

Exam Software Testing & Risk Assessment

June 30, 2021

9:00 — 12:00

Remarks.

- Please provide all answers in English.
- Explain every solution. Without a proper explanation, you may not receive any points for an otherwise correct answer.
- The exam is divided in sections. When answering questions, start each section on a **new page**.
- You are allowed a 1 A4 cheat sheet, double printed/written.

Good luck!

1 Risk Management

The following article appeared on CBS News:

Highly contagious Delta variant could cause next COVID-19 wave: “This virus will still find you”

Whether it’s airports, NBA games, or concerts, crowds are gathering across the nation as Americans start a return to pre-pandemic life.

But with just 45% of Americans fully vaccinated and only 16 states that have fully vaccinated more than half of their populations, health experts are worried about the spread of the highly contagious Delta variant. It is 60% more contagious than the Alpha variant discovered in the U.K., which was the last variant of major concern, according to infectious disease expert Michael Osterholm.

“In the areas where they have large pockets of unvaccinated people, we can surely expect to see surges in cases, in some situations challenging the health care capacity of that local area,” Osterholm told “CBS This Morning” lead national correspondent David Begnaud.

A hospital dealing with an overflow of patients is Mercy Hospital in Springfield, Missouri. Mercy Hospital President Craig McCoy said the hospital is “holding patients in the ER, waiting on admissions, waiting on discharges on any given day”.

In Springfield, only 32% of the surrounding county is vaccinated, and COVID-19 hospitalizations are up more than 210% since June 1. Perhaps most alarming—90% of all COVID samples being sequenced from that county are testing positive for the Delta variant.

1. Describe three aspects / concepts of risk management that are applicable to this article. (3 points)
2. Mention 2 risk strategies that are deployed and categorize them in the four risk strategy classes (the four T’s). (2 points)

2 Fault trees

Consider the fault tree F in Figure 1 for a container seal design. This fault tree has seven basic events (B_1, B_2, \dots, B_7). The probability for the basic events to fail are given by $p_{B_1} = 0.8$, $p_{B_2} = p_{B_4} = p_{B_5} = p_{B_6} = 0.1$, $p_{B_3} = 0.3$, and $p_{B_7} = 0.2$. The failure probability of the top event is P .

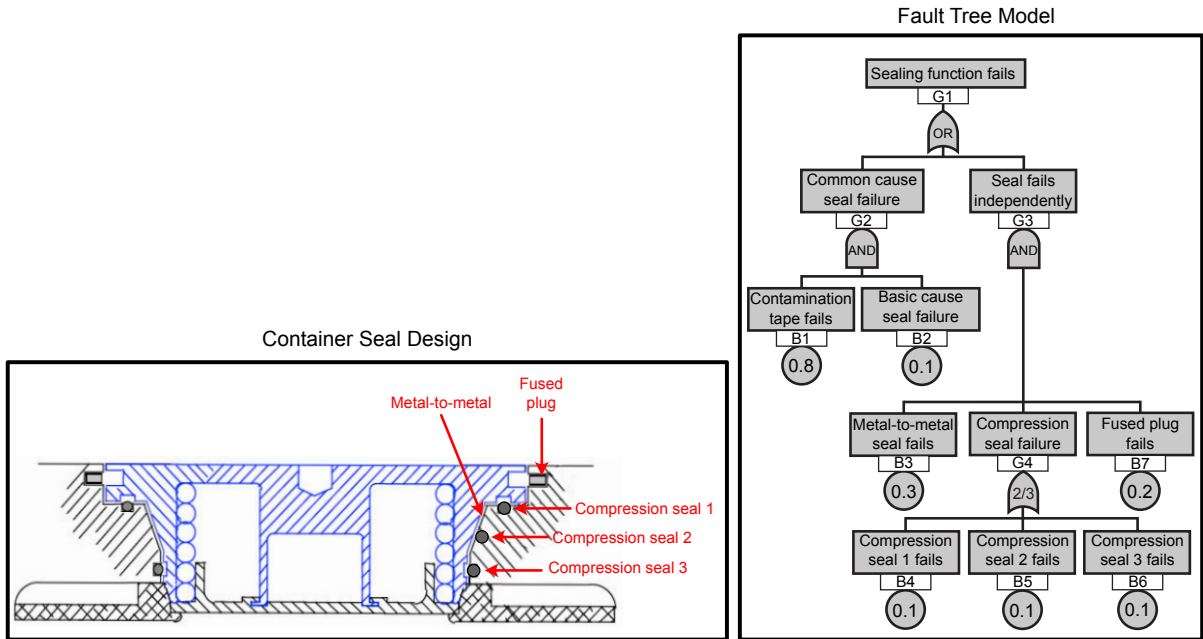


Figure 1: On the left, container seal design system. On the right the associated Fault Tree model F .

1. List all minimal cut sets in F . (1 point)
2. Compute the exact failure probability of the gate G_4 , *compression seal failure* ($p(G_4)$). (1 point)
3. Compute the exact failure probability of the top event (P). (2 points)
4. Approximate the failure probability of the top event (P) using the *minimal cut sets method*, and compare this approximation with the exact solution, what can you conclude? (2 points)
5. Based on the fault tree provided in Figure 1, provide at least one strategy to mitigate the occurrence of the top event *sealing function fails*. (2 points)

3 Exponential distributions

1. Consider a random variable modeling a component failure time (measured in weeks) and that is exponentially distributed expected value $\frac{1}{5}$. What is the probability that the component experiences no failure within the first four weeks? (*2 points*)
2. Give an example of a probability distribution that is not memoryless. (As for the other questions: explain your answer.) (*2 points*)

4 Blackbox Testing.

The function `int days_since_corona(int day, month, year)` takes three integers that are interpreted as a date. The program yields the number of days since March 11, 2020 (= when the WHO officially declared Covid as a pandemic). Dates that result in a negative number of days are not allowed.

We assume that this function has been type checked, so you do not have to check for non-integer values, or the wrong number of arguments.

1. Use the equivalence partitioning technique to divide the input into suitable equivalence classes and give a test suite that covers all equivalence classes. *(3 points)*
2. Extend the test suite using the principle of boundary value analysis. *(3 points)*
3. Extend the test suite using the principle of error guessing. *(1 point)*

Present each test suite in a table.

5 Whitebox Testing.

We consider the following transformation on programs. Given a program A, we obtain a program A' by replacing all statements of the form

```
if C & D
then S
endif
```

by

```
if C
then
  if D
  then S
  endif
endif
```

1. Do these transformations preserve decision coverage? (*3 points*)

(I.e. if a test suite T has 100% decision coverage on program A, does T have 100% decision coverage for the transformed program A' as well?) If your answer is "no", present a program A, its transformation A', and a test suite T such that T has 100% coverage on A, but not on A'.

2. Same question, but for condition coverage. (*3 points*)

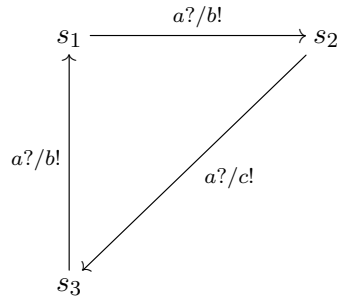


Figure 2: The Mealy Machine A ; s_1 is initial.

6 Mealy Machine testing

Consider the Mealy Machine A in Figure 2.

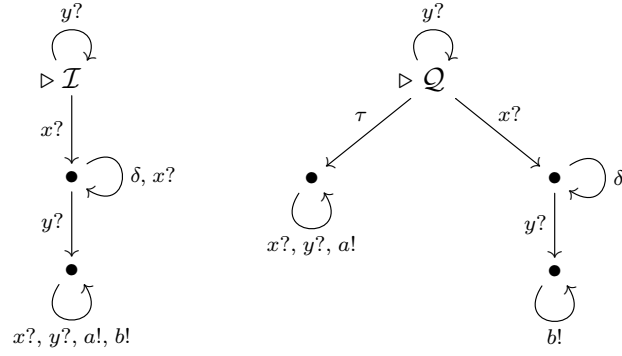
1. If possible, give test suites of A with the following properties. If such a test suite exists, explain why your test suite meets the desired properties. If such a test suite does not exist, explain why.
 - (a) A test suite T_1 consisting of 1 test that is sound. (1 point)
 - (b) A test suite T_2 consisting of 1 test that is complete. (2 points)
2. Do the following sequences / sets exist for all Mealy machines?
 - If so, explain why.
 - If not, provide a counter example (for readability, provide your counter example below the table).

Present your solutions in the table below. (3 points)

sequence	exists? y/n	explanation
state tours		
distinguishing sequences		
W -sets		

7 IOCO

Consider QTSs \mathcal{I} and \mathcal{Q} :



1. Given that $L_{\mathcal{I}}^I = L_{\mathcal{Q}}^I = \{ x?, y? \}$ and $L_{\mathcal{I}}^O = L_{\mathcal{Q}}^O = \{ a!, b! \}$, evaluate $\mathcal{I} \sqsubseteq_{\text{ioco}} \mathcal{Q}$. If the outcome is \perp , give a trace from \mathcal{Q} that prevents $\mathcal{I} \sqsubseteq_{\text{ioco}} \mathcal{Q}$ from evaluating to \top . (3 points)
2. Let \mathcal{A} and \mathcal{B} be two well-formed QTSs such that \mathcal{A} is input-enabled. Prove or disprove that

$$\text{traces}_{\mathcal{A}} = \text{traces}_{\mathcal{B}} \quad \Rightarrow \quad \mathcal{A} \sqsubseteq_{\text{ioco}} \mathcal{B}$$

(4 points)