embeddings)
print('Decided k in k-means : ', bK)

labeller = KMeans(bK)
labeller.fit(actor_embeddings)
```

```
Decided k in k-means :  3
```

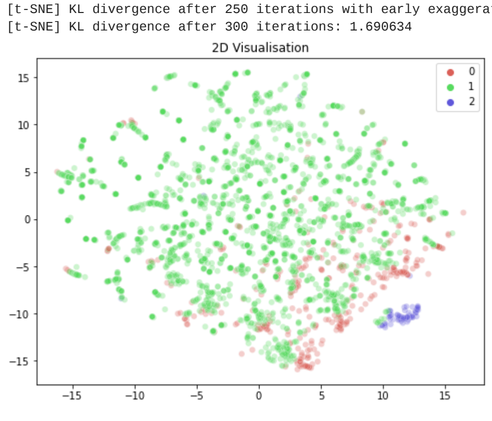
Out[94]:
```
KMeans(n_clusters=3)
```

In [ ]:
```python
#len(labels), len(actor_nodes)
```

Displaying similar actor clusters

In [97]:
```python
labels = labeller.labels_
viz_scatter_plot(actor_embeddings, labels, bK)
```

```
transforming from (3411, 128) to (3411, 2)
[t-SNE] Computing 121 nearest neighbors...
[t-SNE] Indexed 3411 samples in 0.001s...
[t-SNE] Computed neighbors for 3411 samples in 0.367s...
[t-SNE] Computed conditional probabilities for sample 1000 / 3411
[t-SNE] Computed conditional probabilities for sample 2000 / 3411
[t-SNE] Computed conditional probabilities for sample 3000 / 3411
[t-SNE] Computed conditional probabilities for sample 3411 / 3411
[t-SNE] Mean sigma: 0.627668
[t-SNE] KL divergence after 250 iterations with early exaggeration: 78.657715
[t-SNE] KL divergence after 300 iterations: 1.690634
```



Grouping similar movies

In [98]:
```python
bK = decide_k_for_grouping(movie_nodes, movie_embeddings)
print('Decided k in k-means : ', bK)

labeller = KMeans(bK)
labeller.fit(movie_embeddings)
```

```
Decided k in k-means :  3
```

Out[98]:
```
KMeans(n_clusters=3)
```

Displaying similar movie clusters

In [99]:
```python
labels = labeller.labels_
viz_scatter_plot(movie_embeddings, labels, bK)
```

```
transforming from (1292, 128) to (1292, 2)
[t-SNE] Computing 121 nearest neighbors...
[t-SNE] Indexed 1292 samples in 0.001s...
[t-SNE] Computed neighbors for 1292 samples in 0.081s...
[t-SNE] Computed conditional probabilities for sample 1000 / 1292
[t-SNE] Computed conditional probabilities for sample 1292 / 1292
[t-SNE] Mean sigma: 1.376903
[t-SNE] KL divergence after 250 iterations with early exaggeration: 67.443291
[t-SNE] KL divergence after 300 iterations: 1.164645
```