EDA122/DIT061 Fault-Tolerant Computer Systems
DAT270 Dependable Computer Systems

Laboratory Class 2

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING
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1. Introduction

The aim of this laboratory assignment is to study the impact of repair on the availability of computer systems. You will evaluate two different file server configurations using Markov chain models and Generalized Stochastic Petri Nets (GSPNs).

2. Problem A – Simplex server

Consider a non-fault tolerant file server consisting of one processor and one disk system, as shown in Figure 1. Assume that the operation times and the repair times are exponentially distributed. Let λ_p be the failure rate of the processor, λ_d be the failure rate of the disk system, μ_p the repair rate of the processor and μ_d the repair rate of the disk system.

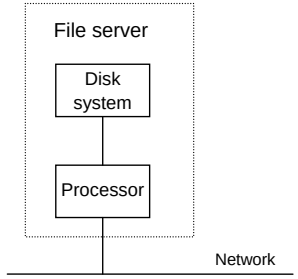

Figure 1

Your task is to compare the availability of the file server for two repair policies:

I.A Each unit has its own repair facility. The units fail independently of each other.

II.A The units share one repair facility. The units fail independently of each other. Repairs are made using a *first-come first-served* policy. (Repairs are not preempted.)

Use the failure and repair rates shown in Table 1.

Table 1

Subsystem	Failure rate (λ)	Repair rate (μ)
Processor	$0.8 \cdot 10^{-3}$ [f/h]	1 [r/h]
Disk	$1 \cdot 10^{-3}$ [f/h]	0.5 [r/h]

2.1 Availability for repair policy I.A

Use SHARPE to calculate the steady-state availability of the simplex server for repair policy I.A. Conduct the calculations using the following three methods and make sure you obtain identical results:

a) Derive an expression for the steady state availability by hand and implement it as a function in SHARPE.
b) Define a Markov chain model of the system.
c) Define a GSPN model of the system.

2.2 Availability for repair policy II.A

Calculate the steady-state availability of the simplex system for repair policy II.A using a Markov chain model and a GSPN model. **Tip**: Ensure that the GSPN model includes a single place that corresponds to a system failure when it holds one or more tokens (this makes it easy to obtain the steady-state availability of the system).

2.3 Comparison of repair policy I.A and II.A

Compare and discuss the results obtained for the two repair policies.

3. Problem B – Duplex server

Now consider a file server with duplicated processors and duplicated disks (mirrored disks) as shown in Figure 2.

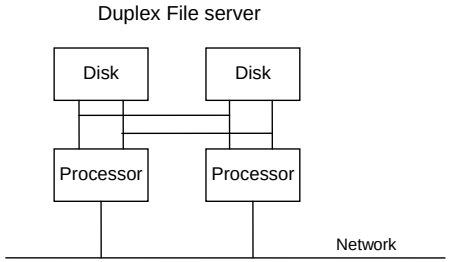

Figure 2

The file server is available as long as at least one disk and one processor are working. Assume that the failure rates and the repair rates are constant. Your assignment is to calculate and compare the steady-state availability of the duplex file server for three repair policies:

I.B There is one repair facility for the processors and one for the disks.

II.B There is one repair facility that can handle one processor or disk at a time. Assume that processor/disk failures do not occur if the system is down. Assume also that processor repairs always are given priority over disk repairs.

III.B As in II.B, there is only one repair facility that can handle one processor or one disk at a time. Assume that processor/disk failures may occur when the system is down and that the failure rate in this case is the same as when the system is working. Assume that processor repairs are given priority over disk repairs in all cases except when both disks have failed and one processor is working. In that case, one disk is repaired first so that the system can be restarted as soon as possible.

3.1 Availability for repair policy I.B

Use GSPN models to calculate the availability of the duplex file server for repair policy I.B.

3.2 Availability for repair policy II.B

Define a GSPN model and a Markov chain model for the duplex file server assuming repair policy II.B. Check that you obtain the same results for both models. Answer the following questions:

1. What is the availability of the system using the failure and repair rates given in Table 1?
2. Assuming that $\lambda_p = 0.8\ \lambda_d$, how high can the failure rates of the processors/disks be if the system availability must be at least 0.99999? (An availability of "five nines" is often required in business critical applications.)

3.3 Availability for repair policy III.B

Define a Markov chain model to calculate the availability of the duplex file server for repair policy III.B. Compare the result with those obtained for policy I.B and II.B. How big impact does the repair policy have on the results?

3.4 Availability with coverage factor with repair policy I.B

The processors and the disks are self-checking to simplify the identification of a faulty unit. Assume that the coverage of the error detection mechanisms is non-perfect, and that a non-covered error leads to a disk or processor subsystem failure. The repair process after a non-covered error is same as when two units in same subsystem have failed. How high must the error detection coverage be to achieve an availability of 0.99999 (five nines) when repair policy I.B is used?

4. Laboratory report

The results shall be documented in a short technical report. Describe your models and the results briefly and write two to three paragraphs that summarize your observations concerning the impact of repair policies and non-perfect coverage on availability. Include figures of Markov and GSPN models (these can be drawn by hand). References to the lab pm is allowed and encouraged for this laboratory assignment. However, the report shall be self-contained, i.e., it should be possible to read the report as a stand-alone document.