Q1.Decision Based Diffusion[50 Points]

0-A. Set-up[-2 if author function is not called]

In [1]:

```
def author(gt_username = 'tpasumarthi3'):
  print("This assignment is submitted by {0}.".format(gt_username))
#Add your GT_UserName below and uncomment the line.
author()
```

```
This assignment is submitted by tpasumarthi3.
```

In [2]:

```
#Installations
!pip install snap-stanford
```

```
Requirement already satisfied: snap-stanford in
c:\users\tyco9\appdata\local\continuum\anaconda3\lib\site-packages (5.0.0)
```

In [3]:

```
import snap
import matplotlib.pyplot as plt
import numpy as np


# Setup
num_voters = 10000
decision_period = 10
```

0-B. Utility Functions[25 Points]

In [4]:

```
#Utility functions:
def read_graph(path):
    """
    Function to read the .txt file to load the undirected graph.

    Args: path: path to edge list file
    Returns: Graph: loaded Graph(snap.PUNGraph)

    """
    Graph = None
    ### Add your code here.[1 Point]
    Graph = snap.LoadEdgeList(snap.PUNGraph, path, 0, 1)
    ######################

    return Graph

def get_neighbors(graph,nodeId):
    """
    Function to get all neighbours of a node in a given graph.

    Arg: graph:  snap.PUNGraph object representing an undirected graph
         nodeId: An integer in the range of (0,num_voters-1)(inclusive)
    Returns: neighbours : List of neighbouring nodes

    """
    neighbours = None
    ### Add your code here.[2 Points]
    neighbours = []
    node= graph.GetNI(nodeId)
    for i in range(node.GetOutDeg()):
        neighbours.append(node.GetNbrNId(i))
    ######################
    return neighbours

def get_vote_count(nodeset, pref, letter):
    """
    Function to get the vote counts for a particular candidate(letter) given a nodeset and their p
references

    Args: nodeset: Set of Graph Nodes
         pref: preference mapping
         letter: Candidate letter
    Returns: vote_count : Vote count for the given candidate

    """
    vote_count = None
    ### Add your code here.[1 Point]
    vote_count=0
    for i in (list(nodeset)):
        if pref[i] == letter:
            vote_count+=1
    ######################
    return vote_count

def winner(pref):
    """
    Function to get the winner of election process.(Please use the appropriate utitlity function(s
) as required.)

    Args: pref: Dictionary object mapping node ids to the voting preferences
    Returns: winner: Winning candidate character(char)
             margin: Margin of victory or loss for A(i.e. margin = a_count - b_count)

    Note: Please note that for margin calculation we're NOT taking the absolute value.
    """
    winner = None
    margin = None
    ### Add your code here.[3 Points]
    winner="A"
    counts= list(pref.values())
    a_count= counts.count("A")
    b_count= counts.count("B")
    if (a_count<b_count):
        winner="B"
    margin=a_count - b_count
    return winner, margin
    ######################

def sort_nodes_by_popularity(graph):
    """
    Function to sort all nodes of the given graph in descending order of their popularity(degree).

    Args: graph: snap.PUNGraph object representing an undirected graph
    Returns: ids: NodeIds list sorted based on their degrees(Descending order)
             degrees: Degrees corresponding to the above node Ids.(Should have one to one
correspondence with the above ids list)

    Example output(dummy): ids: [2,1,3,0]
                           degrees: [3,2,2,0] Note that both node 1 and 3 have the same degree, so
the node with the lowest id
                                              comes first.(Please refer to the question for detail

    """
    degrees = []
    ids = []
    ### Add your code here.[5 Points]
    ids = list(range(graph.GetNodes()))
    for i in range(graph.GetNodes()):
        NI=graph.GetNI(i)
        degrees.append(NI.GetOutDeg())
    degrees=np.array(degrees)
    ids= np.array(ids)
    idx=(-degrees).argsort(kind='mergesort')
    ids= list(ids[idx])
    degrees= list(degrees[idx])
    ######################
    ######################
    for i in range(1, len(degrees)):
        assert(degrees[i] <= degrees[i-1])

    return ids, degrees

def initial_voting_state(Graph):
    """
    Function to initialize the voting preferences.

    Args: Graph: snap.PUNGraph object representing an undirected graph
    Returns: voter_prefs: Dictionary mapping node IDs to initial voter preference
            ('A', 'B', or 'U')
    Note: 'U' denotes undecided voting preference.

    Example: Some random key-value pairs of the dict are
             {0 : 'A', 24 : 'B', 118 : 'U'}.
    """
    voter_prefs = {}

    ### Add your code here.[4 Points]
    for i in range(Graph.GetNodes()):
        mod= i%10
        if mod<4:
            voter_prefs[i]="A"
        elif mod<8:
            voter_prefs[i]="B"
        else:
            voter_prefs[i]="U"

    ######################
    assert(len(voter_prefs) == num_voters)
    return voter_prefs

def iterate_voting(Graph, init_pref):
    """
    Function to perform the 10-day decision process.

    Args: Graph: snap.PUNGraph object representing an undirected graph
         init_pref: Dictionary object containing the initial voting
                    preferences (before any iteration of the decision
                    process)
    Returns: curr_pref: Dictionary containing the voting preferences (mapping node IDs to
                        'A','B' or 'U') after the decision process.

    Hint: Use global variables num_voters and decision_period to iterate.
    """
    curr_pref = init_pref.copy()
    curr_alternating_vote = 'A'

    ### Add your code here.[7 Points]
    for j in range(decision_period):
        for i in range(num_voters):
            if(init_pref[i]=="U"):
                NI=Graph.GetNI(i)
                neighbors= get_neighbors(Graph,i)
                a_ct= get_vote_count(neighbors, curr_pref, "A")
                b_ct= get_vote_count(neighbors, curr_pref, "B")
                if a_ct>b_ct:
                    curr_pref[i]="A"
                elif a_ct<b_ct:
                    curr_pref[i]="B"
                elif curr_alternating_vote == 'A':
                    curr_pref[i]="A"
                    curr_alternating_vote = 'B'
                elif curr_alternating_vote == 'B':
                    curr_pref[i]="B"
                    curr_alternating_vote = 'A'
    ######################
    return curr_pref

def sim_election(Graph):
    """
    Function to simulate the election process, takes the Graph as input and
    gives the final voting preferences (dictionary) as output.

    Args: Graph: snap.PUNGraph object representing an undirected graph
    Returns: pref: Dictionary containing the voting preferences (mapping node IDs to
    Returns: pref: Dictionary containing the voting preferences (mapping node IDs to
                         'A','B' or 'U') after the decision process.
    """
    ### Add your code here.[2 Points]
    init_pref= initial_voting_state(Graph)
    pref= iterate_voting(Graph, init_pref)
    ######################

    return pref
```

1. Basic Setup and Simulation[3 Points]

1-A. Utility Functions

For this part you should complete the following utility functions:

1. read_graph
2. get_neighbors
3. get_vote_count
4. winner
5. initial_voting_state
6. iterate_voting
7. sim_election

1-B. Part 1 Simulation[3 Points]

In [5]:

```
#Q1
def Q1():
    """
    Function to carry out part 1.(Please use the appropriate utitlity function(s) as required.)
    You should be carrying out the following steps:
    1) Load the graphs.
    2) Simulate the election and find final preferences.
    3) Get the winner for both the networks.
    """

    print ("\nQ1:")
    winners = [] #Stores the Winners of the election for both graphs
    ### Add your code here.
    g1=read_graph("graph1.txt")
    cp1= sim_election(g1)
    winners.append(winner(cp1))

    g2=read_graph("graph2.txt")
    cp2= sim_election(g2)
    winners.append(winner(cp2))
    ########################

    for i in range(2):
        print ("In graph {0}, candidate {1} wins by {2} votes".format(
                i+1, winners[i][0], abs(winners[i][1])))
```

2. TV Advertising [10 Points]

In [6]:

```
#Q2
def Q2sim(Graph, k):
    """
    Function to simulate the effect of advertising.(Please use the appropriate utitlity function(s
) as required.)
    Args: Graph: snap.PUNGraph object representing an undirected graph
          k: amount to be spent on advertising
    Returns: margin: The number of votes by which A wins (or loses), i.e. (number of
             votes of A - number of votes of B)
    """
    margin = None
    ### Add your code here.[3 Points]
    init_pref= initial_voting_state(Graph)
    end= int(3000 + (k/100))
    for i in range(3000,end):
        init_pref[i]="A"

    pref= iterate_voting(Graph, init_pref)
    w, margin= winner(pref)
    ########################
    return margin

def find_min_k(diffs):
    """
    Function to return the minimum advertising amount needed for A to win.
    Args: diffs: list of (k, diff), where diff is the value by which A wins
                (or loses) i.e. (A-B), for that k.
    Returns: min_ad_amount: The minimum amount needed for A to win

    """
    min_ad_amount = None
    ### Add your code here.[3 Points]
    for diff in diffs:
        if diff[1]>0:
            min_ad_amount= diff[0]
            break
    ########################
    return min_ad_amount

def make_plot(res, title):
    """
    Function to plot the amount spent(x-axis)(for values k = 1000; 2000; : : : ; 9000)
    and the number of votes the candidate A wins or loses(A-B) by(y-axis).
    Args: res: The list of 2 sublists for 2 graphs. Each sublist is a list
                  of (k, diff) pair, where k is the amount spent, and diff is
                  the difference in votes (A-B).
         title: The title of the plot
    Note: For Graph 1 please use green color and label it as 'Graph1' and for graph2 use red color
and label it as 'Graph2'
    """
    Ks = [[k for k, diff in sub] for sub in res]
    res = [[diff for k, diff in sub] for sub in res]
    plt.plot(Ks[0], [0.0] * len(Ks[0]), ':', color='black')
    ### Add your code here.[2 Point]
    plt.plot(Ks[0], res[0],color="green", label="Graph1")
    plt.plot(Ks[1], res[1],color="red", label="Graph2")
    ########################
    plt.xlabel('Amount spent ($)')
    plt.ylabel('#votes for A - #votes for B')
    plt.title(title)
    plt.legend()
    plt.show()

def Q2():
    """
    Function to carry out part 2.(Please use the appropriate utitlity function(s) as required.)
    You should be carrying out the following steps:
    1) Load the graphs.
    2) Run Q2 Simulations(for details please refer to the question) and find the vote
difference(A-B) for each k
    3) Find the minimum amount needed for 'A' to win the election.
    4) Plot $k (the amount you spend) on the x-axis (for values k =
       1000; 2000; : : : ; 9000) and the number of votes for A minus the number of votes for B on
the y-axis.
    """
    print ("\nQ2:")
    res = None #To be used by make_plot(), check it's documentation for details
    Ks = [x * 1000 for x in range(1, 10)] #List of possible ad amounts.
    ### Add your code here.[2 Points]
    sl1=[]
    sl2=[]
    g1=read_graph("graph1.txt")
    g2=read_graph("graph2.txt")
    for k in Ks:
        d1= Q2sim(g1, k)
        d2= Q2sim(g2, k)
        d2= Q2sim(g2, k)
        sl1.append((k,d1))
        sl2.append((k,d2))
    res=[sl1,sl2]
    mk1=find_min_k(sl1)
    mk2=find_min_k(sl2)
    min_k=[mk1,mk2]
    ########################

    for i in range(2):
        print("On graph {0}, the minimum amount you can spend to win is {1}".format(i + 1, min_k[i]
))

    make_plot(res, 'TV Advertising')
```

3. Wining and Dining [6 Points]

3-A. Utility Functions

For this part you should complete the following utility functions:

1. sort_nodes_by_popularity

3-B. Part 3 Simulation

In [7]:

```
#Q3
def Q3sim(Graph, k):
    """
    Function to simulate the effect of a dining event(Part 3).

    Args: Graph: snap.PUNGraph object representing an undirected graph
         k: amount to be spent on the dining event
    Returns: margin: The number of votes by which A wins (or loses), i.e. (number of
            votes of A - number of votes of B)

    """
    margin = None
    ### Add your code here.[4 Points]
    init_pref= initial_voting_state(Graph)
    ids, degrees= sort_nodes_by_popularity(Graph)
    end= int(k/1000)
    for i in ids[:end]:
        init_pref[i]="A"

    pref= iterate_voting(Graph, init_pref)
    w, margin= winner(pref)
    ########################
    return margin

def Q3():
    """
    Function to carry out part 3.(Please use the appropriate utitlity function(s) as required.)
    You should be carrying out the following steps(Similar to part 2):
    1) Load the graphs.
    2) Run Q3 Simulations(for details please refer to the question) and find the vote
difference(A-B) for each k
    3) Find the minimum amount needed for 'A' to win the election.
    4) Plot $k (the amount you spend) on the x-axis (for values k =
       1000; 2000; : : : ; 9000) and the number of votes for A minus the number of votes for B on
the y-axis.
    """
    print ("\nQ3:")
    Ks = [x * 1000 for x in range(1, 10)] # List of amount of $ spent
    ### Add your code here.[2 Points]
    sl1=[]
    sl2=[]
    g1=read_graph("graph1.txt")
    g2=read_graph("graph2.txt")
    for k in Ks:
        d1= Q3sim(g1, k)
        d2= Q3sim(g2, k)
        sl1.append((k,d1))
        sl2.append((k,d2))
    res=[sl1,sl2]
    mk1=find_min_k(sl1)
    mk2=find_min_k(sl2)
    min_k=[mk1,mk2]
    ########################
    for i in range(2):
        print("On graph {0}, the minimum amount you can spend to win is {1}".format(i + 1, min_k[i]
))

    make_plot(res, 'Wining and Dining')
```

4. Analysis[6 Points]

In [8]:

```
#Q4
def get_degree_frequencies(Graph):
    """ Function to return all distinct degree values and frequencies of those degree
values(fractional)

    Args: Graph: snap.PUNGraph object representing an undirected graph
    Returns: degrees: List of degrees(no duplication)
             frequencies: List of frequencies: frequencies[i] = fraction of nodes with degree degre
es[i]
    """

    degrees, frequencies = [], []
    ### Add your code here.[3 Points]
    counts=[]
    for i in range(Graph.GetNodes()):
        NI=Graph.GetNI(i)
        counts.append(NI.GetOutDeg())
    degrees, frequencies = np.unique(counts, return_counts=True)
    frequencies=list(np.array(frequencies)/np.sum(np.array(counts)))
    ########################
    return degrees, frequencies

def Q4():
    """
    Function to plot the distributions of two given graphs on a log-log scale.
    You should be carrying out the following steps:
    1) Load the graphs.
    2) Get degrees(sorted) and the corresponding frequencies and plot them(loglog plot) for both t
he graphs.
    Note: For Graph 1 use green color and label it as 'Graph1' and for graph2 use red color and la
bel it as 'Graph2'

    """
    print ("\nQ4:")
    ### Add your code here.[3 Points]
    g1=read_graph("graph1.txt")
    g2=read_graph("graph2.txt")
    d1,f1= get_degree_frequencies(g1)
    d2,f2= get_degree_frequencies(g2)
    plt.loglog(d1, f1,color="green", label="Graph1")
    plt.loglog(d2, f2,color="red", label="Graph2")
    ############################################################################
    plt.xlabel('Node Degree (log)')
    plt.ylabel('Proportion of Nodes with a Given Degree (log)')
    plt.title('Degree Distribution for Graphs 1 and 2')
    plt.legend()
```

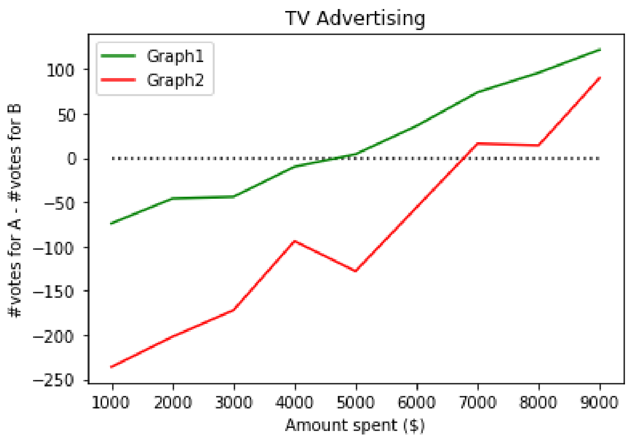
In [9]:

```
def driver():
    Q1()
    Q2()
    Q3()
    Q4()
```

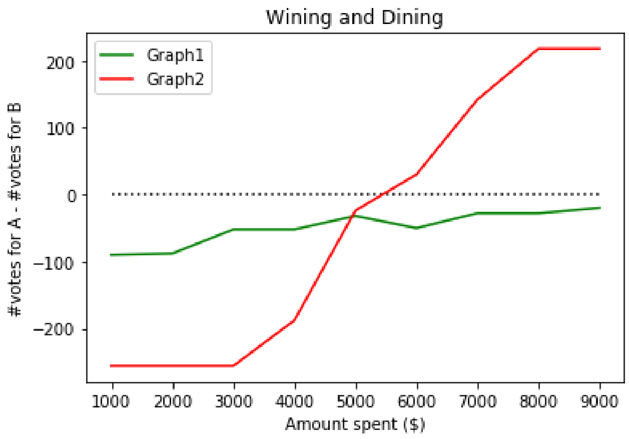
In [10]:

```
driver()
```

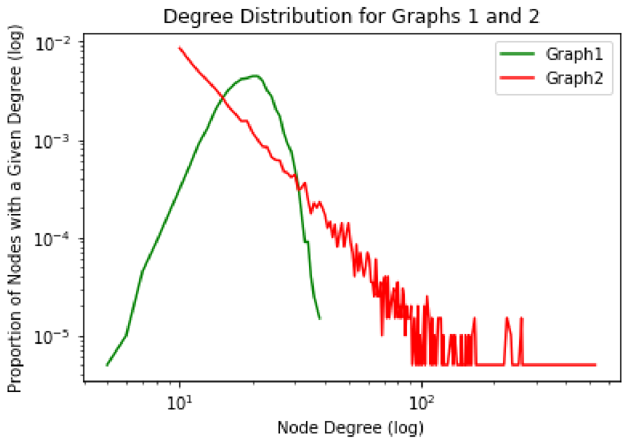
```
Q1:
In graph 1, candidate B wins by 96 votes
In graph 2, candidate B wins by 256 votes

Q2:
On graph 1, the minimum amount you can spend to win is 5000
On graph 2, the minimum amount you can spend to win is 7000
```



```
Q3:
On graph 1, the minimum amount you can spend to win is None
On graph 2, the minimum amount you can spend to win is 6000
```



```
Q4:
```



1.4 Analysis:

Clearly from the node degree distribution, we can see that graph 1 follows a normal distribution where as graph 2 follows a pareto distribution. Therefore, in graph 2, the few highest degree nodes account for a lot more percentage of total node degrees than in graph 1, which is why the high roller strategy in 1.3 was more successful with graph 2, as the highest nodes had significantly more connections, and therefore, more influence.

Deliverables

Run your solved template(make sure all cell outputs are printed as required), convert it into pdf format, rename it to {gt_username}_hw3_q1_cse6240.pdf(e.g. pburdell3_hw3_q1_cse6240.pdf) Add both the .ipynb and .pdf file to the folder {gt_username}_hw3_cse6240, zip it and submit on canvas .[-5 if any instruction is not follwed properly]

{gt_username}_hw3_cse6240 >

1. {gt_username}_hw3_q1_cse6240.ipynb
2. {gt_username}_hw3_q1_cse6240.pdf