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Ruchi Yadav
School of studies in statistics
Vikram University, Ujjain (M. P.) India

Correspondence:
Ruchi Yadav
School of studies in statistics
Vikram University, Ujjain (M. P.) India

Stochastic Behaviour and Busy Period Analysis of a System

Ruchi Yadav

Abstract
Two-unit standby redundant systems have been extensively studied by several authors in the past. Khaled and Said (2010) analyzed a two-unit cold standby system with two stage repair and waiting time. In the present paper the system consists of a two-dissimilar components working in parallel, say A and B. Both the components are operative initially at time t=0. A single repair facility is available for the repair. Upon failure of a component the repair facility, if not busy, is available with some fixed probability p. If repair facility is not available at the time of a failure of a component, it is called for repair. The repair facility appearance time distribution is exponential. When repair facility is busy in repair of the failed component, the other failed component waits for its repair. After repair, the components become as good as new. The repair times of both the components are arbitrary functions of time. Failure time distributions are to be exponential.

Keywords: Reliability, Mean time to system failure, Availability, Exponential distribution.

Introduction
Technological developments lead to an increase in the number of complicated systems as well as increase in the complexity of the system themselves. Equipment breakdown can become a nightmare for the persons engaged in design, manufacture, maintenance and operation. It affects the designer and the manufacturers; quite often the user of the equipment bears the heaviest consequences. Reliability is an important consideration in planning, design and operation of system. People always expect trains to be on time, electric power not to fail and so on.
Two-unit standby redundant systems have been extensively studied by several authors in the past. Khalid and Said (2010) analyzed a two-unit cold standby system with two stage repair and waiting time. In the present paper The system consists of a two-dissimilar components working in parallel, say A and B. Both the components are operative initially at time t=0. A single repair facility is available for the repair. Upon failure of a component the repair facility, if not busy, is available with some fixed probability p. If repair facility is not available at the time of a failure of a component, it is called for repair. The repair facility appearance time distribution is exponential. When repair facility is busy in repair of the failed component, the other failed component waits for its repair. After repair, the components become as good as new. The repair times of both the components are arbitrary functions of time. Failure time distributions are assumed to be exponential.

Busy Period Analysis
Let $B_i(t)$ be the probabilities that the repairman is busy in the repair of sub-unit at time t when system initially starts from regenerative state S_i using some the probabilistic arguments in respect to the definition of $B_i^{'}(t)$, we have the following recursive relation –

$$B_0^o(t) = q_{01}(t)©B_1(t) + q_{02}(t)©B_2(t)$$
$$B_1^k(t) = q_{14}(t)©B_4(t) + q_{18}(t)©B_8(t)$$
$$B_2(t) = W_2 + q_{20}(t)©B_0(t) + q_{24}(t)©B_4(t) + q_{23}(t)©B_3(t)$$

$$B_3(t) = q_{35}(t)©B_5(t) + q_{36}(t)©B_6(t) + q_{32}(t)©B_2(t)$$
$$B_4(t) = W_4 + q_{41}(t)©B_1(t) + q_{48}(t)©B_8(t) + q_{45}(t)©B_5(t)$$
$$B_5(t) = W_5 + q_{58}(t)©B_8(t) + q_{57}(t)©B_7(t) + q_{54}(t)©B_4(t) \; B_6(t) = W_6 + q_{63}(t)©B_3(t)$$
$$B_7(t) = W_7 + q_{75}(t)©B_5(t)$$
$$B_8(t) = q_{80}(t)©B_0(t) \qquad (1\text{-}9)$$

Where

$$W_2 = e^{-(\alpha+\beta+\theta)t};\; W_4 = e^{-(\alpha+\beta+\theta)t};$$
$$W_5 = e^{-(\alpha+\beta+\theta)};\; W_6 = e^{\theta t};\; W_7 = e^{-\theta t}.$$

For an illustration, $B_2^{'}(t)$ is the sum of the following mutually exclusive contingencies –?

i. The repairman remains busy in state S_2 continuously up to time t in the repair of sub-unit. The probability of this event is -

$$e^{-(\alpha+\beta+\theta)t} = W_2(t).$$

ii. System transists from state S_2 to S_0 during time (u, u+du); $u \le t$ and then repairman remains busy in the repair of epoch t starting from state S_0 at epoch u. The probability of this contingency is –

$$\int_0^t q_{20}(u)du B_4^{'}(t-u) = q_{20}(t)©B_0(t)$$

iii. System transits from state S_2 to S_4 during the time (U, u+du); $u \le t$ and then starting from state S_4 at epoch u, the repairman may be observed to be busy in the repair at epoch t. The probability of this contingency is

$$\int_0^t q_{24}(u)du B_4^{'}(t-u) = q_{24}(t)©B_4^{'}(t)$$

iv. System transits from state S_2 to S_3 during the time (u, u+du); $u \le t$ and then starting from state S_3 at epoch u, the repairman may be observed to be busy in the repair at epoch t. The probability of this contingency is

$$\int_0^t q_{23}(u)du B_3^{'}(t-u) = q_{23}(t)©B_3^{'}(t)$$

Taking Laplace transform of relations (1-9) and solving the resulting set of the algebraic equation for $B_0^*(s)$, we get

$$B_0^*(s) = \frac{N_3(s)}{D_2(s)}. \qquad (10)$$

$$N_3(s) = \left(1 - q_{24}^* q_{41}^* q_{14}^* q_{57}^*\right) q_{35}^* W_3^* + \left(q_{01}^* + q_{02}^* q_{23}^* q_{58}^*\right)\left(q_{14}^* W_4^* + q_{18}^* q_{63}^*\right)$$
$$+\left(q_{02}^* + q_{14}^* q_{45}^*\right)\left(q_{25}^* W_5^* + q_{24}^* q_{75}^* W_3^* + q_{80}^* q_{75}^*\right).$$

In the long run, the expected fraction of the time for which the repairman is busy in the repair of the system, is given by

$$B_0 = \lim_{t\to\infty} B_0(t) = \lim_{s\to 0} sB_0^*(s)$$
$$= \frac{N_3(0)}{D_2^{'}(0)}$$

Where

$$N_3(0) = \left(1 - p_{24}p_{41}p_{14}p_{57}\right)p_{35}\mu_3 + \left(p_{01} + p_{02}p_{23}p_{58}\right)\left(p_{14}\mu_4 + p_{18}\right)$$
$$+\left(p_{02} + p_{14}\mu_5\right)\left(p_{25}\mu_5 + p_{24}p_{75}\mu_3 + p_{75}\right).$$

Conclusion

This paper describes an improvement over the Gupta, R, Goel, C.K. and Tomar, (2010) Analysis of a two unit standby system with correlated failure and repair and random appearance and disappearance of repairman. Using regenerative point technique reliability analysis, availability analysis, busy period analysis which shows that the

Proposed model is better than Gupta, R, Goel, C.K. and Tomar, (2010) because we investigate the probabilistic analysis of a two-main unit and four subunit systems. On failure of operating unit, a standby unit is in working mode. The system remains operative if one main unit and two subunit are in working mode.

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