Profit Comparisons of Computer System with S/w Redundancy Subject to Preventive Maintenance Concept

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ABSTRACT

In this paper, author focus on the profits of a computer system with software redundancy by introducing the concept of hardware preventive maintenance (PM), priority to hardware PM and hardware repair over software up-gradation. The system fails independently from normal mode. All the repair activities such as hardware repair, software up-gradation, hardware preventive maintenance before failure and hardware replacement after maximum repair time are carried out by a single server immediately, if required. All random variables are statistically independent. The negative exponential distribution is taken for the failure time of the component while the distributions of repair time, up-gradation time, preventive maintenance and replacement time are assumed arbitrary with different probability density functions. Semi-Markov process and regenerative point technique are used for obtaining the values of various parameters. The behaviour of profits has been examined.

Keywords

Computer System, Software Redundancy, Preventive Maintenance, Replacement, and Profit Analysis.

1. INTRODUCTION

In last few years, the use of computers system is very important in our daily lives. People calculate, examine and test computer system modelling every day. In these years, computers have made life easier with the help of different types of programming or coding. A computer system consists of hardware components that have been carefully chosen so that they work well together and software components or programs that run in the computer. The unit wise redundancy technique has been considered as one of these in the development of stochastic models for computer systems. Malik and Anand (2010), Malik and Sureria (2012) and Kumar et al. (2013) developed computer systems with cold standby redundancy under different failures and repair policies. Also, Malik and Munday (2014, 15, 16) analysed a stochastic model for a computer system by providing component wise redundancy in cold standby. Recently, Munday et al. (2019) and Munday and Permila (2023) developed a computer system with software redundancy in cold standby subject to hardware preventive maintenance and maximum repair time.

The author evaluate the profits of a computer system with software redundancy by introducing the concept of hardware preventive maintenance (PM), priority to hardware PM and hardware repair over software up-gradation . The system fails independently from normal mode. All the repair activities such as hardware repair, software up-gradation, hardware preventive maintenance before failure and hardware replacement after maximum repair time are carried out by a single server immediately, if required. All random variables are statistically independent. The negative exponential distribution is taken for the failure time of the component while the distributions of repair time, up-gradation time, preventive maintenance and replacement time are assumed arbitrary with different probability density functions. Semi-Markov process and regenerative point technique are used for obtaining the values of various parameters. The behaviour of profits has been examined.

2. NOTATIONS

E : Set of regenerative states

$\bar{E}$: Set of non-regenerative states

O : Computer system is operative

Scs : Software is in cold standby

PM : Preventive Maintenance

MRT : Maximum Repair Time

a/b : Probability that the system has hardware / software failure

α_0/β_0 : The rate by which hardware component undergoes for replacement/preventive maintenance

λ_1/λ_2 : Hardware/Software failure rate

HFUr /HFWr : The hardware is failed and under repair/waiting for repair

SFUg/SFWUg : The software is failed and under/waiting for up-gradation

HFURp /HFWRp : The hardware is failed and under replacement/waiting for replacement

HFUPm /HFWPm : The hardware is failed and under replacement/waiting for PM

HFUR/HFWR : The hardware is failed and continuously under repair / waiting for repair from previous state

SFUG/SFWUG : The software is failed and continuously under up-gradation /waiting for up-gradation from previous state

HFURP/HFWRP: The hardware is failed and continuously under replacement /waiting for replacement from previous state

HFUPM/HFWPM : The hardware is continuously under/waiting for Preventive maintenance from previous state

g(t)/G(t) : pdf/cdf of hardware repair time

f(t)/F(t) : pdf/cdf of software up-gradation time

r(t)/R(t) : pdf/cdf of hardware replacement time

m(t) : pdf/cdf of hardware PM time

P : Profit of the base model as shown in Figure 1

P1 : Profit of the Model as shown in Munday et al. (2016)

P2 : Profit of the Model as shown in Munday and Permila (2024)

3. SYSTEM MODELS AND THEIR PROFITS

3.1 Stochastic Modelling of the Computer System with Software Redundancy

The state transition diagram is shown in the following figure:

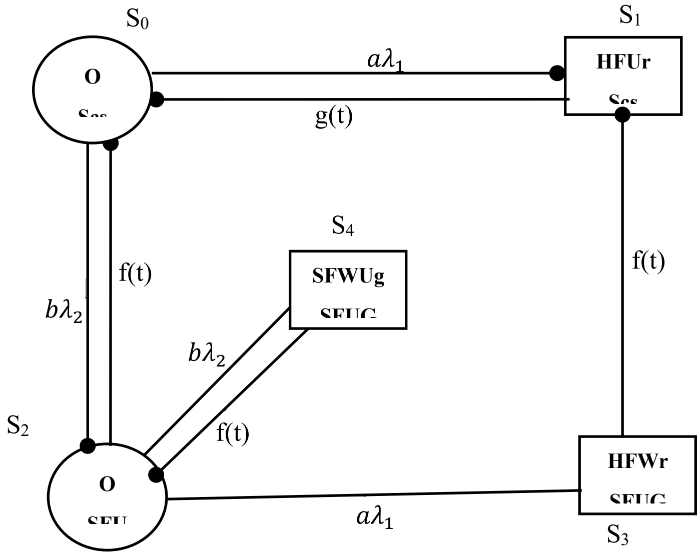

Fig. 1: State Transition Diagram

Table 1: Profit (P) Vs Hardware Failure Rate (λ1)

λ_1	λ_2=0.001, α=2, θ=5, a=0.6, b=0.4	λ_2=0.002	α=3	θ=7	a=0.4, b=0.6
0.01	14961.27261	14960.46912	14971.89929	14961.29714	14942.63532
0.02	14923.50045	14922.69785	14944.67531	14923.52542	14886.14565
0.03	14885.87848	14885.07679	14917.52365	14885.90389	14829.99191
0.04	14848.40581	14847.60503	14890.44401	14848.43165	14774.17111
0.05	14811.08156	14810.28169	14863.43611	14811.10782	14718.6803
0.06	14773.90485	14773.10589	14836.49967	14773.93152	14663.51655
0.07	14736.87479	14736.07676	14809.6344	14736.90188	14608.67699
0.08	14699.99053	14699.19342	14782.84002	14700.01803	14554.15877
0.09	14663.25121	14662.45503	14756.11626	14663.2791	14499.95907
0.1	14626.65597	14625.86072	14729.46282	14626.68426	14446.0751

3.2 Stochastic Modelling of the Computer System with Software Redundancy Subject to Preventive Maintenance

The state transition diagram is shown in the following figure:

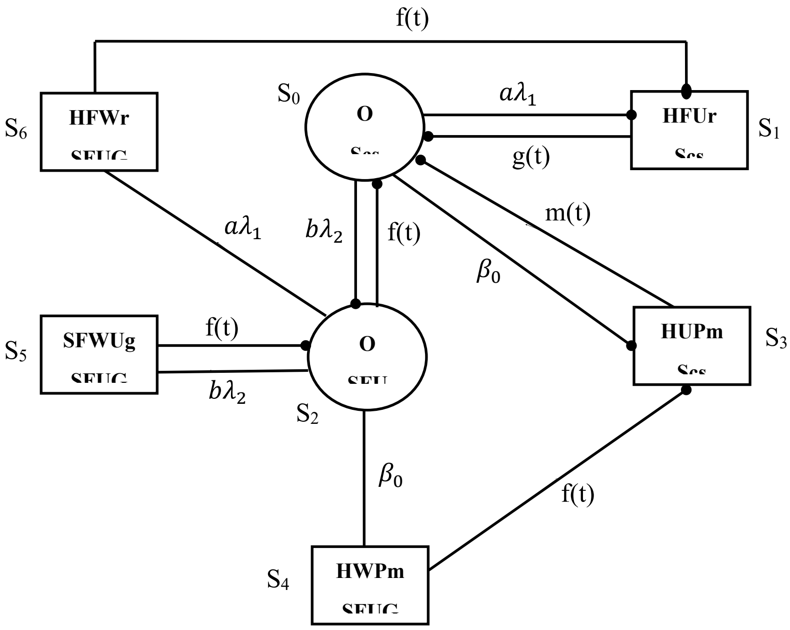

Fig. 2: State Transition Diagram

Table 2: Profit (P1) Vs Hardware Failure Rate (λ1)

λ1	λ2=0.001,α=2,θ=5,a=0.6, b=0.4,γ=0.034,β0=0.001	λ2=0.002	α=3	θ=7	a=0.4,b=0.6	γ=0.035	β0=0.002
0.01	14507.23721	14506.71635	14522.27157	14507.41837	14525.08532	14519.31549	14095.83635
0.02	14453.1246	14452.60404	14483.02939	14453.44501	14488.90386	14465.13748	14043.93027
0.03	14399.32946	14398.80922	14443.94264	14399.7867	14452.86434	14411.27745	13992.32483
0.04	14345.84901	14345.32909	14405.01039	14346.44069	14416.96592	14357.73259	13941.01741
0.05	14292.68048	14292.16089	14366.23173	14293.40426	14381.20777	14304.50015	13890.00541
0.06	14239.82113	14239.3019	14327.60573	14240.67472	14345.58907	14251.57738	13839.28629
0.07	14187.26829	14186.74941	14289.13149	14188.2494	14310.109	14198.9616	13788.85752
0.08	14135.01928	14134.50076	14250.80812	14136.12569	14274.76676	14146.65013	13738.71659
0.09	14083.07147	14082.55332	14212.63472	14084.30097	14239.56154	14094.64033	13688.86103
0.1	14031.42225	14030.90448	14174.6104	14032.77269	14204.49253	14042.92959	13639.28842

3.3 Stochastic Modelling of the Computer System with Software Redundancy by introducing the concept of priority to hardware preventive maintenance (PM) and hardware repair over software up-gradation

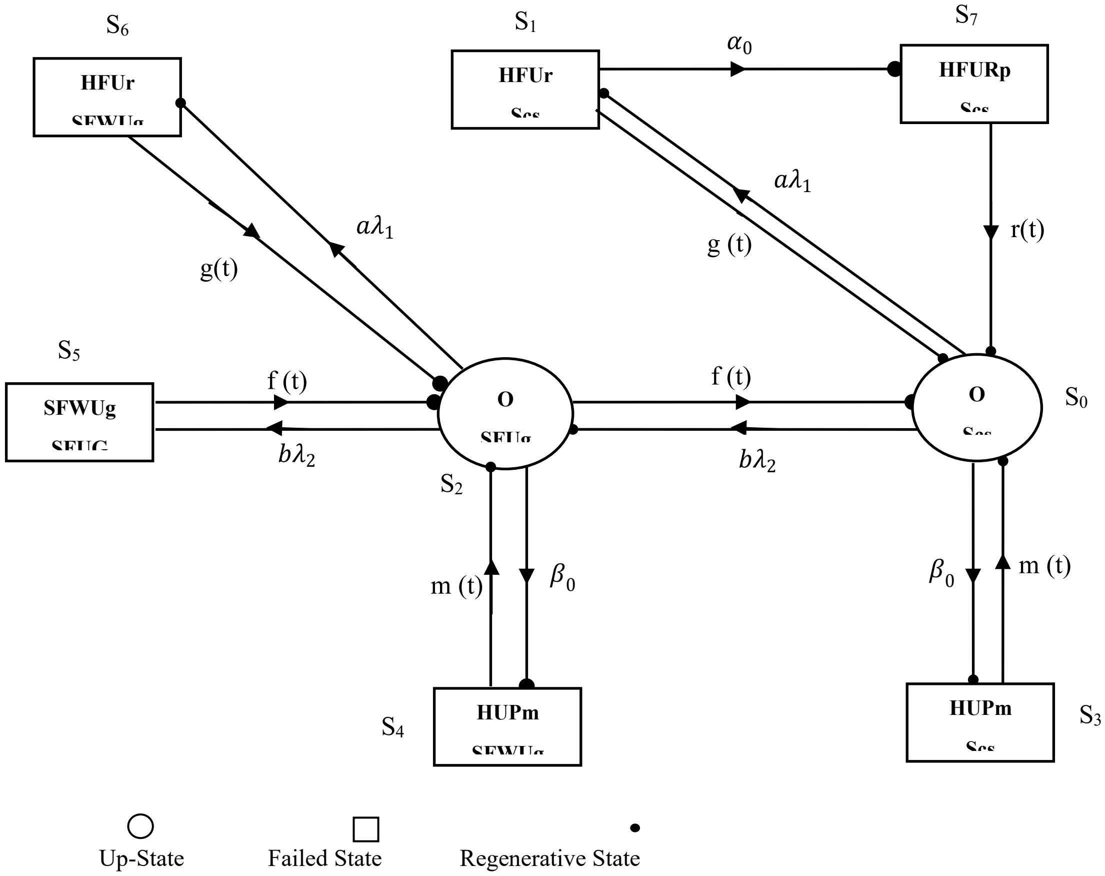

Figure 3: State Transition Diagram

Table 3: Profit (P2) Vs Hardware Failure Rate (λ1)

λ1	λ2=0.001,α=2, θ=5,a=0.6, b=0.4,γ=0.034, β0=0.001, α0=0.1,β=3	λ2=0.002	α=3	θ=7	a=0.4, b=0.6	γ=0.035	β0=0.002	α0=0.15	β=5
0.01	13695.23881	13694.80	13695.64	13695.23	13973.02	13706.04	13326.82	13969.42	13695.74
0.02	12919.31205	12918.95	12920.03	12919.29	13427.05	12928.98	12589.03	13419.93	12920.22
0.03	12220.47325	12220.17	12221.44	12220.44	12919.13	12229.17	11922.79	12908.81	12221.70
0.04	11587.77807	11587.53	11588.95	11587.74	12445.41	11595.6	11318.19	12432.17	11589.26
0.05	11012.26031	11012.06	11013.59	11012.21	12002.56	11019.41	10767.04	11986.64	11013.95
0.06	10486.50426	10486.34	10487.96	10486.45	11587.65	10493.02	10262.56	11569.25	10488.36
0.07	10004.32346	10004.19	10005.88	10004.26	11198.12	10010.29	9799.067	11177.44	10006.31

0.08	9560.516124	9560.41	9562.15	9560.45	10831.71	9566.00	9371.74	10808.9	9562.60
0.09	9150.676738	9150.59	9152.38	9150.61	10486.42	9155.73	8976.53	10461.6	9152.84
0.1	8771.0493	8770.99	8772.80	8770.98	10160.47	8775.72	8609.94	10133.90	8773.28

4. COMPARATIVE STUDY OF PROFIT OF SYSTEM MODELS

The profits of computer system have been obtained by assuming $g(t) = \alpha e^{-\alpha t},\ f(t) = \theta e^{-\theta t}\ and\ m(t) = \Upsilon e^{-\Upsilon t}$. It is analyzed that the profits go on decreasing with the increase of failure rates (λ_1 and λ_2) and the rate (β_0) by which hardware undergoes for preventive maintenance after a pre specific operation time't' while their values keep on moving up with the increase of hardware repair rate (α), software up-gradation rate (θ) and preventive maintenance rate (γ) provided system has more chances of hardware failure. The numerical presentation of the results related to these profits obtained for models are shown in the tables 1 to 3. The profit of the base model has been compared with that of the models discussed in Munday et al. (2016) and Munday and Permila (2024). It is revealed that the base model is profitable over other two models. And, hence we can say that the concept of hardware preventive maintenance in a computer system with component wise redundancy in cold standby is not much helpful in making the system more profitable.

5. FUTURE SCOPE

This idea may be beneficial in automobiles industries and banking system.

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