

Task 1: Terminology

- (a) Define the Terms "Fault, Failure, Error"
- (b) Multiple Choice

Task 2: Risk definition

- (a) How is risk defined mathematically
- (b) Draw and explain the Risk-Severity graph

Task 3: Risk acceptance

- (a) Name and define the three risk-acceptance measures
- (b) Explain the differences between those three
- (c) MEM: Calculate the IRF for a given scenario and rate it

Task 4: Markov Model

Given a scenario with two pumps:

The first pump always works with a workload of 100%, the second pump with 0%. If pump one fails, the second pump will start working immediately to ensure a safe system. If pump two fails additionally, the system fails. The two pumps will be repaired independently, if both pumps fail pump one will be repaired first. Pump one has a failure rate of  $\lambda_{x1}$ , pump two has a failure rate of  $\lambda_{x2}$ , if the workload of pump one is less than 50%. Both pumps have a repair rate of  $\mu_x$ .

- (a) Draw the markov model for the given process using the states

State 1: Everything's working fine

State 2x: Pump x failed, system working

State 3: System failed

Hint: Even if it seems unnecessary to add a transition from State 1 to State 22 since this case should never happen, it has to be added to the graph

- (b) For the states of your Markov model, develop the set of related differential equations

Task 5: Reliability Block Diagram

You have four redundant servers: S1, S2, S3, S4, where two servers each share one power supply: S1 and S2 use P1 and S3 and S4 use P2. Servers and Power supplies may fail. everything fails independent from each other. The system fails if no server is working anymore.

- (a) Draw a RBD
- (b) Calculate the Failure rate

# Task 6: FTA

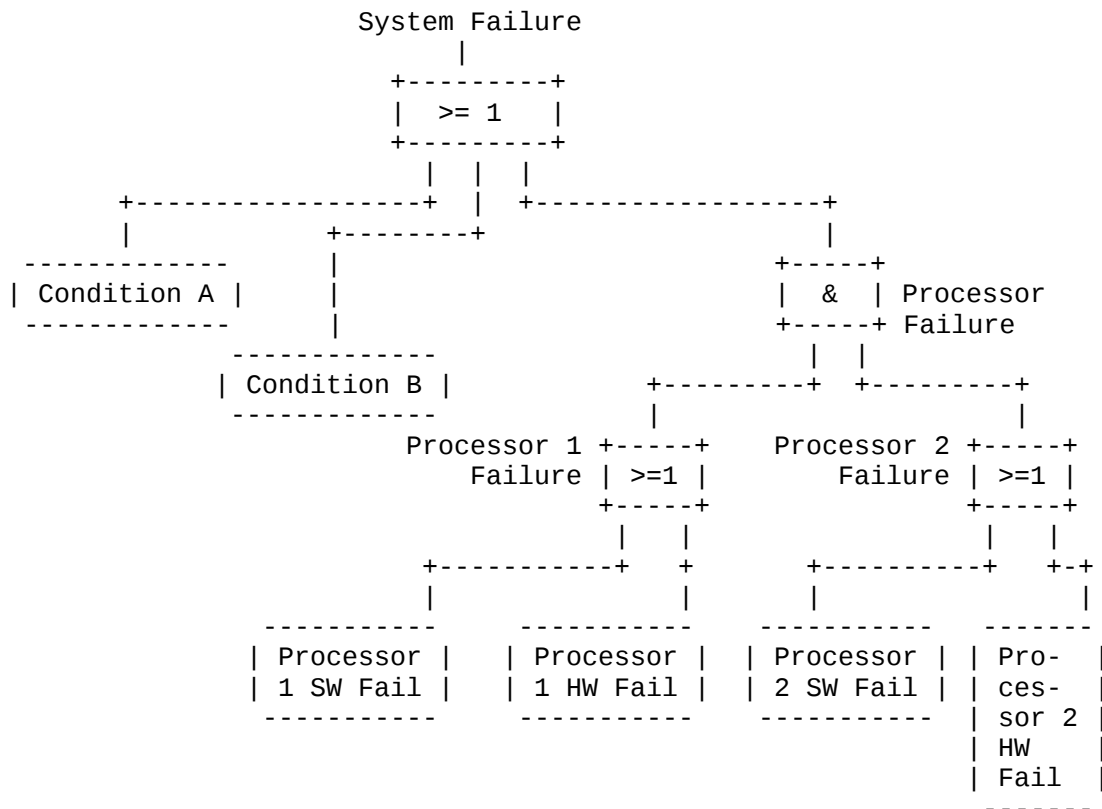
(a) A system can fail if any of the following conditions is true:

- Condition A (some valve didn't work)
- Condition B (some other problem that I don't remember)
- There is a Processor Failure.

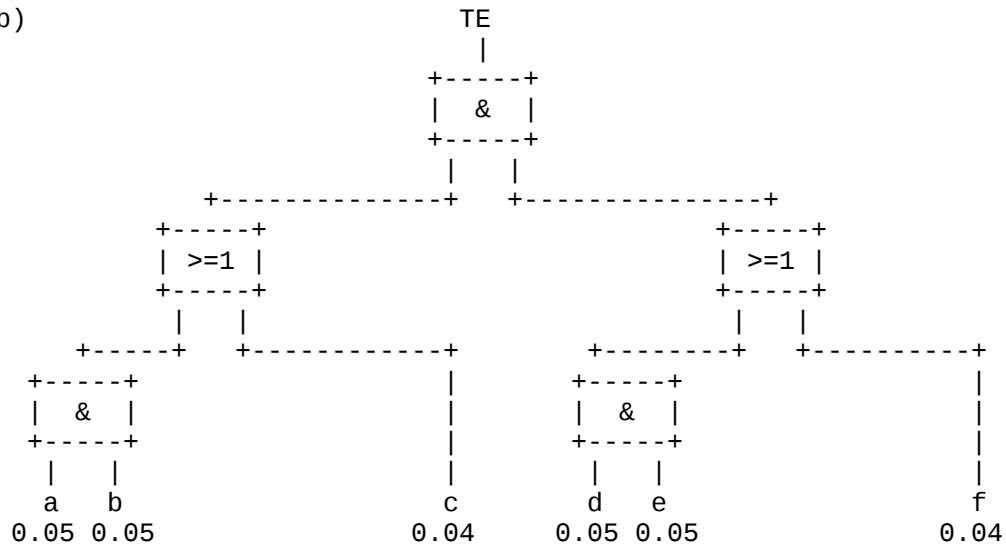
Further, this system relied on two processors and a Processor Failure would only occur if both Processors P1 and P2 failed. For each Processor P<sub>k</sub> (k=1 and 2), a "Processor k Failure" would occur if there is either a software failure or a hardware failure in that processor.

Represent the basic events in circles and the intermediate events in rectangles

Answer:



(b)



Write the resulting ROBDD following the order  
 c -> f -> a -> b -> d -> e

#### Task 7: Bathtub curve

Draw the Bathtub curve and explain where it is possible to use the Exponential and the Weibull distributions and why.



Exponential Distribution: only in the constant part.

Weibull Distribution: Everywhere. But then the parameters need to be adjusted:

Beta < 1: Infant Mortality part

Beta = 1: Normal Life

Beta > 1: Wear-out phase

The Exponential Distribution can only be used in the constant part because it is a specific case of the Weibull Distribution.

[More information in the following link:

<http://www.weibull.com/hotwire/issue21/hottopics21.htm> ]