CMPUT 329 - Computer Organization and Architecture II
Midterm Exam — Fall 2000

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Name:

CMPUT 329 Honor Code

By turning in the exam for grading, I certify that I have worked all the solutions on my own, that I have not copied or transcribed solutions from a classmate, someone outside the class, or from any other source. I also certify that I have not facilitated or allowed any of my classmates to copy my own solutions. I am aware that the violation of this honor code constitutes a breach of the trust granted me by the teaching staff, compromises my reputation, and subjects me to the penalties prescribed in Section 26.1 of the University of Alberta 2000/2001 Calendar.

Edmonton, October 23, 2000.

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Question 1 (XX points): [Combinatorial Logic Design: Social Robots] In a research project investigating "social robots", *i.e.* robots whose behavior is influenced on the observation of social insects, Kube and Zhang propose a simple robot model to perform the task of "box pushing" [**?**]. Each robot has two infra-red sensors that detect proximity with objects, SPR, SPL, two photo-cell sensors that detect light SLR, SLL, and two actuators AR and AL, one for the right wheel motor and one for the left wheel motor. The infra-read sensors are used to detect near object collision and trigger the *avoid behavior*. In the experiment, a lamp is put on top of the box to be pushed, therefore, the photo-cell sensors trigger the *goal behavior*. All the sensors and actuators operate with positive logic, i.e., a sensor that is on produces a logic 1, an off sensor produces a logic 0, a wheel motor is turned on when it receives a 1 and it is turned off when it receives a 0 signal. Extensive simulations indicate that good social behavior of a population of these robots is obtained if:

- The right wheel motor is on if the right proximity sensor is not on, or if the right proximity sensor is on and both the left proximity sensor is on and the right light sensor is on.
- The left wheel motor should be on if the right proximity sensor is on and the left proximity sensor is not on, or if the right proximity sensor is on and the left light sensor is also on.

Design the least costly implementation for a logic circuit that implements the social behavior described above. Use the cost criterion presented in class, i.e., the cost of a circuit implementation is proportional to the number of gate inputs. In this case, you should assume that the complement of the signals from the sensors *is not available*, *i. e.* you must also consider the cost of inversors. What is the cost of your implementation?

Current State	Next State		Outputs	
	Go = 0	Go = 1	Light	Beep
North	South	East	0	0
South	West	SW	1	0
East	South	SW	0	0
West	SE	North	0	1
NW	SE	NW	1	1
SW	NE	West	1	1
NE	NE	West	0	1
SE	West	NW	1	0

Table 1: State Transition Table for the Spacecraft Controller.

Question 2 (XX points): [State Assignment: A Cheater's Dilemma] During the final exams in a third-rate university, Steve, one of the students taking the final, is trying to solve a question that asks the students to finish the design of a controller for a spacecraft in a video-game. The students were presented with the state transitions and outputs shown in Table 1 for the finite state machine:

The students were asked to create the Successor DAG, the Predecessor DAG, and the output DAG for this finite state machine. Fortunately Steve remembers from the lectures that the successor, predecessor, and output rules are stated as follows:

Successor Rule: The next states of a given state should be close to each other.

Predecessor Rule: States that have the same next state for a given input should be close to each other.

Output Rule: States that have the same output should be close to each other.

(a) Knowing these rules, how Steve would have completed the values in each cell of the DAGs in Figure 2?

John's Assignment	
State	**Code**
North	000
South	101
East	100
West	010
NW	011
SW	111
NE	110
SE	001

(a) John's Solution

Tim's Assignment	
State	**Code**
North	000
South	111
East	010
West	101
NW	110
SW	100
NE	011
SE	001

(b) Tim's Solution

Figure 1: Assignments from John and Tim that Steve "accidently" saw.

Steve also remembers that the Predecessor rule is the most important one, followed by the successor rule, and then by the output rule. The exam question continues by asking the students to find a good state assignment and to produce the minimal equations for the D flip-flops excitation and for the outputs. Unfortunately Steve slept through that portion of the class and did not study the class slides. Thus he has no idea how to perform the state assignment. However Steve "accidently" that John, the student to his left, and Tim, the student to his right have chosen the assignments shown in Table **??**. The exam is long, and Steve knows that he does not have time to do the five four-input equation minimizations for each assignment to decide which assignment to use.

(b) Should Steve choose to use John's or Tim's assignment for his solution? Without generating and minimizing the equations, provide a very convincing explanation for this choice.

(c) If Steve is concerned about been caught cheating, what changes could he do to the assignment that he choose to make it look different from the other students without actually changing the cost of the equations that he produces?

	North	South	East	West	NE	NW	SW
South							
East							
West							
NE							
NW							
SW							
SE							

(a) Successor DAG

	North	South	East	West	NE	NW	SW
South							
East							
West							
NE							
NW							
SW							
SE							

(b) Predecessor DAG

	North	South	East	West	NE	NW	SW
South							
East							
West							
NE							
NW							
SW							
SE							

(c) Output DAG

Figure 2: (a) Successor DAG; (b) Predecessor DAG; (c) Output DAG.