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Evaluation criteria for reliability in computer systems

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Abstract: Numerical methods, particularly finite element methods, are widely used in solving different problems. Since these methods are approximate, having a real understanding of the distribution of errors is extremely important. With the increasing number of users, the number of cause dfailuresin creases by their fault. In this article we will discuss per formance evaluation system, the performance evaluation of computer and communication systems for quality research that is finding its profit goals for the number of ways to predict the behavior of the system. One of the main parameters in determining the performance evaluation is reliability and because some complex systems cannot be easily modeled by hybrid methods (RBD), we use Markov method.

Keywords: Performance Evaluation, Reliability, Reliability Block Diagram, Markov Method

1. Introduction

The size and complexity of computer systems have increased with faster than our ability to design, test, implement and maintain it in the last decade. Computer systems are increasingly used in various applications. This will certainly continue in the future. By using computer in all devices, services, and activities of daily life, its importance has increased. With the increasing number of users, the number of failures increases due to their fault, so we need to evaluate the system performance. In this paper we discuss and analyze the reliability and Markov method. Assessing system performance targets in a number of ways isto predict the system behavior. When new systems are built or existing systems will be added or configured, the performance evaluation can be used to predict architectures collision or comprehensive changes in the system efficiency. An important aspect of evaluation and performance is performance measurement and monitoring. By monitoring, operating system informs more about real and important events of the system. Note that the requirement for performance measurement is system availability that can be observed and measured. Therefore, we can better understand performance measurements on systems where it may arise gradually improved with newer systems. Another measure of the most important aspects of the system that is measured to check for changes and to implement special codes need to be time stamps are the event logs writing. Obviously, these changes affect system performance. Monitoring models (software, hardware, and hybrid) is one of the basic models for performance evaluation, but up slightly from replicating or expressing. In the performance evaluation, an abstract described model, which is based on (Mathematics) the concept of a system that is clearly a part of math and interactions, along with theimpact that well-expressed. Most of the time this part of model called the system model screw. Stresses specified in the performance evaluation based model, which means it is in fact the best model for computer communications systems, the task is challenging. In fact, the performance models require a lot of engineering skills that still is not enough [1,2].

2. Reliability Concepts

Definition of system reliability must be defined on the basis of precise concepts. Since the set of same systems that operate under identical conditions, may fail at any point of time, the failure phenomenon can be explained in terms of the follow in gpotential methods[7].

2.1. Check and Calculate the Reliability of a Simple System

Reliability is the probability that a system is intended to mandate ata specific time and specific performance under particular condition to success. System reliability can be used as a measure of success in carrying out their duties properly. For more explanation and understanding of reliability, we need to know, how to calculate the reliability of a simple system, and will continue to obtain a general formula.

System reliability R (T) is the probability that a system meets its functional specifications in the interval [0, t] failsafe function. There is a simple example for calculating the reliability. In this example, we want to estimate the average number of failures in a device or system in the interval [0, t] that is the failure rate. If at time zero, the same number N of normal components (of a sort) have been starting to work. After time t, some components are corrupted. And damaged areas until t (in the interval [0, t]) called F (t) and the normal component of the residual at time t as S (t). The reliability of these components will be equal to [5,4]:

$$R(t) = \frac{S(t)}{N} = \frac{S(t)}{S(t)+F(t)} \tag{1}$$

And so the unreliability of these components will be equal to:

$$Q(t) = \frac{F(t)}{N} \tag{2}$$

Therefore, at any time t, we would have:

$$R(t)+Q(t)=1 \Rightarrow R(t)=1-Q(t) \Rightarrow R(t)=1-\frac{F(t)}{N} \tag{3}$$

To calculate the failure rate, the above equation would be derived with respect to time.

$$\frac{dR(t)}{dt} = -\frac{1}{N}\frac{sF(t)}{dt} \Rightarrow -N\frac{dR(t)}{dt} = \frac{dF(t)}{dt} \qquad (1)$$

$\frac{dF(t)}{dt}$ is an instantaneous failure rate, means the rate attime t components fail. At time t, $S(t)$ the number of components remains intact. In the follow in gequation:

$$Z(t) = \frac{\frac{dF(t)}{dt}}{S(t)} \tag{5}$$

The Z (t) is called the failure rate or hazard represent the instantaneous failure rate at time t relative to the number of components in the areas of time t.

$$Z(t) = \frac{1}{S(t)}[-N\frac{dR(t)}{dt}] = \frac{-1}{R(t)}\frac{dR(t)}{dt} \Rightarrow$$
$$Z(t) = \frac{1}{1-Q(t)}\frac{dQ(t)}{dt} \tag{6}$$

$$\Rightarrow Z(t) = -\frac{\frac{dR(t)}{dt}}{R(t)} = \frac{\frac{dQ(t)}{dt}}{1-Q(t)} \tag{7}$$

Z (t) is time dependent. But experience has shown that for many systems, Z (t) at some time intervals is relatively healthy. Usually hardware component failure rates follow an experimental plot of the bathtub curve. As seen in the chart below, the system life span is divided to three infancy, young, and oldcategories. Intervals failure rate is very high in infancy and old age, but youth has almost constant rate.

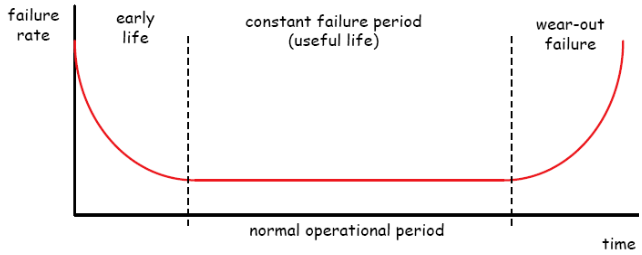

Figure 1. *Bathtub diagram*

Infancy typically in heat and stress tests is done at the factory pass. One can usually assume that the systems are in use in the period of youth. The following equation:

$$Z(t) = \lambda = \frac{-1}{R(t)}\frac{dR(t)}{dt} \Rightarrow \lambda dt = -\frac{dR(t)}{R(t)} \tag{8}$$

Integrating both sides of equation we have:

$$\lambda\int_0^t dt = -\int_1^{R(t)}\frac{dR(t)}{R(t)} \Rightarrow \lambda t\,|_0^t = LnR(t)\,|_1^{R(t)} \Rightarrow$$
$$\lambda t = LnR(t) \Rightarrow R(t) = e^{-\lambda t} \tag{9}$$

This relationship is known as the Exponential failure law. It means with a constant failure rate, reliability varies as a power function of time [5,4].

2.2. Reliability Modeling

Reliability, which can be calculated using various methods, is divided into two main groups: model-based and measurement based. The first method is widely used to evaluate the reliability of complex software / hardware systems is used, which is based on creating a model suitable for systems that briefly, with a sufficient level of detail to provide the aspect of interest to evaluate. Analysis models are classified into two types: Hybrid and state-based. The Hybrid model provides system structure in a logical connecting operation of elements in order to determine the success or failure of the system. The state model offer the behavior of system based on states tracks and available states. Models are used extensively to assess the characteristics of trust, especially reliability analysis. However, with some possible input value, the actual behavior of the system provider may not be accurate enough. Measurement-based approach may provide better results because they are based on actual operating data and application of statistical techniques. However, because the actual data may not be available using this method is not always possible [7].

3. Evaluation of Other Criteria

Reliability is not the only efficient criteria for evaluating the system. The following criterions also are used for this purpose:

3.1. Mean Time to Failure (MTTF)

The mean time to failure is the mean time that the system works before you experience a failure. Consider N systems work identical. If we show the deterioration of system i with ti, we have:

$$MTTF = \frac{1}{N}\sum_{i-1}^{N} t_i \tag{10}$$

We know $\frac{dQ(t)}{dt}$ is the failure density function and the MTTF is in fact expected time of failure. Following:

$$MTTF = \int_0^\infty t\frac{dQ(t)}{dt}dt = -\int_0^\infty t\frac{dR(t)}{dt}dt \Rightarrow MTTF = \int_0^\infty R(t)dt \tag{11}$$

This equation shows that the area under the curve R (t) is compared to the MTTF. However, if the system obeys the exponential failure law, we have:

$$MTTF = \int_0^\infty e^{-\lambda t}dt = \frac{-1}{\lambda}[e^{-\lambda t}]_0^\infty = \frac{1}{\lambda} \tag{12}$$

Means that, MTTF is inversely related to the rate of failure [3].

3.2. Mean Time to Repair (MTTR)

Mean time between failures is mean time between successive failures of the system. The mean time to repair (MTTR) cannot be easily estimated, and based on many parameters such as the type of defect, skills and experience to repair work, repair tools, system testing capabilities, and so on. Usually this time is estimated with the injection error to system and investigatation required time to fix the error. In mostcases, in order to simplify the evaluation, we show μ for the repair rate, fixed and equal to reciprocal of MTTR.

$$\mu = \frac{1}{MTTR} \tag{13}$$

Now, it can be stated maintainability of the system. Maintainability of the system is probability of a system could be damaged in the interval [0, t] to be repaired and re-used. With this definition we have:

$$M(t) = 1 - e^{-\mu t} \tag{14}$$

3.3. Mean Time between Failures (MTBF)

Mean time between failures, is the distance between two successive failures of a system. In other words, after a system crash, the system is repaired and back in operation until the next failure occurs. Based on this definition, the MTBF can be obtained as follows [5,7].

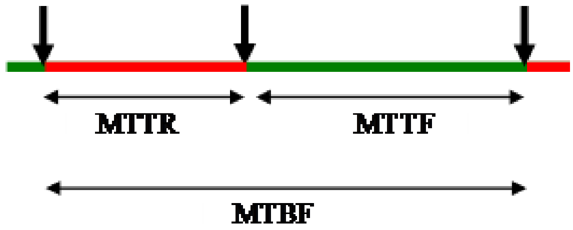

Figure 2. Mean time between failure

$$MTBF = MTTR + MTTF \tag{15}$$

Now based on these criteria, availability can be expressed. Availability is the probability that the system is functioning correctly at a specified time t. As you can see the availability is defined at the moment, but reliability is defined at the time interval.

The system can be accessed but fails repeatedly, and on the other hand have low reliability. If N is the number of failures occurred during the execution time, Steady-state availability is calculated as follows:

$$A_{Steady-State} = \frac{N.MTTF}{N.MTTF + N.MTTR} = \frac{MTTF}{MTTF + MTTR} = \frac{MTTF}{MTBF} \tag{16}$$

If the system abide failure rate and exponential repair, we have:

$$A_{Steady-State} = \frac{\frac{1}{\lambda}}{\frac{1}{\lambda} + \frac{1}{\mu}} = \frac{1}{1 + \frac{\lambda}{\mu}} \tag{17}$$

4. Evaluation of the System Using a Markov Model

Some complex systems cannot be easily modeled by hybrid methods like Reliability Block Diagram (RBD), such as feature detection and fault coverage, to repair and replace a module, the dynamic changes in the configuration of thesystem. The methods used for modeling should alsoconsider the state of the system. RBD shows how system components work properly and is effective in the correct working of the entire system. In this model, each piece of the system is a block that contains the input and output terminals. Block operation is the same as a switch.If the device is in operation mode switch is closed, but if the device is disabled, the switch will open. Given that the failure of any component of the system, some of the blocks are closed and some are open, if there is a path between input and output, the entire system is working well, but if there is no path then the system is disabled. RBD reliability of complex systems is divided in series, parallel, and M out of N. If the above not be solved, we solve by Markov method [5].

4.1. TheMarkov Model

For the Markov process, we divide the time into three periods: past, present, and future. The future of the process does not depend on the direction of the past but only present. For example, the Poisson process is a Markov process because the number of events that occur after a certain time is regardless of the events that happened before that. Markov chains is a special case of Markov process where the parameter T and the system selects only discrete values. Accordingly, a series of random variables X1, X2, X3, ...,Xn is called a Markov chain. Markov model is used for the analysis of stochastic systems based on the notions of states and transitions between states of the system, the system state is a combination of distinct modules, andthe system shows the healthy and faulty. If the system has n modules and each module has a health condition or damaged, then 2n can be considered for the position. State transitions model changes between states of the system that this changes can be result of a malfunction, or the repair of a faulty module, such as a TMR, when the system works properly that the 2 or 3 module works correctly [5,6].

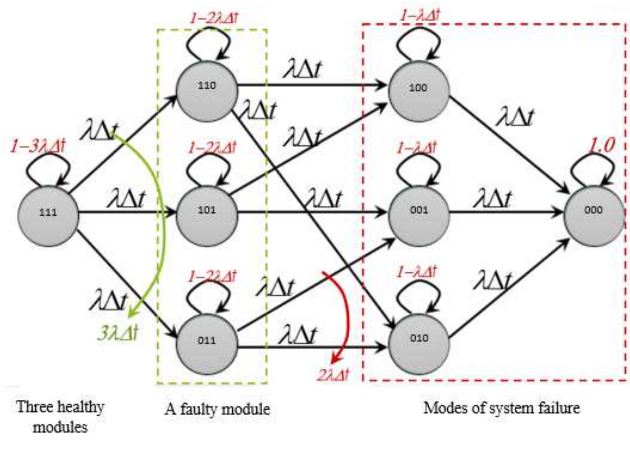

Figure 3. *Markov model for a TMR system*

In general, the probability of the system at time t + 1 in a given case depends on the state of the system at time t, t-1, t-2 and so on. The first order Markov model, the state of the system at time t + 1 depends the state of the system at time t not on the state of the system to chain all transitions between state before time t, in this model because there is only a failure between t and to t + 1 to describe many systems, is sufficient with memory length 1. If the system state at time t + 1 is independent of the previous state of the system, the Markov model is zero-order, such as polynomial is a probability distribution, and this model does not have a memory. In m-order Markov model, the order of a Markov model is equal to the amount of memory that it is possible to calculate the next state. For example, the next state in a second-order Markov model depends on two previous states.

The possibility that one module at a time breaks at $t+\Delta t$ time, provided that the module worked properly at t time (healthy) is equal to:

$$P = 1 - \frac{R(t+\Delta t)}{R(t)} \tag{18}$$

If the failure of modules subordinate Exponential failure law, we have:

$$R(t) = e^{\lambda t} \Rightarrow P1 - \frac{e^{-\lambda(t+\Delta t)}}{e^{-\lambda t}} \tag{19}$$

$$\begin{aligned} e^{-\lambda\Delta t} &= 1 + (-\lambda\Delta t) + \frac{(-\lambda\Delta t)^2}{2!} + \ldots \Rightarrow P = 1 - e^{-\lambda\Delta t} \\ &= 1 - P[1 + (-\lambda\Delta t) + \frac{(-\lambda\Delta t)^2}{2!} + \ldots] \Rightarrow P = (-\lambda\Delta t) - \frac{(-\lambda\Delta t)^2}{2!} - \ldots \end{aligned} \tag{20}$$

In Markov model, the possibility of a module failure rate λ in the considered time step Δt is considered $\lambda\Delta t$.

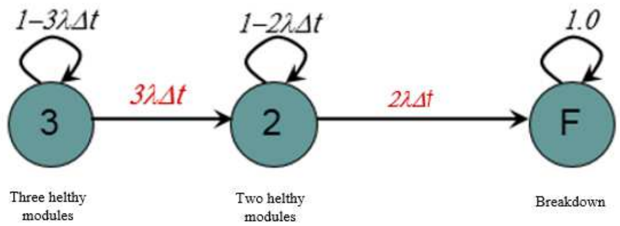

Figure 4. *Simplified model of a TMR system*

Since the first order Markov model is used, the system state at time $t+\Delta t$ depends only on the system state at t time. Thus we have:

$$P(t+\Delta t) = A.P(t) \tag{21}$$

The probability of being in different states of the system can be showed in matrix:

$$\mathbf{P}(t+\Delta t) = \mathbf{A}.\mathbf{P}(t) \tag{22}$$

$$\begin{bmatrix} P_3(t+\Delta t) \\ P_2(t+\Delta t) \\ P_F(t+\Delta t) \end{bmatrix} = \begin{bmatrix} 1-3\lambda\Delta t & 0 & 0 \\ 3\lambda\Delta t & 1-2\lambda\Delta t & 0 \\ 0 & 2\lambda\Delta t & 1 \end{bmatrix} . \begin{bmatrix} P_3(t) \\ P_2(t) \\ P_F(t) \end{bmatrix}$$

To calculate the probability of each state of the system at time t, we open up above matrix equation and sides of each share would be divided by Δt to a differential equation then solving the probability of being in each state of the system at time t is calculated. TMR, system reliability is equal to:

$$P_{TMR}(t) = P_3(t) + P_2(t) = 1 - P_F(t) \Rightarrow 3e^{-2\lambda t} - 2e^{-3\lambda t} \tag{23}$$

The result is identical with the result obtained from the TMR model helping the block diagram reliability [1].

Various types of Markov can be noted discrete Markov and Hidden Markov processes. If we have a system at any moment in a distinct states S1, ..., SN, at discrete times or regular intervals, the system state changes according to a set of possibilities. Appropriate to describe the current system needs to know the current status along with all the previous cases is that for the special case of a first order Markov chain, describing the probability is determined only by the current state and the previous state [2].

$$P(q_t = S_j \mid q_{t-1} = S_i, q_{t-2} = S_k, ...) = P(q_t = S_j \mid q_{t-1} = S_i) \quad (24)$$

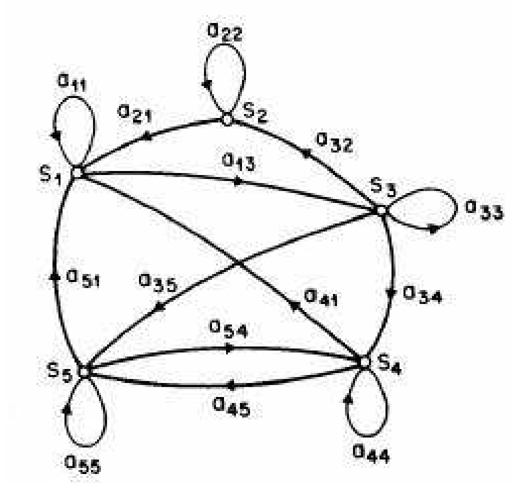

Figure 5. *A Markov chain with 5 states*

We consider only processes in which the right side of the above equation is independent of time and that's why we have a set of transition probabilities between states.

$$a_{i,j} = P(q_t = S_j \mid q_{t-1} = S_i) \; 1 \le i, j \le N \quad (25)$$

The above random processis calleda Markov model, because the output is a set of states that their exposure is associated with a view. We can produce the sequence of observations required to calculate the probability that the Markov chain. In this model, each state corresponds to an observable event, but the hidden model of the observation is probabilistic functions of states. The resulting model is a stochastic model is underlying (hidden) and only by a set of random processes that produce the sequence of observations is observed [2].

5. Discussion and Conclusion

This paper presented the system performance goals and evaluation criteria including reliability. The system performance evaluation purposes is the number of ways for predicting the behavior of the system, monitoring performance measurement, andpredicting changes in the system concept in new architectures. In this paper, we examined the reliability criterionand because complex systems cannot be easily combined with hybrid techniques such as RBD model, we usedMarkov methods. Markov models are used for theanalysis of stochastic systems based on the concepts of states of transition between states of the system, wherethe unknown probabilities can be obtained by iteration.

References

[1] BOUDEWIJN R.HAVERKORT, PERFORMANCE OF COMPUTER COMMUNICATIN SYSTEM: A Model – Based Approach. John Wiley & Sons, Inc. New York, NY, USA ©1998, ISBN:0471972282.

[2] Piet van Mieghem, Performance Analysis Of communications Networks And Systems, 2006. Book DOI:http://dx.doi.org/10.1017/CBO9780511616488

[3] M. Danielle Beaudry, performance-related reliability measures for computing system, IEEE TRANSACTIONS ON COMPUTERS, VOL. c-27, NO. 6, JUNE 1978

[4] Dhirajk.Pradhan".Fault-Tolerant Computer System design." by Prentice Hall PTR, A Simon &Sxhuster Company Upper Saddle River, New Jersey 07458,1996

[5] Zarandi, HR. Markov systems and evaluate the system performance ", Amirkabir University (Tehran Polytechnic), second edition. September 2011.

[6] Moatar, Mohammad Hussain. "Hidden Markov models and training algorithms", Amirkabir University of Technology (Tehran Polytechnic), 2006.

[7] Abbas Abadi, S. Reliable, Humayun. "Component-based software reliability prediction using stochastic Petri nets and Markov chains". International Symposium on Modeling and Optimization, Tehran, 2012.