BIRLA INSTITUTE OF TECCHNOLOGY AND SCIENCE PILANI, PILANI CAMPUS

First Semester 2017-18, Comprehensive exam

G626: Hardware Software Co-design.

Duration: 3 hours **Date of exam:** 11/12/2017 **Max. Marks: 70**

Please read all questions carefully. Answer in as much detail as asked for.

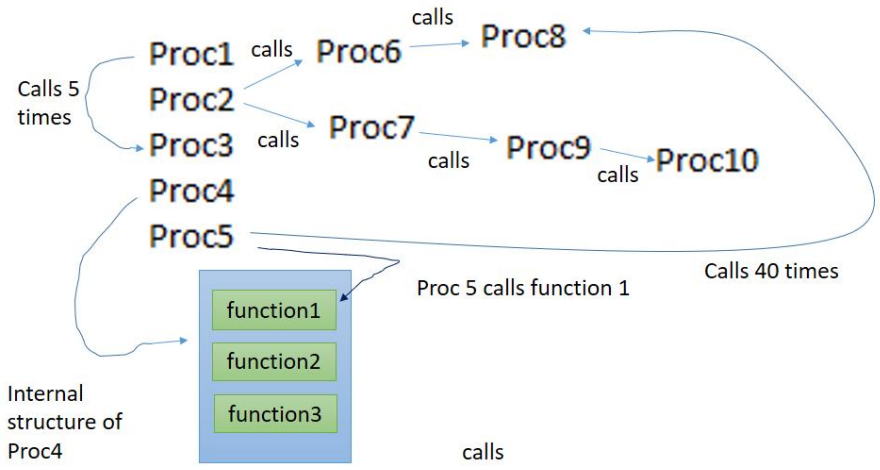
[Closed Book] – 52 marks

Q1. Answer the following questions [4 marks]

a. What is hardware Software Co-design? [1]
b. What are its advantages over traditional design methodology? [1]
c. Draw the flow diagram showing the different steps involved in HW-SW Codesign ? [2]

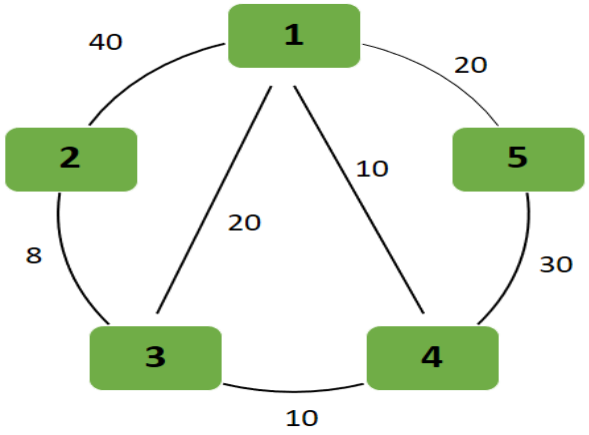
Q2. Answer the following questions [10]

a. Draw the flow diagram of the three step partitioning methodology proposed by Frank Vahid? [2]
b. How is clustering different from granularity selection and N-way assignment? [2]
c. Explain the following terms and their effect on granularity. [3]
   i. Procedure exlining
   ii. Procedure inclining
   iii. Procedure cloning
d. Consider the following process having different sub-procedures as shown below. Apply each of the above three in part (c) to the most suitable places within the process [3]



Q3. Answer the following questions [5]

a. Mention some advantages of Hierarchal clustering? [1]
b. Apply hierarchical clustering to the following topology. The weights indicated on the links in the topology indicate the closeness function. During clustering assume the modified closeness function to be the arithmetic mean of the prior weights (as discussed in the class too). [3] At the end summarize the existing clusters at the different steps/points in the clustering. [1]



Q4. Consider the partitioning problem where you have N objects (o_1, o_2, …, o_n, …. , o_N) to be assigned to K partitions where the partitions are given by (p_1, p_2… p_k, … p_K). The cost if object o_n is assigned to partition p_k is given by $c_{n,k.}$

Given that your objective is to minimize the overall cost of the system and an object is assigned to only one partition and a partition cannot accommodate more than **h** number of objects, formulate the petitioning problem as a Linear Integer Programming problem (which can be input to a LP tool). [4 marks]

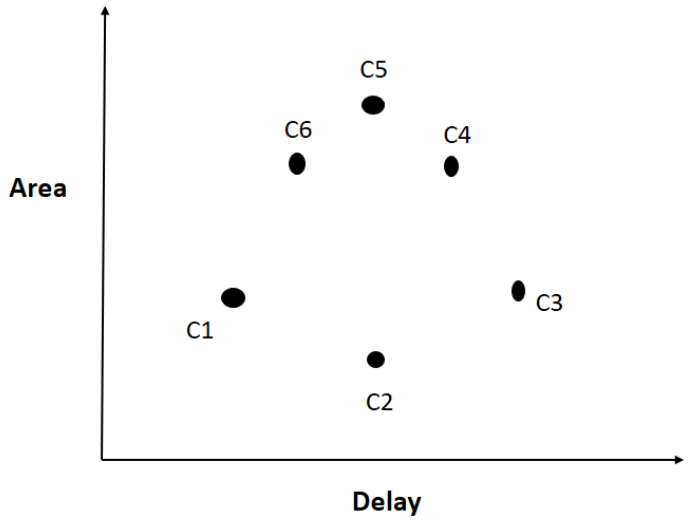
Q5. Answer the following [5 marks]

a. Why do we need performance estimation? [1]
b. Describe four ways/methods by which one can do system's performance estimation? [2]
c. Differentiate between Static analytic models and Dynamic analytic models for performance estimation giving examples and highlighting their features. [2]

Q6. Answer the following [7 marks]

a. Define pareto dominance? [1]
b. What are pareto optimal points and what is the benefit of noting which all points are pareto optimal in the course of finding the optimal solution. [1]

c. Identify the pareto optimal points in the following graph [2]



d. You are given the task of writing a pseudo code to evaluate the pareto optimal points in the following scenario where you have been given 10 different possible partition configurations and 3 parameters are evaluated (delay(**D**), area (**A**) and power (**P**)) for each of them as shown in the table below. Write a pseudo code (in logic language) to evaluate the pareto optimal points among the different configurations. (Note: you just need to write the pseudo code and not do any mathematical calculations for this part). [3 marks]

Configuration	Delay (D)	Area (A)	Power (P)
C1	0.2980943	2.045916	0.339449
C2	0.3572273	1.56495	0.77384
C3	4.0907428	2.452641	5.779517
C4	0.7493272	1.978816	4.14876
C5	4.8648728	1.946974	6.402645
C6	2.2689885	1.297175	6.60251
C7	0.4173491	0.399513	1.387109
C8	1.954689	2.494139	6.426915
C9	0.3023559	1.197773	4.215007
C10	2.0839973	1.97058	5.023787

Q7. Answer the following [5 marks]

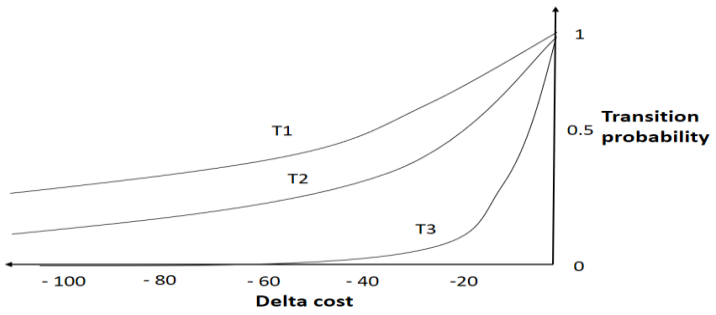
a. Simulated Annealing is a technique which is at times applied to partitioning. How does it give better performance as compared to greedy heuristic approach? [1]

b. What is the underlying philosophy of Simulated Annealing [Hint: $P(e_i, e_{i+1}, T) = e^{\frac{e_i - e_{i+1}}{k_B T}}$] [1]

c. Consider the following table for different configurations in which partitioning can be done (i.e. different objects/functions mapped to different partitions). The cost is evaluated as C = D + A + P. Evaluate the following state transition probabilities given that the Boltzmann constant for the simulated annealing is taken as 0.3 and the temperature is taken as 100 K.
   i. P (C2, C8) [1]
   ii. P (C2, C1) [1]

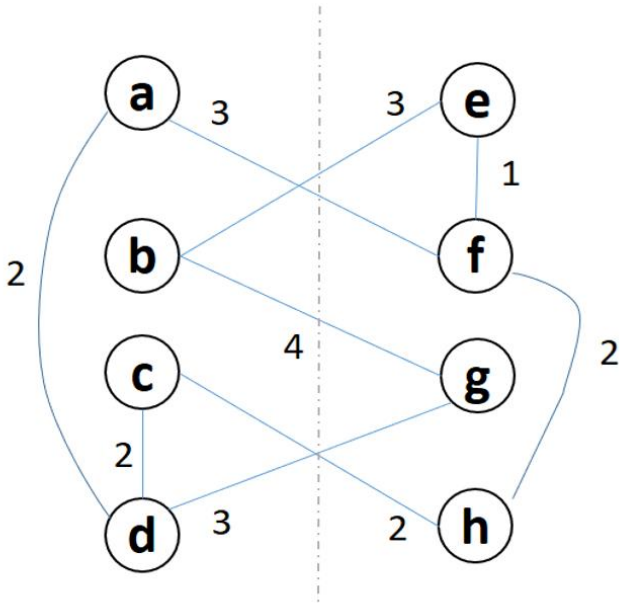
Configuration	Delay (D)	Area (A)	Power (P)
C1	5	10	5
C2	15	20	10
C3	20	15	15
C4	6	30	20
C5	15	10	10
C6	20	6	8
C7	25	5	5
C8	30	25	20

a. Given the following graph showing the relationship between the delta cost (i.e. cost difference between a state and next state) and the probability of transition, which of the following is true [1]
   i. T1= 100K, T2= 50K, T3= 10K
   ii. T1=10K, T2= 50K, T3= 100K
   iii. T1= 50K, T2= 100K, T3= 10K
   iv. T1= 10K, T2= 100K, T3= 50K



Q8. Answer the following questions [12 marks]

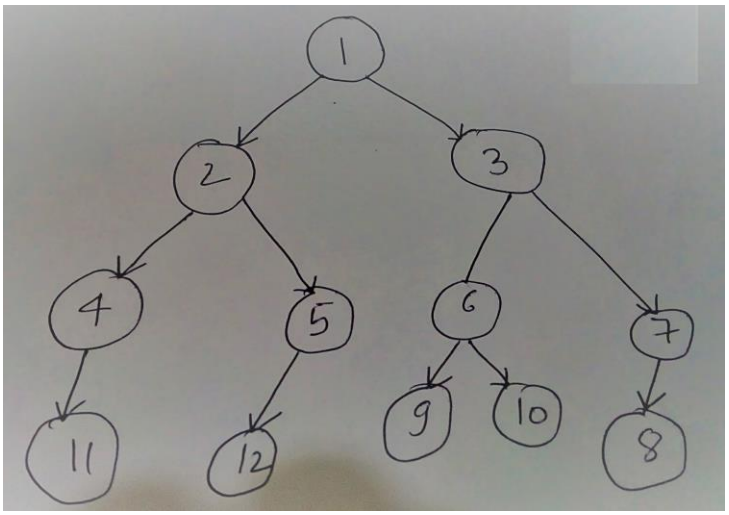
a. What is the basic principle of KL algorithm ? [1 marks]
b. Consider the problem of partitioning nodes in a process into two partitions.The process has 8 functions (nodes) with the cost function between the different nodes indicated on the links shown below. Apply KL algorithm to the following process and show the swapped nodes and evaluate the cutsize at every step of KL algorithm [6+2]. Evaluate the optimal partitioning after one pass of KL algorithm (i.e. after all the nodes have undergone swapping) [2]. Assume the initial partition for the KL algorithm as shown below.



[OPEN BOOK] - 18 marks

Q1. [10 marks] GCLP is a popular partitioning/mapping algorithm which is used in the opensource codesign tool *Ptolemy*. Consider the following application graph and the parameters associated with each of the nodes.

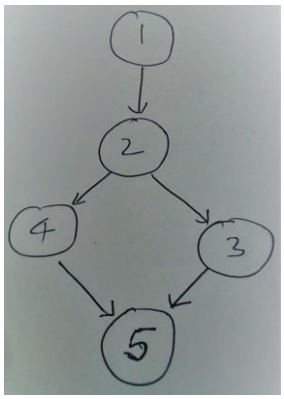
node	ts_i	th_i	BLIM_i	ah_i	size_i
1	5	1	0.5	50	100
2	12	8	0.1	40	200
3	15	5	0.5	150	500
4	4	1	0.6	16	50
5	6	3	0.3	120	80
6	5	4	0.1	80	60
7	8	2	0.7	60	180
8	9	2	0.8	20	150
9	2	1	0.3	15	50
10	2	1	0.3	15	40
11	10	5	0.4	50	50
12	4	2	0.2	120	100



a. Identify the hardware extremity nodes and the software extremity nodes given that α = 33.34 percentile and β= 33.34 percentile. [3]
b. Evaluate the extremity measure for the extremity nodes identified in the previous part [3].
c. Given that the software repeller property considered is Bit level instruction mix (BLIM_i) and the hardware repeller property considered is ah_i (hardware area), evaluate the repeller value R_i for all the nodes. [4]

Q2. [8 marks] Consider the application graph shown below with 5 nodes and the parameters associated with the different nodes shown in the table below. Given α = 20 percentile and β= 20 percentile and the priority function for moving from s/w to h/w is given as **pf**= 2 ts_i + 4 (ts_i/th_i) + 50/ah_i. Further the time deadline given by the client is 30 s. Answer the following:

a. Identify the h/w and s/w extremity nodes. [2]
b. Neglect repeller properties (repeller measure). Assume that initially all nodes are unmapped. Solve for the first two mappings done by the *GCLP algorithm* and indicate the ready nodes at each step of the GCLP algorithm. [5 + 1]



node	ts_i	th_i	ah_i	size_i
1	5	1	50	300
2	12	8	40	400
3	15	5	150	500
4	4	1	16	50
5	6	3	120	80