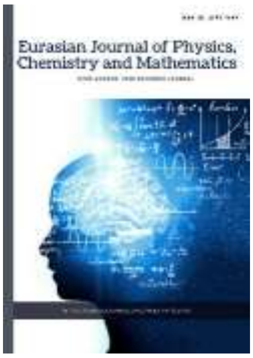

Employing a bees colony algorithm to solve the problem of improving the reliability of a complex network

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ABSTRACT

In The allocation of reliability and optimization for each part of the complex system has been determined in this paper, in order to solve the problem of allocation and to improve network stability we will use Bees Colony Optimization (BCO). The three cost functions are also introduced (exponential behavior with feasibility factor model, exponential behavior model and logarithmic model). After solving the allocation problem. The aim of this paper is to compare the effects of the three cost functions using Bees Colony algorithm in terms of reliability allocation and optimization to determine which is more efficient.

Keywords: Reliability Allocation; Reliability Optimization; Allocation, , Bees Colony algorithm

1. Introduction

In the present article, we watched the installed complex system's efficiency. By using limited paths across relation matrices, this system was found to be efficient. (To create minimum paths, remove nodes) as well as Boolean algebra. The goal of evaluating to be learn about the protection of the sophisticated unit that has been built [1-3]. Despite the networks' foundations, the optimum distribution dependability is treated as a mathematical task in this research. Each and every dynamic component Each device offers a unique set of features. dependability standards that are optimized and reliant on its importance [2, 4-6]. In order to achieve the highest level of efficiency in general, depending on the position of each element in the System, which varies between the component and the component, such components may require large allocations. Engineers working on improving mechanical and electrical systems encounter a variety of challenges [7]. The focus of this work is on complicated structure allocation and improvement, in addition to the cost system, which can be assessed in terms of size, and proportion, or other criteria. The dependability of this component is based on two keys needs. To begin, the model should be used to determine the input variable reliability. You will change the parameters of the suggested cost parameter [3, 8-10]. Engineers may now upgrade their duties for each machine and prepare for the utmost Each device's productivity, second, the model's analytical performance should be balanced of the input system. This can be a huge difficulty in simple structures, but it can be In complex systems, this is a significant issue [11]. The expenses are calculated using the Bees Colony Optimization algorithm, which uses complex systems to solve optimization problems. The algorithm uses three cost functions " Modeling activity exponentially with the viability factor, The exponential behavior paradigm and a logarithmic model". The goal is to improve device reliability while lowering total expenses.

2. Optimization of complex system

Consider a system of interconnected components. [1-3]. We are reliant on statements.: $0 \le R_i \le 1$ dependability of a component i ; $C_i(R_i)$ the Individual Costs, Components i , C ($R_1,\ldots,R_n$) = $\sum_{i=1}^{n} a_i c_i$ (Ri) Parts' Prices $a_i > 0$; The effectiveness of the system is measured in R_S , the device's reliability objective is denoted by the letter RG. Each component of the scheme has a distinct goal, and there are several options. Device modules have their own set of features. varying levels of assurance in the same characteristics. The objective is to ensure that any or all gadget components are trustworthy. The Q issue is a non-linear threshold with an evaluable cost and function [12-15]. Seek out

$$\text{Minimize}C(R_i,\ldots,R_n) = \sum_{i=1}^{n} a_i C_i(R_i), \quad a_i > 0, \qquad (1)$$

within the terms of

$$R_G \le R_S$$

$0 \le R_i \le 1$, such $i = 1,\ldots,n$.

Let's pretend the cost function is appropriate.. $C_i(R_i)$ satisfies those requirements [12, 16]. The favorable, unique role is being improved.

$\left[\Rightarrow \frac{dC_i}{dR_i} \ge 0\right]$.

The goal of the prior strategy was to achieve a cost basis that included everything [2, 4]. The stability limit of the system has been lowered. However It's in the vicinity the scope of R_G.

3. Application to complex network

All components in the complex network illustrated have the same as in fig. (1) primary trust level of 90% at the specified periods [11]. The system's aim for stability is 90 percent at any given time. The dependability polynomial for the proposed technique was found using the approach to minimal path [14].

$$\begin{aligned}R_S = {} & R_1R_9R_{10} + R_2R_8R_{10} + R_2R_5R_7R_{10} + R_3R_4R_7R_{10} + R_1R_6R_8R_{10} + R_2R_6R_9R_{10} - R_1R_2R_6R_8R_{10} - R_1R_2R_6R_9R_{10} + R_1R_5R_6R_7R_{10} - R_1R_2R_8R_9R_{10} + R_3R_4R_5R_8R_{10} - R_2R_5R_7R_8R_{10} \\ & - R_1R_6R_8R_9R_{10} - R_2R_6R_8R_9R_{10} - R_1R_2R_5R_6R_7R_{10} - R_2R_3R_4R_5R_7R_{10} - R_2R_3R_4R_5R_8R_{10} - R_1R_2R_5R_7R_9R_{10} - R_1R_3R_4R_7R_9R_{10} - R_2R_3R_4R_7R_8R_{10} + 2R_1R_2R_6R_8R_9R_{10} \\ & - R_1R_5R_6R_7R_8R_{10} + R_3R_4R_5R_6R_9R_{10} - R_3R_4R_5R_7R_8R_{10} - R_1R_5R_6R_7R_9R_{10} - R_2R_5R_6R_7R_9R_{10} - R_1R_3R_4R_5R_6R_7R_{10} - R_1R_3R_4R_5R_6R_8R_{10} - R_1R_3R_4R_5R_6R_9R_{10} \\ & + R_1R_2R_5R_6R_7R_8R_{10} - R_1R_3R_4R_6R_7R_8R_{10} - R_2R_3R_4R_5R_6R_9R_{10} + 2R_2R_3R_4R_5R_7R_8R_{10} + 2R_1R_2R_5R_6R_7R_9R_{10} - R_1R_3R_4R_5R_8R_9R_{10} - R_2R_3R_4R_6R_7R_9R_{10} \\ & + R_1R_2R_5R_7R_8R_9R_{10} - R_3R_4R_5R_6R_7R_9R_{10} - R_3R_4R_5R_6R_8R_9R_{10} + R_1R_5R_6R_7R_8R_9R_{10} + R_2R_5R_6R_7R_8R_9R_{10} + R_1R_2R_3R_4R_5R_6R_7R_{10} + R_1R_2R_3R_4R_5R_6R_8R_{10} \\ & + R_1R_2R_3R_4R_5R_6R_9R_{10} + R_1R_2R_3R_4R_5R_7R_9R_{10} + R_1R_2R_3R_4R_6R_7R_8R_{10} + R_1R_2R_3R_4R_5R_8R_9R_{10} + R_1R_2R_3R_4R_6R_7R_9R_{10} + R_1R_2R_3R_4R_7R_8R_9R_{10} + 2R_1R_3R_4R_5R_6R_7R_8R_{10} \\ & + 2R_1R_3R_4R_5R_6R_7R_9R_{10} + 2R_1R_3R_4R_5R_6R_8R_9R_{10} + 2R_2R_3R_4R_5R_6R_7R_9R_{10} + R_1R_3R_4R_5R_7R_8R_9R_{10} + R_2R_3R_4R_5R_6R_8R_9R_{10} - 2R_1R_2R_5R_6R_7R_8R_9R_{10} +\end{aligned}$$

$R_1 R_3 R_4 R_6 R_7 R_8 R_9 R_{10} + R_2 R_3 R_4 R_6 R_7 R_8 R_9 R_{10} + R_3 R_4 R_5 R_6 R_7 R_8 R_9 R_{10} - 2 R_1 R_2 R_3 R_4 R_5 R_6 R_7 R_8 R_{10} - 3 R_1 R_2 R_3 R_4 R_5 R_6 R_7 R_9 R_{10} - 2 R_1 R_2 R_3 R_4 R_5 R_6 R_8 R_9 R_{10} - 2 R_1 R_2 R_3 R_4 R_5 R_7 R_8 R_9 R_{10} - 2 R_1 R_2 R_3 R_4 R_6 R_7 R_8 R_9 R_{10} - 3 R_1 R_3 R_4 R_5 R_6 R_7 R_8 R_9 R_{10} -2 R_2 R_3 R_4 R_5 R_6 R_7 R_8 R_9 R_{10} + 4 R_1 R_2 R_3 R_4 R_5 R_6 R_7 R_8 R_9 R_{10}$

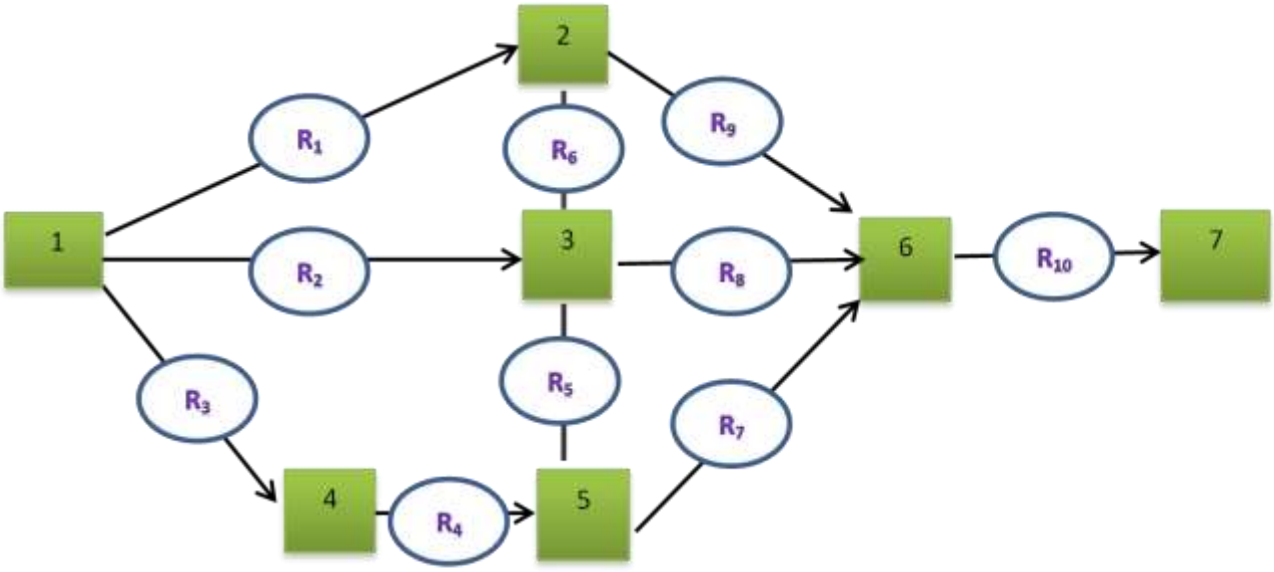

Figure 1 : Complex Network

4. Three cost models for reliability.

4.1 Model of exponential behavior with a feasibility parameter

Suppose $0 < f_i < 1$ be the feasibility factor, $R_{i,min}$ be minimum reliability and $R_{i,max}$ be maximum reliability[3,4]. Exponential behavior is another important cost function.

$$C_i(R_i) = \exp[(1 - f_i)\frac{R_i - R_{i,min}}{R_{i,max} - R_i}],\ R_{i,min} \le R_i \le R_{i,max},\ i = 1,2,3, \dots, n. \quad (4.1)$$

The issue of optimization then:

Minimize $C(R_i, \dots, R_n) = \sum_{i=1}^{n} a_i \ \exp[(1 - f_i)\frac{R_i - R_{i,min}}{R_{i,max} - R_i}],\ i = 1,2, \dots, n.$

Subject to:

$$Rs \ge R_G$$

$$R_{i,min} \le R_i < R_{i,max},\ i = 1, \dots, n.$$

Table 1: The Optimal Reliability Allocation (ACO).

Components	R_i	C_i
R_1	0.85675	19.894
R_2	0.91404	203.7
R_3	0.805	7.8782
R_4	0.86674	25.843
R_5	0.77627	5.6679
R_6	0.78884	6.4744
R_7	0.86263	23.102
R_8	0.775	5.597
R_9	0.91404	203.7
R_{10}	0.91404	203.7
R_S	0.90555	352.78

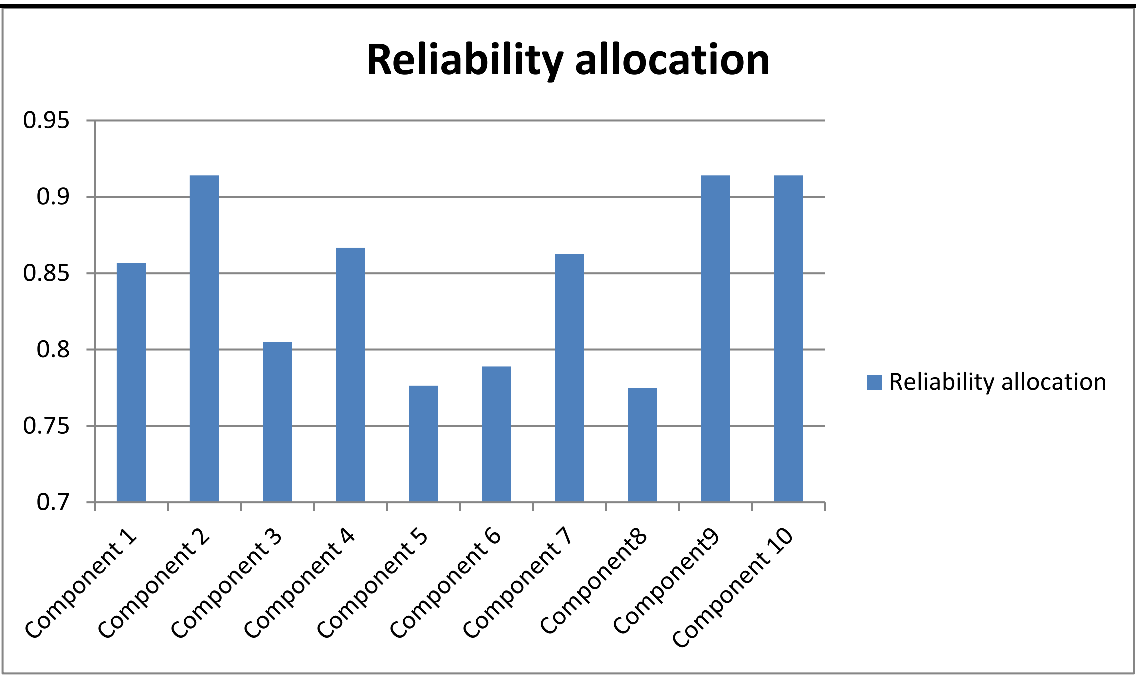

Figure 2: Allocating reliability using exponential behavior model with feasibility factor model for complex network.

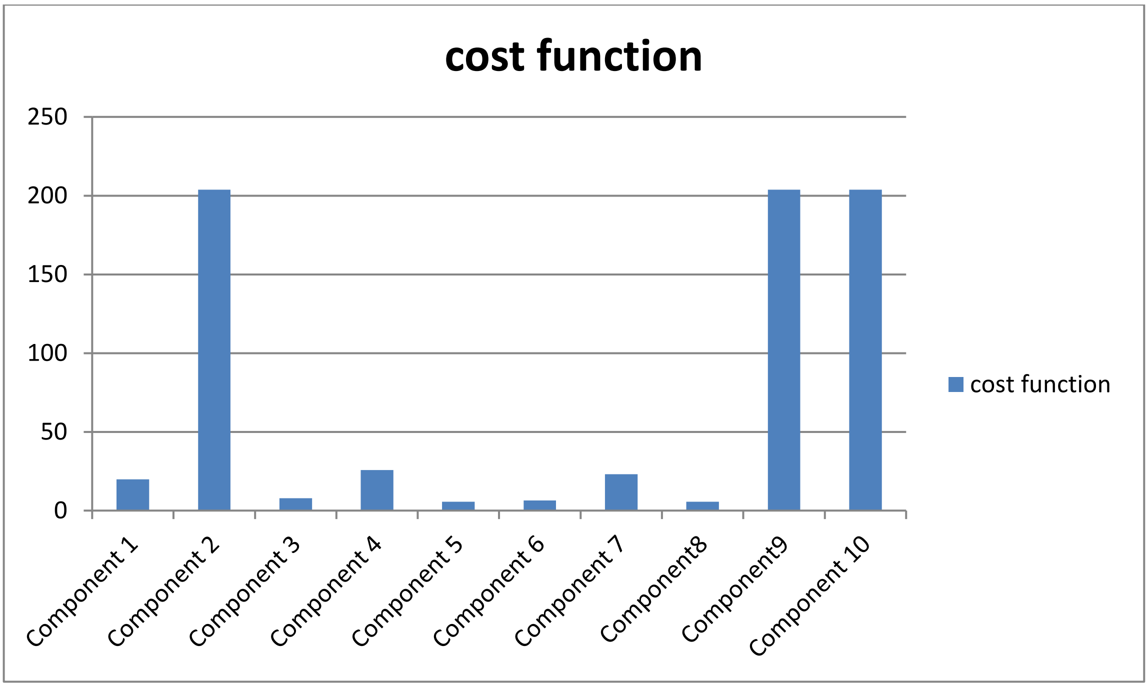

Figure 3 : A cost function for a model-viable exponential behavior process.

4.2 Exponential behavior model

Suppose $0 \leq R_i$, and $R_i \leq 1$ and, Constants a_i and b_i, where $i = 1, \dots, n$.. The exponential procedure is the most important cost function. Suggested it in the following format:

$$C_i\,(R_i) = a_i e^{\left(\frac{b_i}{1-R_i}\right)}, a_i > 0, b_i > 0, \quad \text{where} \quad i = 1, \dots, n. \qquad (4.2)$$

The issue of optimization then:

$$\text{Minimize } C(R_i, \dots, R_n) = \sum_{i=1}^{n} a_i\, e^{\left(\frac{b_i}{1-R_i}\right)}, \text{ where } i = 1, \dots, n.$$

Subject to:

$$R_G \le R_S$$

$$0 \le R_i \le 1, \quad \text{where} \quad i = 1, \ldots, n.$$

Table 2: The Optimal Reliability Allocation (ACO).

Components	Ri	Ci
R_1	0.863	38.461
R_2	0.877	58.267
R_3	0.87131	48.68
R_4	0.87117	48.475
R_5	0.825	17.412
R_6	0.912	293.48
R_7	0.912	293.48
R_8	0.876	56.388
R_9	0.79158	11.013
R_{10}	0.912	293.48
R_S	0.90461	579.57

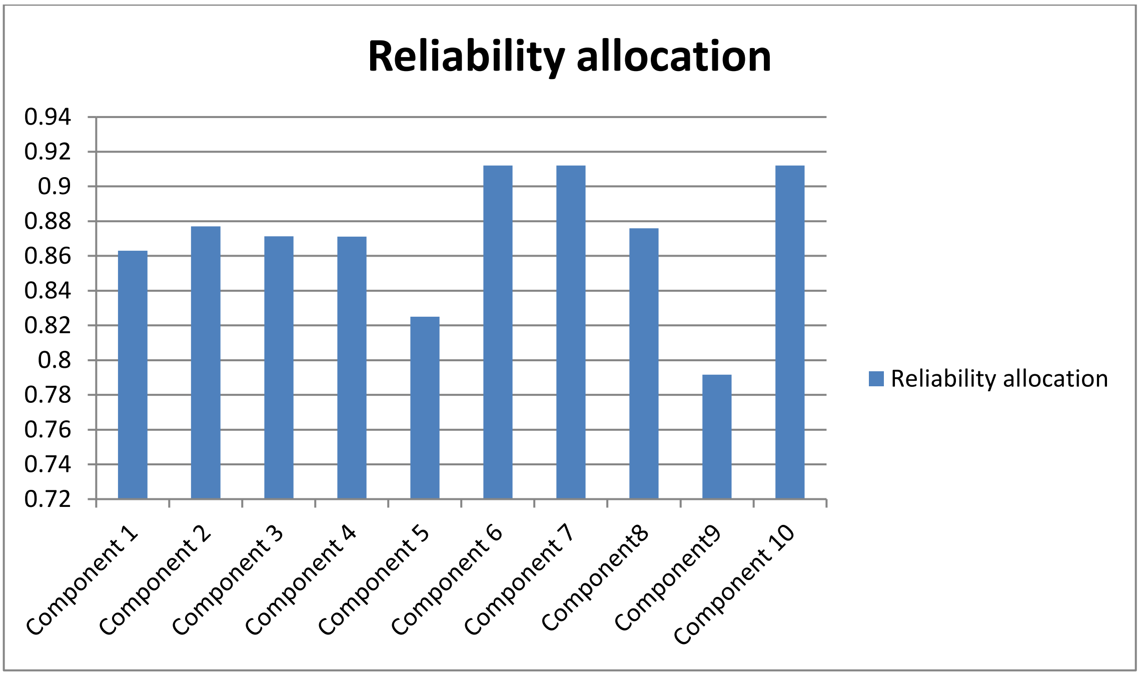

Figure 4: Allocating reliability for complex network by the exponential behavior model..

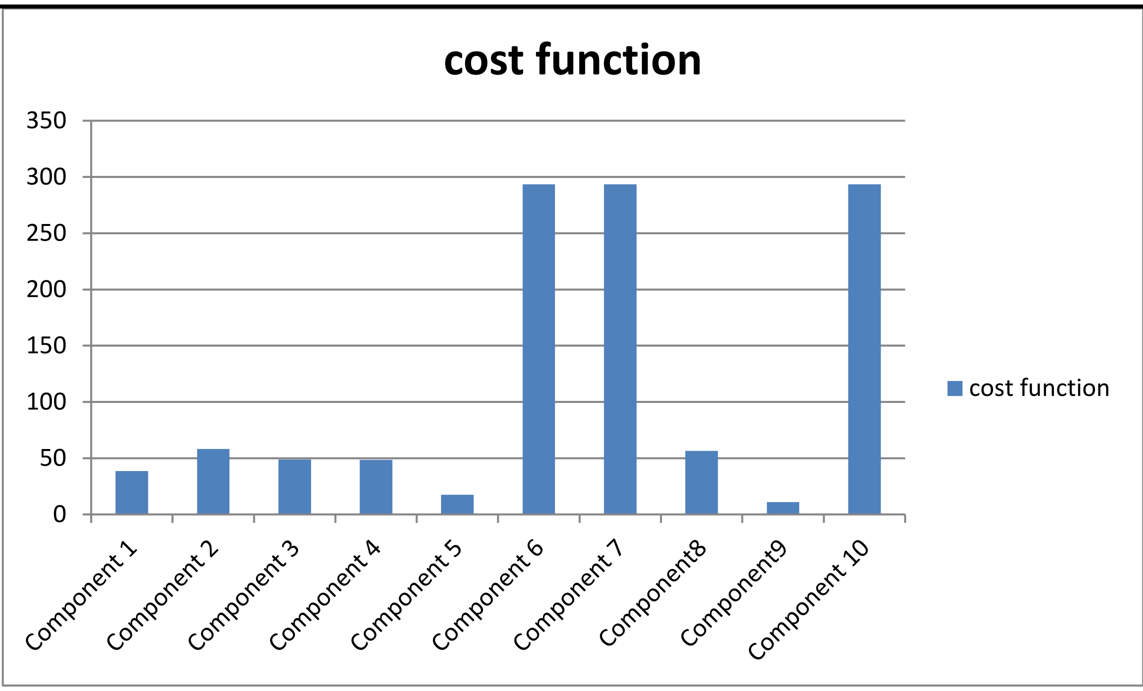

Figure 5: A cost function of a complicated network is determined using the exponential behavior model.

4.3 Logarithmic model

Let $0 \leq R_i$, and $R_i \leq 1$ and, Constants a_i where $i = 1, \ldots, n$. Let's suppose it in the form

$$C_i(R_i) = a_i \ln\left(\frac{1}{1-R_i}\right), a_i > 0\ ,\ i = 1, \ldots, n \qquad (4.3)$$

The issue of optimization then.:

$$\text{Minimize}C(R_i, \ldots, R_n) = \sum_{i=1}^{n} a_i \ \ln\left(\frac{1}{1-R_i}\right), \quad \text{where} \quad i = 1, \ldots, n.$$

Subject to:

$$R_G \leq R_S$$

$$0 \leq R_i \leq 1, \quad \text{where} \quad i = 1, \ldots, n.$$

Table 3: Table for ACO-Based Optimal Reliability Allocation

Components	R_i	C_i
R_1	0.997	5.8091
R_2	0.852	1.9105
R_3	0.55	0.79851
R_4	0.586	0.88189
R_5	0.57	0.84397
R_6	0.592	0.89649
R_7	0.637	1.0134
R_8	0.997	5.8091
R_9	0.977	3.7723
R_{10}	0.997	5.8091
R_S	0.99564	13.772

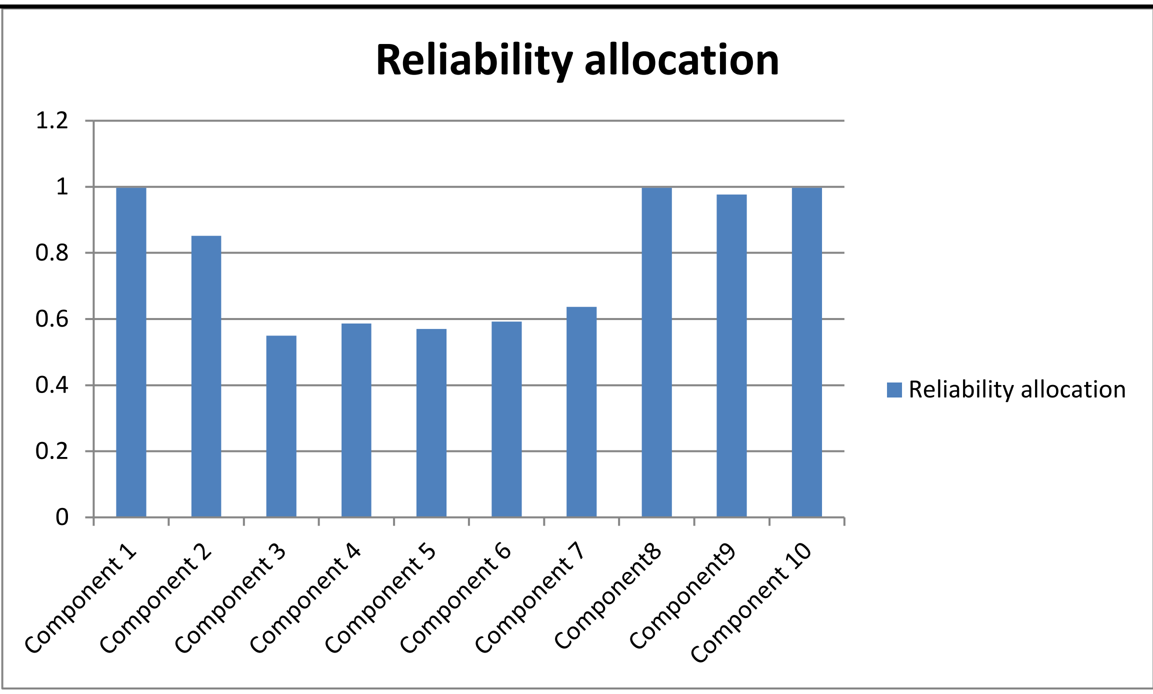

Figure 6: Allocating reliability for complex systems using the logarithmic model.

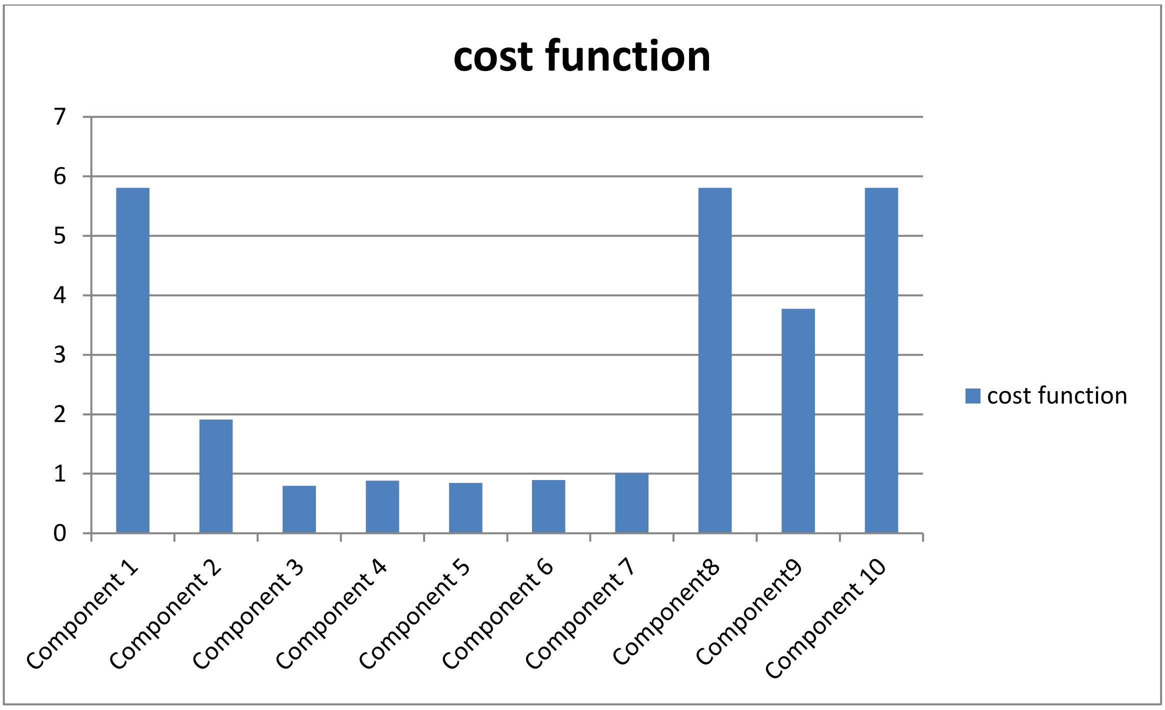

Figure 7: A logarithmic formula is by to calculate a cost function for a complex structur

Table 4 : The Presenting Three Cost Function Models' Solutions to The Reliability Allocation Problem's (ACO)

Components	The first cost function	The second cost function	The third cost function
R_1	0.85675	0.863	0.997
R_2	0.91404	0.877	0.852
R_3	0.805	0.87131	0.55
R_4	0.86674	0.87117	0.586

R_5	0.77627	0.825	0.57
R_6	0.78884	0.912	0.592
R_7	0.86263	0.912	0.637
R_8	0.775	0.876	0.997
R_9	0.91404	0.79158	0.977
R_{10}	0.91404	0.912	0.997
R_S	0.90555	0.90461	0.99564

5. Discuss the outcomes

The last table shows the three cost functions we employed. and found that the logarithmic model provided the best results, with Rs=0.99564. Despite the fact that the cost of each complicated system component was computed, the overall each cost function's cost was determined using the (BCO), and a function's value was an exponential behavior model with a feasibility factor of (352.78). While a function's cost with an exponential behavior model is (579.57) and the logarithmic model's last cost of a function (13.772).

6. Conclusions

The challenge of enhancing a complicated network was handled in this article by assigning the dependability of system components according to their significance. For three costs with constraints, the topic was also treated as a nonlinear programming challenge (reliability of complex systems). To tackle the reliability allocation problem, the ant colony optimization (BCO) method was utilized. A comparison was made between the findings when the data and discussions when the three cost functions were examined, The Logarithmic model proved to be the more effective than them. Component 10 earned the highest support, according to the reliability allocation issue. The benefit of this paradigm is that it accepts any algorithm., no matter how complex, to be implemented using mathematical techniques.

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