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Safety and Reliability of Embedded Systems (WS 19/20)

Problem Set 4

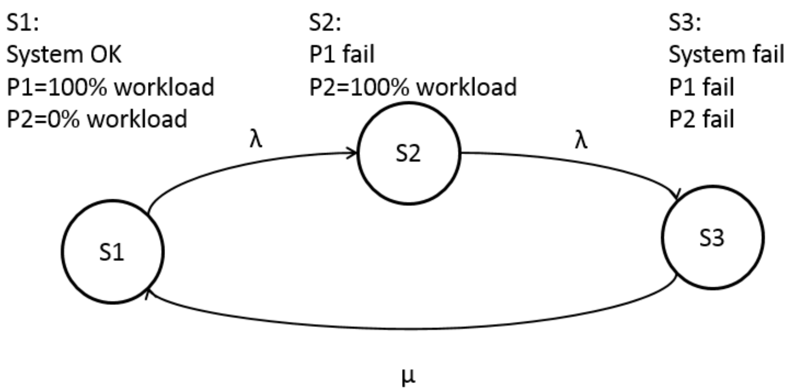
Problem 1: Quantitative Markov Modeling

Consider the two given Markov models below. They depict a pump system with two pumps, P1 and P2, where P2 runs in a **cold** standby (P1 = ON with a workload of 100%, P2 = OFF with a workload of 0%). If P1 fails, P2 will be switched ON and overtake the complete workload immediately. The Pumps are identical and have a failure rate of 0 at a workload of 0% and a failure rate of 2 per year (λ = 2/365 d) at a workload of 100%. If both pumps fail, the whole pump system fails. The two Markov models depict different repair strategies:

1. **Both pumps have to be repaired together**
2. **Each pump has to be repaired separately after a failure**

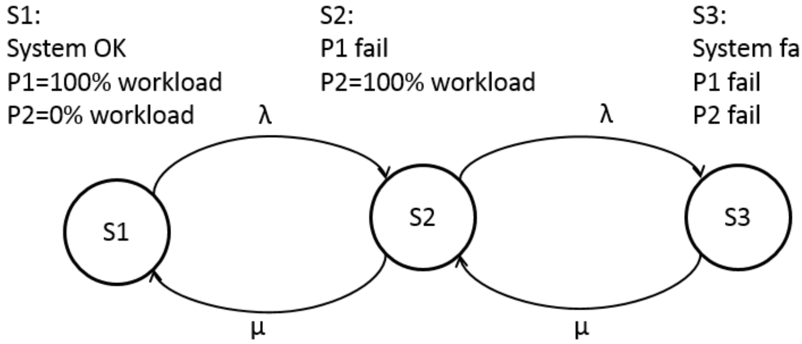
Derive the differential equations for both Markov models and determine a steady state analysis for both models. Assume λ=2/365 d and μ=1/d. Give a statement which repair strategy is the best w.r.t. a lower probability of the system's fail state.

> ***Hint***: *For calculating the stationary availability t is approximated to infinity. In this case we can set the differential equations to 0 ($dP_{Sx}(t)/dt=0$) and we get constant probability values ($P_{Sx}(t) = P_{Sx}$). So we get a homogeneous linear equation system.*



1.

2.


S1:
System OK
P1=100% workload
P2=0% workload
S2:
P1 fail
P2=100% workload
S3:
System fail
P1 fail
P2 fail
λ
λ
S1
S2
S3
μ
μ