INDIAN INSTITUTE OF TECHNOLOGY, KHARAGPUR

Date 24.04.2006 AN *Time:* 3 Hrs. *Full Marks* **50** *No. of Students:* **19**
Spring Semester:, 2006 Department: Computer Science and Engineering Sub. No: CS 60078
4^{th} **and** 5^{th} Year Sub. Name: Complex Network

Instructions : Answer at least 50 marks. If you get ≥ 50, your marks gets reduced to 50, if you get < 50, it stays as it is. **Please write short and precise answers.**

1. Write down the algorithm of Tabu Search in not more than 5 steps. (2)
2. Take the problem where we have to find the ideal sequencing of 1 to 7. Each sequence (say) η = 1, 5, 4, 6, 2, 7, 3 produces a value f(η). Show (with illustration) how the above Tabu search algorithm will be implemented here. Show it within four iteration steps. (4)
3. Consider the table

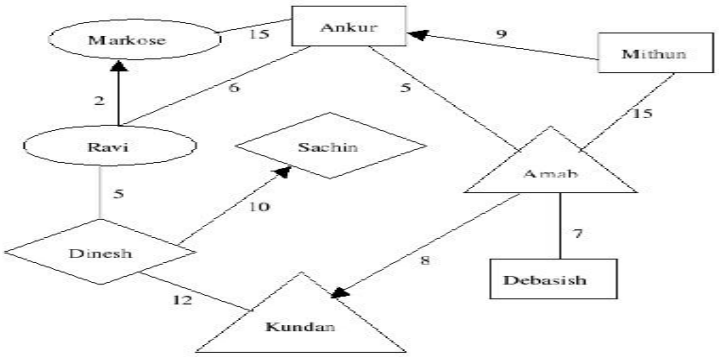
		Women			
		black	Hispanic	white	other
M	black	506	32	69	26
e	Hispanic	23	308	114	38
n	white	26	46	599	68
	other	10	14	47	32

   Derive the normalized mixing matrix and hence derive the associativity coefficient from the above matrix. (3)
4. Suppose that in a community of 1000 people, each person knows between zero and five of the others, the exact number of people in each category being, from zero to five: {86, 150, 363, 238, 109, 54}. Suppose that in a community of 1000 people, each person knows between zero and five of the others, the exact number of people in each category being, from zero to five: {86, 150, 363, 238, 109, 54}. Write the generating function of the corresponding graph as well as calculate the mean of the degree distribution, the probability p_k, and n^{th} moments. (3)
5. Find the clustering coefficient of a regular one dimensional lattice having $2k$ neighbors, k on each side of the lattice. (4)
6. State the algorithm of Albert Barabasi growth model for powerlaw graphs in clear defined steps. (2)
7. Derive the formula $p_k \propto k^{-3}$ (p_k - the probability of a node having degreee k) applicable for Albert Barabasi growth model. (5)
8. State the algorithm of Watts and Stogartz small-world model. (2)
9. Derive the phase transition equation $\sum_k k(k-2)p_k = 0$ related to random graphs for giant component formation, using generating function formalism. (6)

10. State the algorithm of configuration model (forming graph of any arbitrary degree sequence) in 2-3 steps. (2)

11. What are the different kinds of data objects in Pajek? Explain in a single line each of these data objects. You can give examples if necessary. (4)

12. Give a Pajek equivalent representation of the following network. (3)



13. Consider the following network in Pajek representation

*Vertices	9
1	"a"
2	"b"
3	"c"
4	"d"
5	"e"
6	"f"
7	"g"
8	"h"
9	"i"

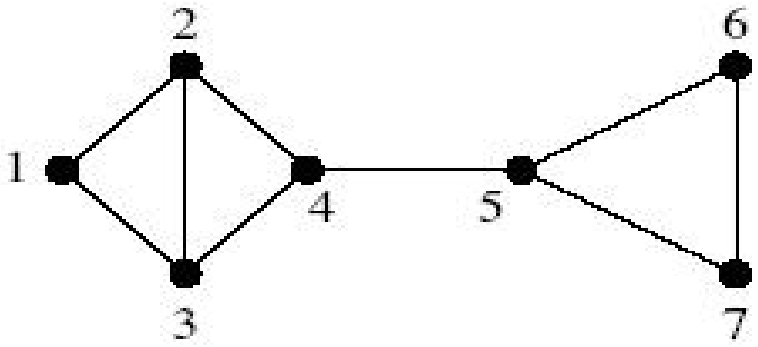
*Edges	
1	2
2	3
3	4
4	5
5	6
6	7
7	8
8	9

(a) What kind of a network is the above? What is the betweenness centrality of the node labeled 'c'? (1.5)

(b) You can find the shortest path between nodes 'b' and 'f' very easily using Pajek. How does Pajek represent this output shortest path? (1.5)

14. Analytically derive the formula of random walk betweenness for an edge(u,v). (5)

15. Consider the following network



(a) Find the structural similarity matrix M for this network where structural similarity is calculated using Pearsons correlation coefficient. (3)

(b) Using M show the steps of hierarchical clustering for this network. (3)

(c) Compute the edge-betweenness for each edge of this network. What happens when the edge with highest edge-betweenness is removed? (3)

(d) Explain the Radicchi et al algorithm with the help of this network. (3)