Introduction to Electronic Design Automation

Spring 2014
National Taiwan University

Problem Set 1

Due on 2014/04/07
Please drop your solution in the instructor's mail box at EE2 building by 17:30

1 [Design Flow]

(10%) Please sketch the typical synthesis flow of VLSI design, and describe the synthesis tasks at every stage.

2 [Design Style]

(10%) Suppose you are to choose a best design style, either full custom, ASIC, or FPGA, given the following constraints.

- Expected market price: $50 per chip
- Expected product volume: 100,000,000
- Market loss: $1,000,000 per month delay
- FPGA unit cost: $20 per chip
- ASIC unit cost: $0.5 per chip
- Full custom unit cost: $0.1 per chip
- FPGA design time: six months
- ASIC design time: one year
- Full custom design time: three years

What is your choice? Why do you make such a decision?

3 [Algorithm and Complexity]

(20%) Given a sequence of real numbers $a_n, a_{n-1}, \ldots, a_1, a_0$, and a real number x, we would like to compute the value of the polynomial

$$P_n(x) = a_n x^n + a_{n-1} x^{n-1} + \cdots + a_1 x + a_0.$$

(a) **(10%)** Analyze the computational complexity of the recursive computation

$$P_n(x) = P_{n-1}(x) + a_n x^n,$$

where $P_{n-1}(x) = P_{n-2}(x) + a_{n-1}x^{n-1}$, ..., and $P_0(x) = a_0$. In particular, how many multiplications and additions are needed?

(b) **(10%)** Analyze the computational complexity of the recursive computation

$$P_n(x) = x \cdot P'_{n-1}(x) + a_0,$$

where $P'_{n-1}(x) = x \cdot P'_{n-2}(x) + a_1, \ldots$, and $P'_0 = a_n$. In particular, how many multiplications and additions are needed?

4 [(Integer) Linear Programming]

(20%)

(a) **(10%)** Suppose we would like to minimize the objective function

$$\max\{x_1, \ldots, x_n\}$$

subject to a certain set of linear constraints $L(x_1, \ldots, x_n)$ over real variables $x_1, \ldots, x_n$. Please reformulate the problem in terms of linear programming, whose objective function as well as the constraints must be in a linear form.

(b) **(10%)** For a set of linear constraints

$$a_{11}x_1 + \cdots + a_{1n}x_n \geq b_1,$$
$$a_{21}x_1 + \cdots + a_{2n}x_n \geq b_2,$$
$$a_{31}x_1 + \cdots + a_{3n}x_n \geq b_3,$$

suppose we require **at least one** of them to hold. (Assume all the above variables and coefficients are real numbers with absolute values no greater than some bound, say 100.) Please reformulate the requirement in term of mixed integer linear programming (MILP), where real and integer variables may present simultaneously.

5 [Model of Computation]

(20%)

(a) **(8%)** Models of computation are essential to formal system construction, analysis, and verification. Please describe the features of timed automata and Petri nets, and give their application examples.

(b) **(6%)** Please draw a finite automaton that accepts the language $1(00)^*1$.

(c) **(6%)** Consider the state transition graph of Figure 1. Please analyze the system behavior by plotting the value of T over time within 30 seconds, given that $T = 20°C$ initially. (For simplicity, assume a transition is taken immediately when the condition (guard) on the corresponding edge is satisfied.)

6 [Scheduling]

(20%) Given the data-flow graph of Figure 2, assume that multiplication takes 2 clock cycles and addition takes 1 clock cycle. Perform scheduling based on

(a) **(5%)** ASAP scheduling,

(b) **(5%)** ALAP scheduling, and

(c) **(10%)** critical-path list scheduling under the allocation of one ALU (that can perform both multiplication and addition) and one multiplier.

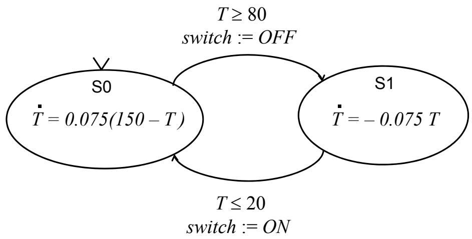

Fig. 1. A hybrid automata.

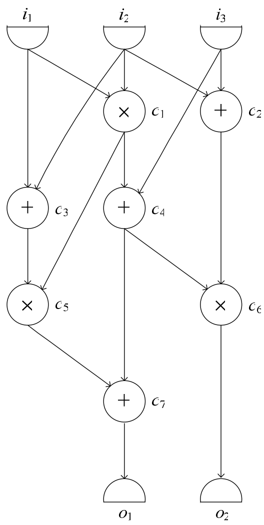

Fig. 2. A data flow graph.