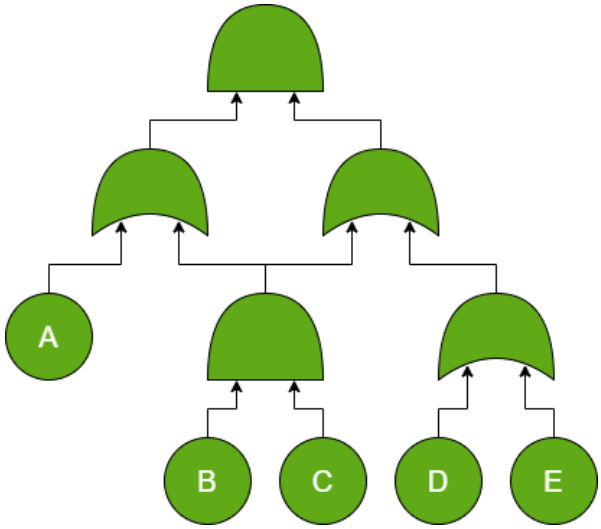
Exercises week 2

*Exercises marked with * are extra challenging.*

Problem 1 (Homework): For the fault tree to the right:

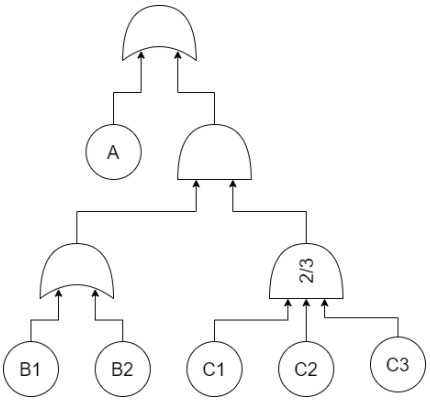
1. What are the minimal cut sets?
2. Create a BDD for this fault tree, with variable order A,B,C,D,E.
3. Suppose the failure probabilities are p_A = 1/2, p_B = 1/3, p_C = 1/4, p_D = 1/5, p_E = 1/6. Calculate the fault tree's unreliability using the BDD.



Problem 2: Approximate the unreliability of the FT of problem 1 via the cut set method. Is this an over- or underapproximation?

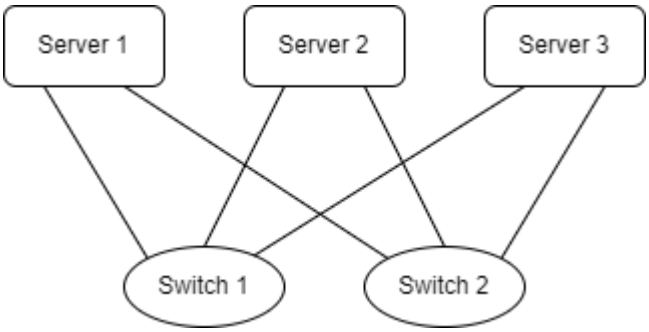
Problem 3: In the FT to the right, the failure probability of each BE is *p*.

1. Suppose you want to calculate the failure probability of the FT exactly. Do you use the bottom-up method, the BDD method, or the cut set method? Why?
2. Use the method you selected in the previous question to calculate the failure probability.



Problem 4: Find a variable order for the FT of problem 1 that results in a smaller BDD than that from 1.2.

Problem 5: Consider the following situation: You are the reliability engineer of the company CoolCloudSolutions. Your boss has promised your customers a reliability of 99%. The architecture is depicted in the figure below:



1. Model this system as a FT. Assume that all servers have the same functionality. For the system to be operational, at least one of the 3 servers must be operational, together with its network cable and one core switch.
2. How many minimal cut sets are there of order 1,2,3?
3. What are the most critical elements?
4. Suppose the servers have failure probability 0.1, the switches have failure probability 0.2, and the cables have failure probability 0.2. Does this architecture meet the reliability requirements?
5. *How many cut sets are there in total?

Problem 6: Suppose that we extend the fault tree formalism with an XOR (eXclusive OR) gate. This has at least 2 children, and fails if exactly one of its children fails. Now consider a XOR-gate with independent children A and B.

1. Assume that A and B fail with probability p_A and p_B respectively. What is the probability for the XOR gate to fail?
2. Suppose the probability for A to fail within time t is given by $p_A(t) = 1 - e^{-\lambda t}$ and probability for B to fail within time t is given by $p_B(t) = 1 - e^{-\mu t}$. What is the probability for the XOR gate to fail within time t?
3. *Which of the following failure probability computation methods still work for XOR-FTs?
    1. The bottom-up method (for FTs that are actually trees, i.e., nodes do not share children)
    2. The BDD method
    3. The cut set method for overapproximating probabilities.