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## CS226 Practice Problem Set 7 (Spring 2016)

Date posted: April 25, 2016

Expected Solving Time: 45 mins

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- *Be brief, complete and stick to what has been asked.*
- *Unless asked for explicitly, you may cite results/proofs covered in class without reproducing them.*
- *If you need to make any assumptions, state them clearly.*
- *All problems in this problem set are for your practice. You need not turn in any of them.*
- *You are strongly encouraged to solve these on your own to ensure you understand the material being taught in class.*

1. Consider the sequential circuit shown in Fig. 1. The state variables of the circuit, as indicated in Fig. 1, are  $x_1, \dots, x_6$ . The circuit has a single primary input named  $i$ . The blue rectangles denote D flip-flops. All the flip-flops are clocked by the same clock, which is not shown to reduce clutter in the figure.

You are told that the circuit can start in any initial state (i.e. valuation of  $x_1, \dots, x_6$ ) that satisfies the formula  $(x_1 + x_2 + x_3) \cdot (x_4 + x_5 + x_6)$ . In other words, the Boolean formula  $(x_1 + x_2 + x_3) \cdot (x_4 + x_5 + x_6)$  represents the set of initial states of the circuit.

You are required to find out the set of unreachable states of this circuit, as a Boolean formula on the variables  $x_1, \dots, x_6$ . Use the method of symbolic forward reachability analysis discussed in class to determine the required Boolean formula.

2. Consider the same sequential circuit, as shown in Fig. 1. You are now told that the initial state of the circuit is  $x_1x_2x_3x_4x_5x_6 = 000000$ . You are also told that the set of “undesirable” states of the circuit (i.e., states in which you would not like the circuit to get into) is given by the Boolean formula  $(x_1 + x_2 + x_3) \cdot (x_4 + x_5 + x_6)$ .

Determine the set of states from which an “undesirable” state can be reached, by using symbolic backward reachability analysis.

Determine whether it is possible to reach an “undesirable” state from the initial state by checking if the initial state lies within the set of backward reachable states computed above.

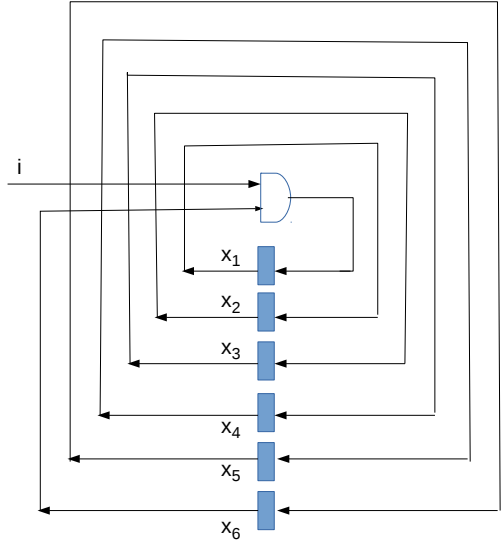


Figure 1: Sequential Circuit