3. Übung, WS 2012/13
Zuverlässige Systeme/ Dependable Systems
Ausgegeben am 22.11.2012
Vorstellung 6.12.2012

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Assignment 1. Safety Analysis on a Markov Graph

Consider first the graph on the left in the figure. From the initial state 1, which represents a behaviour without fault, the system degrades with the appearance of faults; it evolves towards the states 2, 3, and 4 which are failing states. On the contrary, protective and repair mechanisms are going to make the system evolve towards better states, for example state 3 towards state 1! The arcs between states indicate the hourly rate of evolution (probabilities): p1, p2, p3, p4 for the degradations and r1, r2 for the corrections and repairs.

Assume all $p_i = 0.01$ and $r_i = 0.8$.

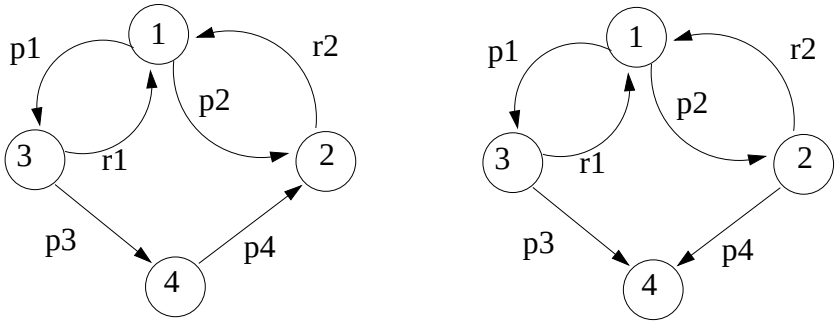

Figure 1: Markov Graph

Study the evolution of the graph from state 1 towards state 4, which is here supposed to be chatastrophic, i.e. formulate the probability matrix. Determine the steady state probability of the system being in state 4 and the probability of the system being operational.

Consider then the graph on the right where even in the catastrophic case repair is still possible with probability $p4 = 0.001$. Compare the systems with respect to their probability of being in state 4.

Assignment 2. Triple Modular Redundancy

Determine the reliability of a TMR system, where all components have the same component reliability R assuming the following cases:

1. perfect voter,
2. unreliable voter with failure rate $\lambda = 10^{-5}$
3. two redundant voters both with failure rate $\lambda = 10^{-5}$

Plot the reliability curve for all values of R in comparison with the simplex system.

Assignment 3. Representation of a System by a Stochastic Petri net

Assume a system with three redundant active units and one inactive spare unit. The regular function is assured as long as two of the active units are operational. When a unit fails, a reconfiguration process is started: this process replaces the faulty unit by the spare unit, if this unit has not already been used.

Represent the system with a Petri net using three places, one for the number of active units, one for the number of failed units and one for the spare unit. The spare unit has failure rate $\lambda_s = 10^{-5}$ and repair rate $\mu_s = 1$ while the redundant units have failure rate $\lambda_s = 10^{-7}$ and the same repair rate.

Formulate a Petri net for the system and derive the steady-state probability of the system being operational.

Assume a repaired redundant unit can replace the spare one and modify the Petri net accordingly.

Assignment 4. Reliability of a stand-by system

Develop a model of a stand-by system with one on-line element and two stand-by elements, all with identical failure rate $\lambda = 10^{-7}$. Formulate the Markov model and solve for the reliability.

Assignment 5. Application of Fault-Trees

Use the Fault-Tree Method to calculate the reliability of the following system. Determine the minimal cut set and compare with the Reliability Block Diagram method.

The system consists of two duplex units and one triplex unit that are combined using majority voting. Voting and Comparison have reliability of 0.99, while all other modules have reliability 0.9.