CSE435 Introduction to EDA & Testing - Spring 2022

Homework Assignment #4

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1. (25%)

   (a) (10%) For state transition fault model, explain why there are M(N-1) faults for a M-transition N-state machine. Similarly explain why there are N^M-1 multiple state transition faults.

   Solution: Denote M and N as the number of transitions and states, respectively.

   Single-state-transition (SST) fault For each transition, the possible destination could be either one of the states, so there are (N-1) faulty cases and 1 faultless case. The SST could occur at either one of the transitions, producing M(N-1) distinguishable faults.

   Multiple-state-transition (MST) fault For each transition, the possible destination could be either one of the states, so there are N cases. Since each transition is independent to other transitions, there are N^M distinguishable state-transition diagrams. Disregarding 1 faultless diagram, the number of faults in MST is thus N^M-1.

   (b) (10%) For stuck-at fault model, explain why there are 2K single stuck-at faults. Similarly explain why there are 3^K-1 multiple stuck-at faults.

   Solution: Denote K as the number of lines in the circuit.

   Single-stuck-at (SSA) fault The SSA fault would occur at either one of the lines, and in the SSA faults, there will be the case of stuck-at-0 and stuck-at-1. So the number of distinguishable SSA faults would be 2K.

   Multiple-stuck-at (MSA) fault For each lines, there are three possible cases: no-error, stuck-at-0 or stuck-at-1. With K lines, there would be 3^K possible circuits, including 3^K-1 faulty ones and 1 faultless one.

   (c) (5%) Please show the similarity and differences of (single, multiple) fault numbers between the state transition fault model and the stuck-at fault model.

   Solution:

Single Both the numbers of faults of SST and SSA fault are multiples of the numbers of transitions and lines, respectively. However, the multiplier of the SST fault depends on the number of states, while the one of the SSA is fixed to 2 (sa0, sa1).

Multiple In the power of both the numbers of faults of SST and SSA fault. The exponents are the numbers of transitions and lines, respectively. However, the base of the MST fault depends on the number of states, while the one of the MSA is fixed to 3 (no-error, sa0, sa1).

2. (20%) Prove that for combinational circuits **faults dominance is a transitive relation**, i.e. if f dominates g and g dominates h, then f dominates h.

Solution: A fault α is said to dominate another fault β in an irredundant circuit, iff every test for β is also a test for α. If f dominates g, then every test for g is also a test for f. If g dominates h, then every test for h is also a test for g. Since every test for g is a test for f, every test for h is thus also a test for f.

3. (55%) In the circuit shown in Figure 1,

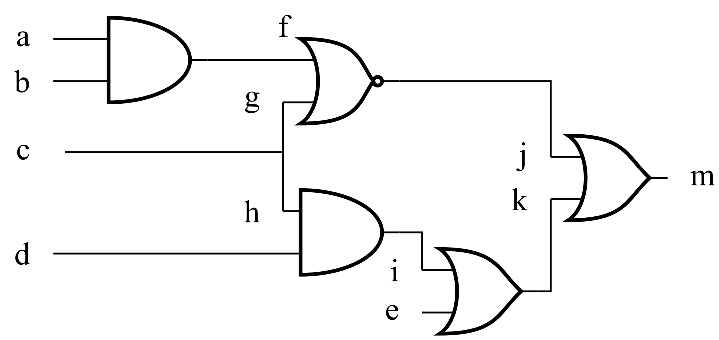

Figure 1

(a) (5%) How many single stuck-at faults needed to be considered initially?

Solution: There are 12 lines in the circuit. Therefore, there are $2 \times 12 = 24$ SSA faults initially.

(b) (25%) Applying the **check point theorem (incl. fault dominance)**, how many check point faults needed to be considered?

Solution: Primary inputs and fanout branches form a sufficient set of checkpoints in an irredundant combinational circuit. Therefore, there are 7 checkpoints in this circuit, as shown in Figure 2.

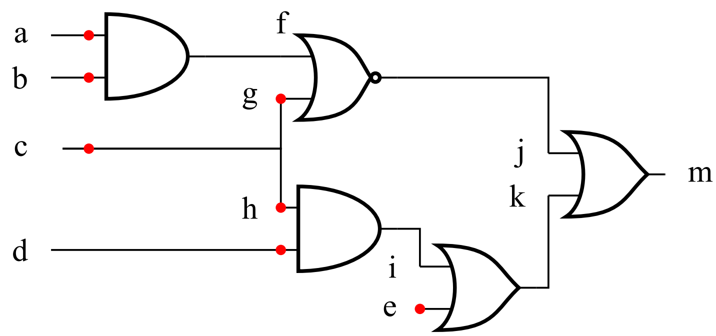

Figure 2

These 7 checkpoints could produce $2 \times 7 = 14$ SSA faults.

Gate	Equivalence Set(s)	Dominant Set(s)
OR	{a-sa1, b-sa1, out-sa1}	{out-sa0: a-sa0, b-sa0}
NOR	{a-sa1, b-sa1, out-sa0}	{out-sa1: a-sa0, b-sa0}
AND	{a-sa0, b-sa0, out-sa0}	{out-sa1: a-sa1, b-sa1}
NAND	{a-sa0, b-sa0, out-sa1}	{out-sa0: a-sa1, b-sa1}
Buffer	{in-sa0, out-sa0}	null
	{in-sa1, out-sa1}	
NOT	{in-sa1, out-sa0}	null
	{in-sa0, out-sa1}	

(c) (25%) Using **fault dominance** and **fault equivalence** relations to further reduce the number of stuck-at faults? How many remaining faults needed to be considered?

Solution: