2020 NetSci Final Exam

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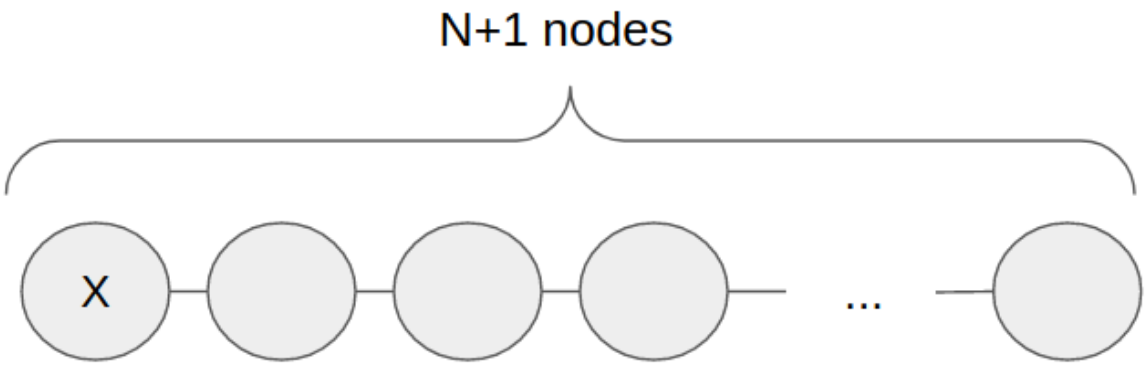
* Required

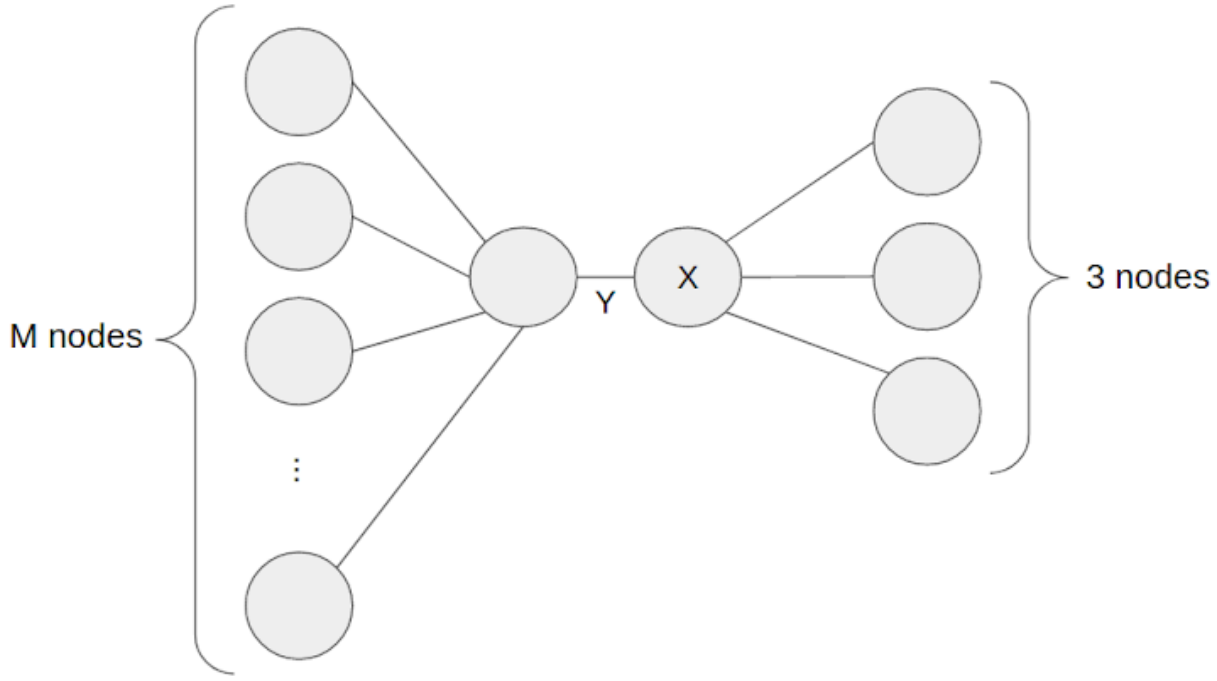
1. Email *

Figure 1.



2. Q1 [1 point]. Consider the graph of Figure 1, which is formed by N+1 nodes arranged on a line. Indicate the closeness of the node marked with an "X".

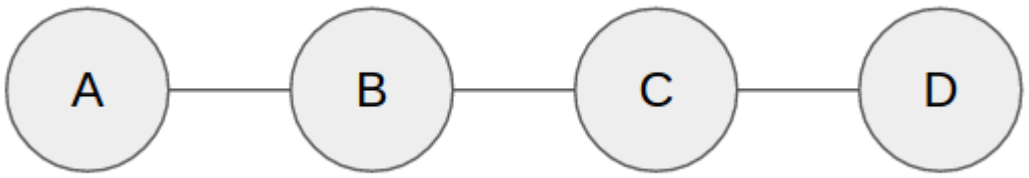
Figure 2.



3. Q2 [1 point]. Consider the graph in Figure 2, which is formed by M+5 nodes. Indicate the edge betweenness of the edge marked with a Y.

4. Q3 [1 point]. Consider the graph in Figure 2, which is formed by M+5 nodes. Indicate the node betweenness of the node marked with an X.

Figure 3.



5. Q4 [2 points]. Consider the graph in Figure 3. Use Brandes-Newman's algorithm to compute the edge betweenness of each edge in the graph. Indicate clearly your final answer.

   Files submitted:

Figure 4.

$$min \sum_{(i,j)\in A} k_{ij} y_{ij}$$

$$u_i - u_j + y_{ij} \geq 0, (i,j) \in A$$

$$y_{ij} \geq 0$$

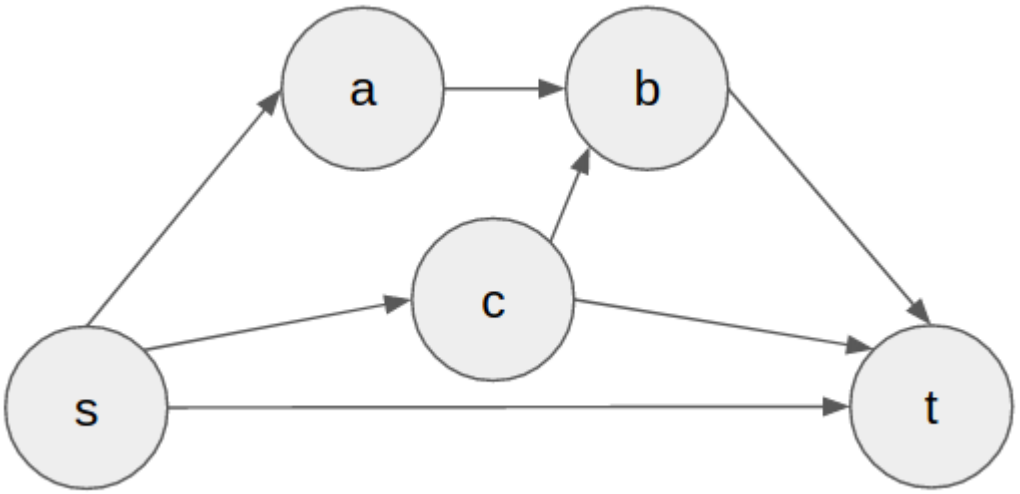
$$u_s = 0, u_t = 1$$

6. Q5 [1 point]. In class we studied the min-cut algorithm as the dual of the max-flow algorithm, with the system of equations indicated in Figure 4. Indicate the meaning of each variable.

   Mark only one oval per row.

	Flow going through an edge	Side of the cut to which nodes belong	Whether an edge belongs to the cut	Whether a node's net flow is zero	Indicators of the source and target nodes	Capacity of an edge
Variables k_ij	◯	◯	◯	◯	◯	◯
Variables y_ij	◯	◯	◯	◯	◯	◯
Variables u_i	◯	◯	◯	◯	◯	◯

Figure 5.



7. Q6 [1 point]. By visual inspection, what is the minimum cost of an (s-t)-cut in the graph of Figure 5, if each edge has cost 2?

8. Q7 [1 point]. Run one iteration of the randomized (s-t)-cuts algorithm and indicate the cost you find on Figure 5, assume this time that each edge has cost 1.

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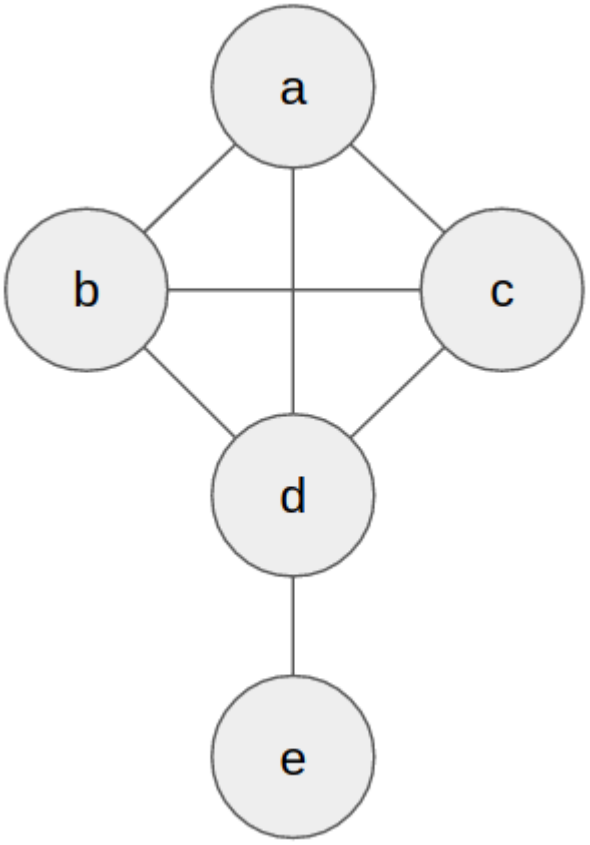
9. Q8 [1 point]. In the graph of Figure 3 (line graph with 4 nodes), if you run k-core decomposition, how many nodes are in the 2-core?

Figure 6.



10. Q9 [2 points]. Draw the construction on Goldberg's dense subgraph algorithm for the graph on Figure 6. Use such construction to answer the question on whether the graph has a dense subgraph of density 3 (that is a subgraph S such that d(S) = 2 |E(S,S)| / |S| = 3). Your answer must include (i) the construction with edge weights clearly indicated, (ii) the cut you find and its cost, which should be less than 2|E|=14, (iii) the set of nodes in the dense subgraph S you find. Mark these with (i), (ii), (iii) in your drawing.

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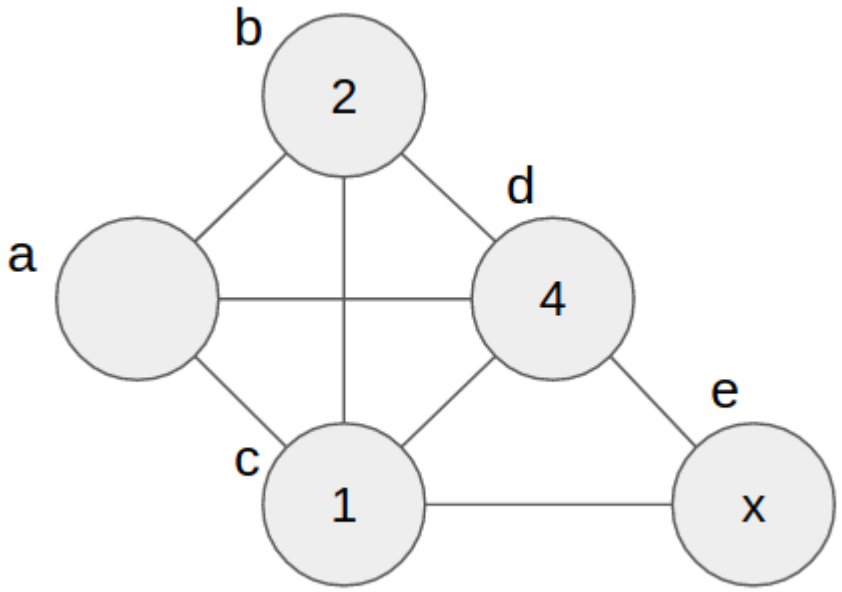
11. Q10 [1 point]. Run one iteration of Charikar's randomized algorithm for densest subgraph, indicating the density (|E|/|V| in Charikar's algorithm) of the subgraph you found. Indicate clearly the list of nodes in the densest subgraph and its density.

    Files submitted:

Figure 7.



12. Q11 [1 point]. In Figure 7, we want to run the Linear Threshold model. Each edge has weight 1, and each node has the threshold indicated inside it (node b has threshold 2, node c has threshold 1, node d has threshold 4, node e has threshold x). The infection starts with node *a* infected. What is the minimum value that x must take if we want node *d* to get infected?

13. Q12 [1 point]. In the graph of Figure 3 (line graph with 4 nodes), under the Independent Cascade node with an infection starting at node A, and assuming each edge has infection probability p, what is the probability that node C gets infected, but not node D?

14. Q13 [1 point]. Under the SI model, the number of new infected per unit of time, di(t)/d(t), is a function of i(t), <k> and b, where i(t) is the fraction of nodes infected, <k> is the average degree, b is the probability that a contact causes an infection. What are the 4 possible ways in which the number of new infected per unit of time can become zero? (Write a brief, precise answer, please)

15. Q14 [1 point]. Under the SIS model, an infection can become endemic. What does this mean? What are the three main elements that affect the final number of infected in the endemic state? (Write a brief, precise answer, please)

16. Q15 [1 point]. What is the characteristic time ("tau") of an infection, precisely? How does it differ between a random network (ER) and a scale-free network with exponent gamma less than 3? (Write a brief, precise answer, please)