M.Sc. Qualification exam - spring 2009

Date: 24.04.08
Time: 3 hours
Answer **4 out of 5 questions**

Important: In the following table, circle the numbers of the four questions you chose to answer

Question	Grade
1	**/25**
2	**/25**
3	**/25**
4	**/25**
5	**/25**

Question 1: Algorithms (Tami)

In each of the following questions, there is a list of conditions for a graph $G= (V,E)$ over $V=\{a,b,c,d,e\}$. You have to draw a graph fulfilling all the conditions (simultaneously), or explain why such a graph does not exist. If a graph exists, explain why the graph you draw fulfills the conditions. Each question worth 6 pts. One bonus point will be given for choosing this question.

1.

a. G is an undirected graph having an Euler path.
b. In any execution of *BFS(a)*, in the resulting spanning tree, $degree(a)=3$ and $degree(b)=1$.
c. In any execution of *DFS(a)*, in the resulting spanning tree, $degree(a)=1$ and $degree(b)=3$.

2.

a. G is a simple (no self loops, no parallel edges) undirected graph.
b. All edges have the same weight, for any edge (u,v), $w(u,v)=1$.
c. $|E|=5$
d. G has exactly two different minimum spanning trees.

3.

a. *G* is a simple (no self loops, no parallel edges) directed acyclic graph.
b. *a,b,c,d,e,* is a topological sort of *G*.
c. *Out-degree(b)=In-degree(b)*
d. *Out-degree(d)=In-degree(d)*
e. *|E|=8*

4.

a. G is a directed acyclic graph, describing a flow network.
b. *a* is the source, *e* is the target. *In-degree(a)=Out-degree(e)=0.*
c. All edges have the same capacity, for any edge *(u,v), c(u,v)=1*.
d. The maximum flow in the graph has value *3*.
e. For exactly one edge in the network the following holds: If the capacity of the edge is increased by x, then the value of the maximum flow in the resulting network is increased by x.

Question 2: Operating System (Anat)

Write a pseudo code for three processes using semaphores as the only synchronization tool. State the initialization value of each semaphore. You can use as much semaphores as you like.
The three processes should run infinitely according to the following scenario.
- Process 1 begins to run.
- When process 1 finishes to run, then both process 2 and process 3 can start to run.
- When processes 2 and 3 finish their run, process 1 can start running again.

Question 3: Computer Networks (Gadi)

Consider a client that wants to retrieve a Web document at a give URL. The client initially knows the IP address of the Web server. The (html) document has **17** embedded GIF images. **13** of these images do not reside at the same sever as the original document, and they reside at **12** different servers. The client initially knows all the IP addresses of the servers. Suppose the time needed to contact and receive a reply from any server is one RTT. Assume that persistent connections with no pipelining, and with parallel connections are used. How many RTT's are needed at least from when the user first enters the URL until the complete document (including the images) is displayed at the client? Justify your answer.

Question 4: Computability and Complexity (Alon)

a) Define the classes NP and coNP.
b) Does coNP have a complete problem? Justify your answer.
c) Prove or disprove:
   I. If P = NP then NP = coNP.
   II. P is not contained in the intersection of NP and coNP.
   III. The class coNP is contained in the class PSPACE.

<u>Question 5</u>: Data structures (Arik)

You are given a set of n real values v_i i=1…n, and a range [a,b] where a,b are also real numbers.

1. Give an algorithm (pseudo code) to find which values (and how many) fall within this range (i.e. a <= v_i <= b)? What would be its worst case complexity?
2. Assume you need to apply this query many times on the same set of values but for different ranges [a,b] – would you use a different algorithm? If so, describe the algorithm (no need for sedudo-code), and explain how would you store the values v_i i=1…n? What would be its worst case complexity?
3. Assume that you are given n 2D points instead of real values. Describe an algorithm (no need for sedudo-code) to find all points that fall within a given rectangle [a,b]x[c,d]. What would be its worst case complexity?

G O O D L U C K