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Some Methods of Calculating the Reliability of Mixed Models

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Abstract

In this paper some approximation techniques were used to find the reliability of complex systems such as the Min.cut , path tracing and reduction to the system to series elements, then some comparisons have been made.

الخلاصة

في هذا البحث تم أستعمال بعض تقنيات التخمين لأيجاد وثوقية الأنظمة المعقدة كطريقة أقل قطع، طريقة المسار ، بالأضافة الى طريقة أختزال النظام الى نظام متسلسل ، ثم قمنا بأجراء بعض المقارنات فيما بينها لأيجاد أفضل ثقة للنظام المعقد .

1. introduction

In the first I discuss reliability of mixed configuration , that is , systems consisting of elements connected in series and parallel . for the sake of simplicity I will consider configuration consisting of four elements . the elements could be independent identical units. several authors are interested in studying the various method to find the reliability of complex system such as path set method , matrices method , reduction to series element … etc. , for example Govil (1983) , Srinath (1985), Trindade, David C., (2010).

2. Some Definition and Concepts

The terminology to follow is very important in creating and analyzing reliability block diagrams.

2.1 Complex System [Trindade, David C., 2010, Paul Barringer, P.E., **2000**] :

is a collection of devices or subsystem interconnected to fulfill complex operation .

2.2 The reliability of a system [Srinath, 1985]:

it is probability that the system will adequately performed its intended function under started environmental for a specified interval of a time. We shall denote the reliability of system by R(t).

3.Solving methods

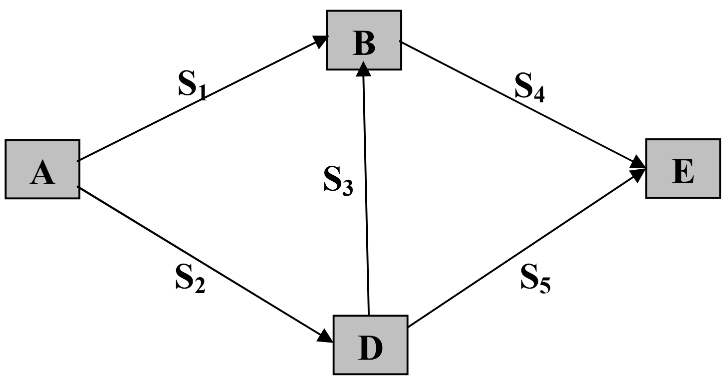

fig (1)com plex system

The system in fig (1) cannot be broken down into a group of series and parallel systems . this is primarily due to the fact that component A, D has two paths leading among from it . whereas B have only one ,

Besides S_1, S_2 , S_3 , S_4 and S_5 are called subsystems , several methods exist for obtaining the reliability of a complex system including [Srinath, 1985, AL-Ali, Abdul Ameer, 1998, Constantin Tarcolea, Adrian Paris, Cristian Andreescu, 2008]:-

3.1 path tracing – method

With the path-tracing method, every path from a starting point to an ending point is considered. Since system success involves having at least one path available from one end of the reliability block diagram to the other, as long as at least one path from the beginning to the end of the path is available, then the fig.(1) can be replaced to another fig(2) that will be representing reliability of series parallel system as follows [AL-Ali, Abdul Ameer, 1998, Srinath, 1985]:

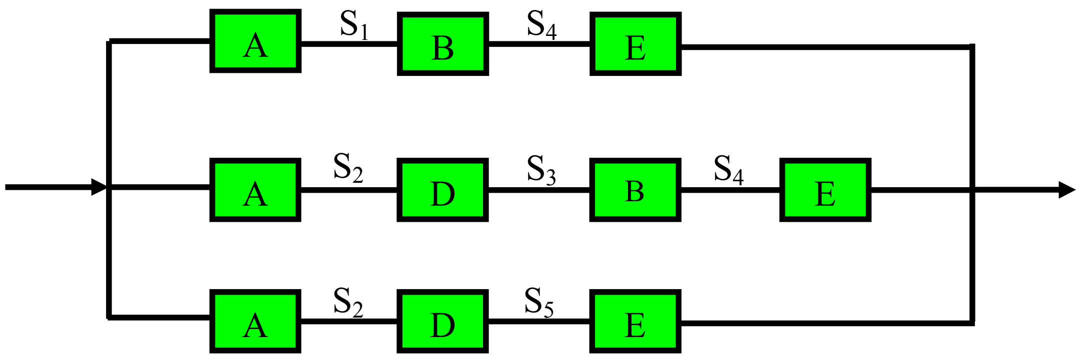

Fig.(2):series-parallel system

Suppose reliability of subsystems (S_i:i=1,2,3,4,5) that $R_i(t)$, and the reliability of series paths is denoted by $Rs_j(t)$ such that (j=1,2,3) and due to compute reliability of paths we will use the following eq:

$$Rs_j(t) = \prod_{j=1}^{n} R_j(t) \qquad ...(1)$$

Such that n is the number of subsystems in path Sj and from fig.(2) we will get the following equations :

$$\left.\begin{aligned} Rs_1(t) &= R_1(t).\ R_4(t) && ... \\ Rs_2(t) &= R_2(t).\ R_3(t).\ R_4(t) && ... \\ Rs_3(t) &= R_2(t).\ R_5(t) && ... \end{aligned}\right\} \quad (2)$$

Now we can obtain the reliability of parallel system that we denoted by Rp(t) as follows :

$$Rp(t) = 1 - \prod_{j=1}^{m} \left(1 - Rs_j(t)\right) \qquad ...(3)$$

Where m is the number of the paths

$R\,p(t) = 1-[(1- Rs_1(t)).(1- Rs_2(t)).(1- Rs_3(t))]$

$= 1-[1-(R_1(t).\ R_4(t)).(1- R_2(t).\ R_3(t).\ R_4(t)).(1- R_2(t).\ R_5(t))]$

$= R_2(t).\ R_5(t) + R_2(t).\ R_3(t).\ R_4(t) - R_2(t).\ R_3(t).\ R_4(t).\ R_5(t) + R_1(t).\ R_4(t)$

$- R_1(t).\ R_2(t).\ R_4(t).\ R_5(t) – R_1(t).\ R_2(t).\ R_3(t).\ R_4(t)$

$+ R_1(t). R_2(t). R_3(t). R_4(t). R_5(t)$ … (4)

If we take $R_1=R_2=\ldots=R_5=0.9$, with independent identical paths we get

$Rp(t)= 2 R^2(t) + R^3(t) – 3 R^4(t) + R^5(t)$

$= 0.97119$

3.2 Minimal Cut Method [Quek S-T. , Ang A. H-S. , **1986**, Constantin Tarcolea, Adrian Paris, Cristian Andreescu, **2008**].

I will assume that $R_i(t)$ represent the reliability of i th component in a cut set M_{Cj} , , j = 1,2,3 . there fore there are three possibilities of cut sets its representation shows as a series – parallel system as shows in fig.(3) , any failure occurs in a cut set that will cause the system fail

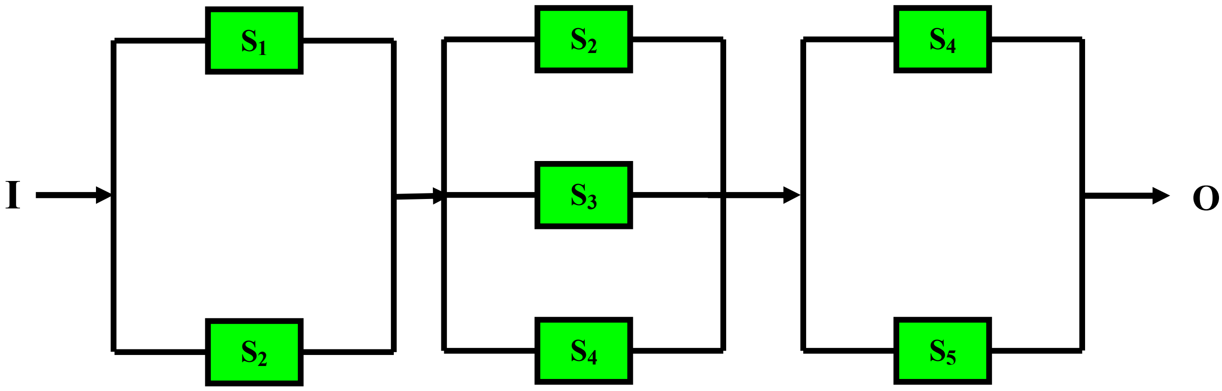

Fig. (3)

$$\left.\begin{aligned} Mc_1 &= 1- [(1-R_1(t))\,(1-R_2(t))] \\ Mc_2 &= 1- [(1-R_2(t))\,(1-R_3(t))\,(1-R_4(t))] \\ Mc_3 &= 1- [(1-R_4(t))\,(1-R_5(t))] \end{aligned}\right\} \quad \ldots(5)$$

Then the reliability system by this method that we denoted by $R_{Mc}(t)$ is

$$R_{Mc}(t) = \prod_{j=1}^{3} M_{Cj}(t)$$

$=[1- [(1-R_1(t)) (1-R_2(t))] \times[1- [(1-R_2(t)) (1-R_3(t)) (1-R_4(t))] \times[1- [(1- R_4(t)) (1-R_5(t))]]]$

$= R_1(t) R_4(t) + R_2(t) R_4(t) + R_2(t) R_5(t) – R_2(t) R_4(t) R_5(t) + R_1(t) R_3(t) R_5(t) - R_1(t) R_3(t) R_4(t) R_5(t) - R_1(t) R_2(t) R_3(t) R_5(t) + R_1(t) R_2(t) R_3(t) R_4(t) R_5(t)$

If we take $R_1=R_2=\ldots=R_5=0.9$, with independent identical units we get

$R_{Mc} (t) = 3R^2(t) – R^3 (t) - 2R^4 (t) + R^5(t)$ …(6)

$= 0.9788$

3.3 Reduction to series element

[Constantin Tarcolea, Adrian Paris, Cristian Andreescu, **2008**]

Form previous method we shown that the system in fig. (1) can be transform into the parallel – series system that is depicted in fig (3) , in this method we systematically replace each parallel path by an equivalent single path and ultimately reduce the given system to one system consisting of series elements.

We can explain the solving of this method by the following steps.

Step 1: The parallel paths s_1, s_2 will be first replaced by an equivalent series element. ***Say P1***

$R_{P1} (t) = 1- [(1-R_1(t)) (1-R_2(t))]$

If we take $R_1=R_2= 0.9$, with independent identical units we get

$R_{P1}(t) = 1 - [(1-R(t))^2]$ …(7)

$= 2R(t) - R^2(t) = 0.99$

Step (2): parallel elements s_2, s_3, s_4 can be replaced by an equivalent element whose reliability is obtained from the rule that. **Say P2**

$R_{P2}(t) = 1 - [(1-R_2(t))(1-R_3(t))(1-R_4(t))]$

If we take $R_2 = R_3 = R_4 = 0.9$, with independent identical units we get

$R_{P2}(t) = 1 - [(1-R(t))^3]$ …(8)

$= 3R(t) - 3R^2(t) + R^3(t) = 0.999$

Step (3): parallel elements s_4, s_5 can be replaced by an equivalent element whose reliability is obtained from the rule that. **Say P3**

$R_{P3}(t) = 1 - [(1-R_4(t))(1-R_5(t))]$

If we take $R_4 = R_5 = 0.9$, with independent identical units we get

$= 1 - [(1-R(t))^2]$ …(9)

$= 0.99$

Step 4: The system has now been reduced to a system contains series elements as:

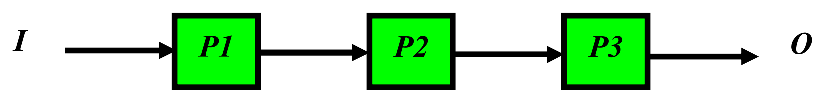

Fig. (4)

The system reliability of Fig. (4) is

$R_S(t) = R_{P1}(t) \times R_{P2}(t) \times R_{P3}(t)$ …(10)

$= 0.97$

Conclusion

in this work , we study three –method to find the reliability of complex system , path tracing method , reduction to series element method and the minimal cut method.

We concluded

1- The of elements of the system depends on the method used to calculate system reliability.

2- the system reliability in the second method as in iq.(6) is largest than the reliability of the first and third method as an eq.(4) and (10) respectively .

3- the system reliability is bounded between the upper as in eq.(6) and lower bound as in eq.(10).

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