CSC 539 Computational Epidemics
Summer 2022
Jackson State University
Exam 3
Instructor: Dr. Natarajan Meghanathan

Total Points: 125 **Due: July 27th, 2022, 11.59 PM in Canvas**

Q1: 10 pts) Consider a social network of 150 nodes that is vulnerable to the spread of a virus under the SIS model. If the spreading rate of the virus is 0.5, what is the maximum number of links that can be allowed among the nodes in the social network so that the virus spread will die down on its own and not become an endemic in the long run?

Q2: 20 pts) Consider a social network of 100 nodes with 250 links. Consider the spread of a contagion under the SIS model in this social network such that at least one node will remain "infected" in the endemic state. If the link infection probability is 0.05, what is the minimum expected value for the number of days (an integer value) it would take for the infection to recover?

Q3: 30 pts) Consider the following degree distribution for a scale-free network and a simulation of the SIS model on this network with a spreading rate of 0.6. Determine the following:

- The degree exponent, γ
- The fraction of infected neighbors of the susceptible nodes in the endemic state.
- The fraction of infected nodes in the endemic state.

K	P(K)
1	0.750
2	0.133
3	0.048
4	0.023
5	0.013
6	0.009
7	0.006
8	0.004
9	0.003
10	0.002

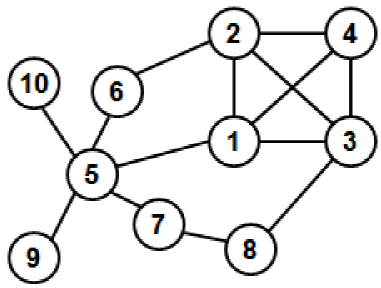
Q4: 30 pts) Consider a scale-free network modeled using the power-law, $P(K) = CK^{-\gamma}$. Upon an analysis of the degree distribution, it was observed that approximately 4% of the nodes are with degree 5 and 12% of the nodes are with degree 3. Using the above information, determine the degree exponent γ and the proportionality constant C.

- Let the kmin value for the network be the smallest K value for which $P(K) \leq 1$. Using the above results, determine the Kmin value for the above network.

- Assume the SIS model is simulated on the above scale-free network and the network has reached an endemic state with 1% of the nodes observed to have been infected. Determine the spreading rate λ and the fraction Θ of infected neighbor nodes for the susceptible nodes.

- Using the above information and the results obtained, what can you say about the average degree of the nodes in the scale-free network?

Q5: 35 pts) Consider the graph given below.



Simulate the working of the <u>SIS model</u> on the graph with **node 2 as the initially infected node** in round 0 and the rest of the nodes are susceptible. As shown in the slides, show the status (susceptible or infected) of the nodes at the beginning and end of each round. For each round, show the nodes that become infected or stay susceptible. The duration of infection is $1/\mu = 2$ rounds and the link infection probability (β) is 0.5. **Continue your simulations until each node in the graph has been infected at least once.**

Generate random numbers in Excel for each round for each link and include them as part of your answer. Use the random numbers generated for each link and the link infection probability to decide which nodes become infected in a round.

A node chosen to get infected during a round is considered to have become infected at the end of the round and stays infected for the next $1/\mu$ rounds, and is considered to recover in the beginning of the subsequent round. For example, with $1/\mu = 2$ rounds, a node infected in round 1 will stay infected for the complete execution of rounds 2 and 3, and will recover at the beginning of round 4.

a) Show the changes in the status of the nodes for each round, keep track of the nodes supposed to recover at the beginning of a round as well as nodes that get infected at the end of a round.

b) For each of the degree values observed for the nodes in the network, determine the average number of rounds the nodes of a certain degree stay infected. Interpret the results for any pattern of increase or decrease with node degree.

c) Show the total # nodes (vs. the round #) that are infected at the end of each round. Interpret the results for any pattern of increase or decrease with the round #.