A Reliability Allocation scheme for Component Based Software using Fuzzy Analytic Hierarchy Process and Dynamic Programming

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***Abstract-* Reliability of a system plays a vital role in determining the quality of software. A thorough understanding of software design, reliability apportionment, and software characteristics significantly increases software reliability. A review of the literature revealed that reliability allocation is a crucial step during the development of software. Various reliability allocation techniques are available in the literature to calculate reliability of components in Component Based System (CBS). The current research proposes a reliability allocation method for CBS using Fuzzy Analytical Hierarchical process (FAHP) along with dynamic programming. This method incorporates user point of view about system with programmer point of view for reliability allocation. The system is organized into a hierarchical structure to apply FAHP and to accommodate both the views. The model has been compared with an existing model using sensitivity analysis. Finally, a concrete example has been provided to highlight the viability and efficacy of the suggested approach.**

Keywords- Component Based Software Engineering (CBSE), Reliability, Fuzzy, FAHP.

1. INTRODUCTION

The accuracy and dependability of the software systems must be verified because military and other sophisticated systems frequently rely on the software. In other words our existence and employment depends on software reliability and precision to a significant degree. Software reliability is described as the probability of a specified system performing its job effectively for a specified period of time under the definite operating conditions. Reliable software ensures that no bug will be reported by the user during the execution period under stated conditions [1].

Software design engineers of modern era try to develop highly reliable software"s. For this purpose they need to estimate the reliability at an early stage such as requirement analysis or design stage. Reliability allocation technique plays an important role to fulfill this requirement of fixing and allocating target reliability to the components of a system. Reliability allocation is defined as a technique of assigning the pre-defined reliability targets amongst the subsystems [2].

Accelerating software development and lowering overall development costs have become two of software developers' top priorities in recent years. It was made possible by Component Based Software Engineering (CBSE), which increased productivity, quality, and reusability while lowering maintenance costs. CBSE is a process that focuses on the design and development of computer-based systems with the use of reusable software components [3].

All the software development phases such as requirement analysis, design, coding and maintenance activities are carried out by human beings and these activities have fuzziness in them. So, for establishing software dependability models, the fuzzy set theory concept is appropriate. Software reliability allocation problem is an optimization as well as decision-making problem and many factors influence the reliability allocation [4] [5] [6].

The objective of the current study is to suggest a concept for architecture-based software reliability allocation, using FAHP to accommodate fuzzy factors and using dynamic programming for cost cutting.

The proposed model creates a hierarchy for component based software that associate user"s view regarding reliability with the software programmer"s view. The basic goal of the model is to obtain the reliability allocation parameters that are required, and then use dynamic programming to speed up and lower the cost of computations. The reliability allocation problem of software that may be divided into hierarchical levels, such as component-based software, will be suitable for the suggested solution. Results of the proposed FAHP method are compared with the method that used AHP. Sensitivity analysis has been used to evaluate exactly how the suggested model performs.

The remainder portion of this is structured as follows: Section two presents relevant research in the fields of reliability allocation, AHP, and FAHP. The remaining part of this paper is organized as follows: Section two describes related work in the field of reliability allocation, AHP, and FAHP. Section three describes research background necessary to understand the current research. In Section four explains the proposed Component based software system reliability allocation model. Section five illustrates the proposed method by an example. Section six concludes the paper. Referred papers are listed at the end.

2. LITERATURE SURVEY

In early times reliability allocations were applied only on hardware systems. Afterwards it was approved as significant characteristic for software reliability also.

Yi and Chengwen (2009), in their research stated that these factors contain a lot of ambiguous fuzzy qualities, making it challenging to create a mathematical model that includes them. This study uses AHP with fuzzy decision (FAHP) to solve the component-based software reliability allocation problem. This paradigm offers an integrated strategy that incorporates the user's needs with the technical framework of the software and its elements. This methodology offers an integrated approach where the technical framework of the software and its constituent parts are combined with the user's requirements. The Proposed model conclude reliability goal at the initial phases such as requirement, planning and design phase of software [7].

M.E. Helander and Niclas Ohlsson initially came up with the concept of software reliability allocation. They described a reliability allocation model called RCCM (Reliability Constrained Cost Minimization), which is used to assign the reliability to various subcomponents [8]. Zahedi and Ashrafi also use the AHP technique to model the software architecture with cost constraints, and they also put out a model for maximising system reliability. They proposed software reliability allocation based on analytical hierarchical process (AHP) for maximizing the user‟s utility based on expenditure [9].

Boehm presents a method for evaluating software development cost by using COCOMO model [10]. In order to optimise the reliability allocation and testing schedule for a software system while taking into account the reliability growth of its components, Lyu, M. R., Rangarajan, S., and Van Moorsel, present a solution. The aforementioned concepts and techniques, however, are used in the later stages of software development as opposed to the initial stages. It is known that later the defects are found, the higher cost needs to be paid for their maintenance. Software architecture is required for reliability allocation in early stages of software development [11].

In 2009, Guan, Wang, and Chen, prepared an architecture based model to optimize the reliability of software. Dynamic programming algorithms are employed to assign the reliability to each component to achieve the desired reliability with minimum design cost [12].

In the past, researchers have used architecture-based models to meet the desired reliability of a software system while dealing with constraints like budget, delivery time etc.

Kubat proposed a stochastic model that tried to minimize the cost in addition to reliability allocation [13].

Rani and Misra proposed monetary model for minimizing cost such as development cost and failure cost for the optimal allocation of reliability [14].

Traditionally reliability allocation was based on only one or two decisive factors like maximization of reliability or minimization of expenditure. During recent years researchers concentrated on multi-attribute based reliability allocation techniques by considering various software characteristics such as availability, reliability criticality, complexity, functionality etc.

A software system hierarchy that incorporated the views of consumers and developers was acknowledged by Chatterjee, Misra, and Alam. To fulfill the weight criteria for reliability allocation, they used the Fuzzy Analytical Hierarchical Process (FAHP). The software system was divided into three components, namely functions, programs, and modules, according to the system hierarchy. The factors connected to the components become fuzzy as a result of human involvement in every stage of the software development process, from requirement analysis to coding and maintenance.. Hence, there arises an ardent need to develop the software reliability models based on the concept of fuzzy set theory [15].

Zadeh explained that AHP is a form of multi-criteria decision-making technique (MCDM) for the comparison of pairs. He extended AHP into fuzzy environment to accommodate uncertainty and vagueness involved in real life application [16].

In the proposed paper, the reliability allocation problem for software systems has been optimized using FAHP. This paradigm combines the user's preferences and requirements with the software's technical framework, including its components. Proposed model determines reliability goal at the initial phases of software development such as planning and design phase. The suggested paradigm creates a hierarchy that connects users' perceptions of reliability to software managers' and programmers' perceptions of the software. Deriving the parameters necessary for the creation of a reliability allocation model is the structure's ultimate purpose.

3. RESEARCH BACKGROUND

3.1 Fuzzy sets and fuzzy number

In order to address uncertainty by imprecision in information, data, or systems, Zadeh created fuzzy set theory in 1965.This theory comprises fuzzy numbers, and membership function to transform fuzzy information into functional data efficiently [17].

1) *Fuzzy number:* A fuzzy number is a simplification of a real number that does not refer to one sole value but to a related set of possible values, where every possible value has its own weight between 0 and 1. This weight is referred as the membership function [17].
2) *Triangular fuzzy number:* A triplet (a1, a2, a3) is identified as Triangular Fuzzy Number (TFN), where "a1" represents minimum value, "a2" the most probable value, and "a3" the leading value of any fuzzy event. A TFN shown in fig. 1 is a simplest form of a fuzzy

number, whose membership function‟s graph forms, a triangle [17].

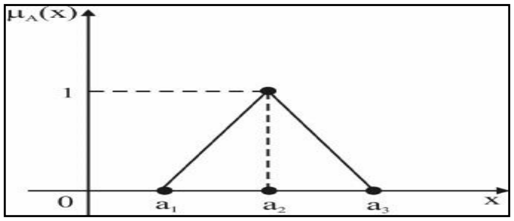

Fig. 1 A Triangular Fuzzy Number

The arithmetic operations on the TFN are defined by equation 1, 2 and 3 [18]:

(a1, b1, c1)+ (a2, b2, c2) = (a1 + a2, b1 + b2, c1 + c2) (1)

(a1, b1, c1)*(a2, b2, c2) = (a1 × a2, b1 × b2, c1 × c2) (2)

(a, b, c)−1 = (1/a, 1/b, 1/c) (3)

3.2 Analytic Hierarchy Process (AHP) and Fuzzy analytic hierarchy process (FAHP)

Thomas Saaty was the first researcher to introduce AHP in 1980 and subsequently it has been utilized in various applications for judgments and decision making of a complex or a hierarchical structure.

It offers a systematic method to decompose a problem into smaller components [19].

The conventional AHP requires crisp judgments. Though, a lot of complexity and uncertainty is involved in real world decision problems, so generally a decision-maker feel more confident to endow with fuzzy judgments than crisp comparisons [20] [21] [22] [23]. Three important step for fuzzy AHP, given by Buckely (1985) and Chang (1996) are as follows:

Step 1: Express an unstructured problem into hierarchical structure along with its goal. Also identify decision elements of the problem such as decision criteria and decision alternatives.

Step 2: Pair wise comparisons of decision elements are needed to be performed to create a judgment matrix (fuzzy) and a weight vector (fuzzy).

Step 3: The final step is to calculate the combined relative weights of all the decision-making criteria, get an overall rating for each option, and pick the most favorable one.

Recently Saaty‟s AHP has been extended to fuzzy AHP technique by combining it with fuzzy set theory. This paper utilizes Chang extent analysis method, and the procedure is alike conventional AHP and comparatively simpler than the fuzzy approaches [24]. FAHP based on Chang‟s extent analysis is used in diverse areas by various researchers [24] [25] [26] [27]. The following section describes Chang (1996) extent analysis method on FAHP.

Let Z = {z_1, z_2... z_n} be an object set, and G = {g_1, g_2, . ,g_k} be a goal set. Each object was taken into account according to its extent in Chang's analysis, and each goal gi had its own extent analysis run. Therefore, it is possible to acquire k extent analysis values that may be shown to be K^1_{gi}, K^2_{gi}, K^k_{gi}; where i=1, 2, . . . , n, and K^j_{gi}(j = 1, 2, . . . , m) are TFNs.

Following steps are describing Chang‟s extent analysis:

A triangular fuzzy comparison matrix is expressed as follows:

$$X=(a_{ij})=\begin{pmatrix} (1,1,1) & (l_{12},m_{12},u_{12}) & \cdots & (l_{1m},m_{1m},u_{1m}) \\ (l_{21},m_{21},u_{21}) & (1,1,1) & \cdots & (l_{1m},m_{1m},u_{1m}) \\ \vdots & \vdots & & \vdots \\ (l_{12},m_{12},u_{12}) & (l_{1n},m_{1n},u_{1n}) & \cdots & (1,1,1) \end{pmatrix}$$

Where a_{ij}= (l_{ij},m_{ij},u_{ij}) and a^{-1}_{ij}= (1/l_{ij}, 1/m_{ij}, 1/u_{ij})

The following actions need to be undertaken in order to determine a priority vector for the aforementioned triangular fuzzy comparison matrix.

Step1: Fuzzy arithmetic procedures are used to add each row of the fuzzy comparison matrix X:

$$K^j_{gi} = \sum_1^m a_{ij} = \left(\sum_1^m l, \sum_1^m m, \sum_1^m u\right) \quad (4)$$

Perform the fuzzy addition operation on (K^j_{gi}) and compute the vector's inverse using Equation (8) to obtain such that

$$(K^j_{gi})^{-1}=\left[\left(1/\sum_1^k u\right) \ \left(1/\sum_1^k m\right) \ \left(1/\sum_1^k l\right)\right] \quad (5)$$

Now, normalize the above row sums by:

$$A=K/\sum_{j=1}^m K \quad (6)$$

Step 2: The definition of V for the degree of possibility of A_2 = (l_2, m_2, n_2) = A_1 = (l_1, m_1, n_1) is V= (A_i≥ A_j)

$$= \begin{cases} 1 & if\ m_2 \geq m_1 \\ 0 & if\ l_2 \geq u_1 \\ (l_1-u_2)/(m_2-u_2)-(m_1-l_1) & \text{Otherwise} \end{cases} \quad (7)$$

To compare A_1 and A_2, both the values V(A_1≥ A_2) and V(A_2≥ A_1) are required.

Step 3: Likelihood that a convex fuzzy number will grow to be higher than k convex fuzzy numbers K_i (i = 1, 2, . . . , m) has been determined by equation (8)

V(K≥ K_1, K_2. . . K_k) = min V(K≥ K_i), for i = 1, 2, . . . , k. (8)

Consider d‟(A_i) = min V(S_i ≥ S_k) for k = 1, 2, . . . , n; The weight vector is given by equation (9) if k is not equal to i.

$$W'= (d'(A_1), d'(A_2), \ldots, d'(A_n))^T \quad (9)$$

where A_i (i = 1, 2, . . . , n) are n elements.

Step 4: Equation (10) gives the normalized weight vectors.

$$W = (d(A_1), d(A_2), \ldots, d(A_n))^T \quad (10)$$

W is a non-fuzzy number in this case.

4. PROPOSED MODEL

The proposed model calculates the reliability of components of component base software using reliability allocation, FAHP and extent analysis method. For calculating the reliabilities of components; software manager‟s view, programmer view and user‟s view are collaborated to get efficient outcomes. Ultimate judgment of system‟s quality and reliability is in the control of user. Any system that is developed must be built on the basis of their attitude toward the dependability of various functions. Software manager and programmer view generally differ from user‟s opinion. For attaining the goal reliability, one must combine all opinions for allocating the reliability values to various components of the component based software.

4.1. Hierarchy of Component based software system

In the proposed model, a hierarchy structure has been established, and its main objective is to determine the parameters required for the creation of a reliability allocation scheme for component-based systems. The target problem is organized into a hierarchy using the top-down approach known as AHP. In this proposed approach, the hierarchy starts from the top and define the overall system reliability goal. Fig. 2 show the hierarchical structure of Component based System architecture.

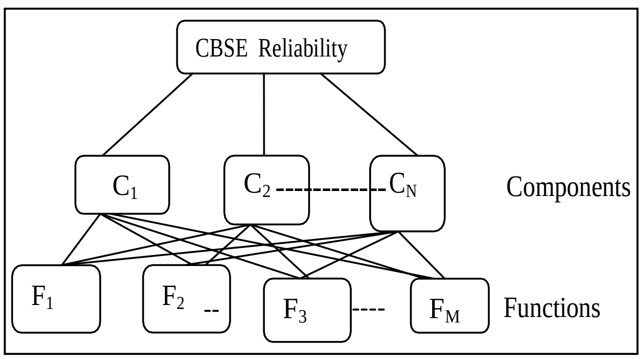

Fig. 2 Hierarchical Structure of Component based System

A component-based system's reliability is specified at the initial level. The components adapted to carry out the system's prescribed functions are represented at the second level of the hierarchy. In addition to it, software engineer's (SE) perspective for the software is also represented at this level. Various components have distinct functionality within them. Suppose there are M functionalities needed by the user; then there may be N components that perform these functionalities. Components are denoted by C_1, C_2….C_N.

The software's quality and functionality, which are represented at the third level of the hierarchy, are where the user's evaluation begins. The software must carry out a specific set of tasks and deliver the desired outcome, according to the user. Let's say a typical user specifies f such a functions and refers to them as F_1, F_2,... F_M.

This research paper, assumes that all the functions are sovereign units that may have sub component, however at final stage of hierarchy each sub component belongs to only one function. Additionally, hierarchical structures have been stopped at the level of the independent functions to avoid complications.

4.2 Calculations of relative reliability weights

With the proposed method one can establish the comparative weights of all the modules using FAHP. The objective is to determine, based on knowledge about the user's reliability goal R at the first level of the hierarchy, the relative weights of each Function F_i at the third level and each component C_i at the second level. The user of the component based system has the knowledge about each function F_{iS} but doesn‟t have any information about components. The system is only partially visible to the programmer because he can only see the second layers C_{iS}. Therefore to attain the target, FAHP is a way of combining the two perspectives such that the user's opinion on the component-based program is combined with the relative reliability weights of the functions and components. FAHP procedure involves three essential steps as discussed in section 3.2

Since the problem has already been broken down into a hierarchy, Fig. 2 completes the first phase. To accomplish the comparison in second step, data is collected in pair wise fuzzy judgment matrix articulated as equation 11.

$$\begin{pmatrix} (1,1,1) & (l_{12},m_{12},u_{12}) \text{-------------} & (l_{1m},m_{1m},u_{1m}) \\ (l_{21},m_{21},u_{21}) & (1,1,1) \quad \text{----} & (l_{1m},m_{1m},u_{1m}) \\ | & | & | \\ | & | & | \\ (l_{12},m_{12},u_{12}) & (l_{1n},m_{1n},u_{1n}) \quad \text{----} & (1,1,1) \end{pmatrix} \qquad (11)$$

The priority vector of the aforementioned triangular comparison matrix has been evaluated using section 3.Chang‟s (1996) (extent analysis method). To accomplish step 3, Users at stage three are asked to compare the functions (F_{is}) pair wise, to examine each function's significance in relation to the overall evaluation of the software reliability goal. Users compare two alternatives at one time for all possible combinations of comparisons. Therefore, the total number of pair wise comparisons is given by equation 11.

Total number of comparisons (C) = [F! / 2*(F-2)]! (11)

The total number of functions used to evaluate the software is indicated by the letter F. User‟s reliability requirements are input as a comparison matrix. User might suggest that function F_1 is more significant than F_2 and extremely significant than F_3; their answers are stored in TFN (Triangular Fuzzy Number) [15].

After pair wise comparisons, results are needed to be stored in an input matrix M_f= [a_{ij}], which is F*F matrix. The components of matrix Mf specify how much more significant function „i‟ is than function 'j'. Since the diagonal entries of the matrix represent a comparison of function „i‟ with function „i‟ itself, they will always be 1. The elements in the matrix's lower triangle are the opposite of their counterparts in the upper triangle. The relative relevance of each function has been determined in order to create software reliability goals using

Chang's extent analysis method. These are referred to as relative weights of functions that are (WF_1, WF_2... WF_f).

Subsequently, to determine the relative reliability requirements of functions and achieve the system reliability objective, these weights must be combined. User‟s reliability requirements are stored in another input matrix M_c. Input matrices M_f, M_c are created by pair wise comparison and relative weights are deliberated. Matrix in equation 12 shows relative weights for the functions.

$$\begin{bmatrix} WF_{11} & WF_{12} \text{-----------} WF_{1N} \\ WF_{21} & WF_{22} \text{-------} WF_{2N} \\ WF_{N1} & WF_{N2} \text{-----------} WF_{NN} \end{bmatrix} \quad (12)$$

WF_{ij} are the relative weights at the function level for the comparison of ith function with jth function.

$WF_i = (WF_i, n) \forall\ i=1,2,\ldots.n$ (13)

Consequently, the allocated reliability will became

$RF_i = (RC)^{WF_i} \forall\ i = 1, 2,...,f$ (14)

The reliability numbers for the function j will vary depending on the function. Two values of reliability with respect to each of the two functions to which the function j is related are therefore available. The highest reliability value is used as a precaution.

RC_j = Maximum $(RF_{ij})\ \forall\ j = 1, 2, \quad , n$

Hence RF_i, RC_j are the allocated reliability values.

5. Illustration by Example

This section uses an example to demonstrate how the suggested method might be used. Fig. 3 depicts the proposed reliability allocation model's hierarchical structure.

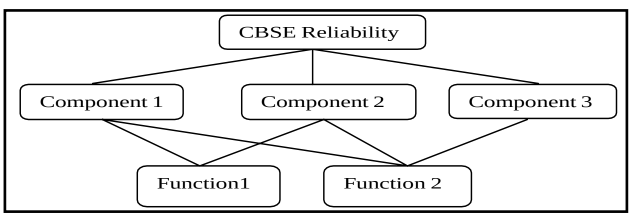

Fig. 3 Hierarchical structure for component based system

According to the figure, assume that component based software has been developed with three components C_1, C_2, C_3 and user‟s requirement of system reliability goal is 0.94. Users are now encouraged to compare the C_{is} components pairwise. Three pairwise comparisons are done since there are three components at the first level.

The fuzzy scale for pairwise comparisons of one characteristic with another is shown in Table 1. The experts feel more comfortable at providing linguistic statement as compared to crisp values for pair wise comparison.

Proposed research used TFNs as the membership function. Pair-wise comparison of the components can be used to establish the function's relative value in relation to the software reliability goal.

TABLE I Fuzzy Scales for pair wise comparisons of characteristics

Scale	Triangular scale	Reciprocal scale
Almost Equal	(1,1,1)	(1,1,1)
Equal Importance	(1/2,1,3/2)	(2/3,1,2)
Less Important	(1,3/2,2)	(1/2,2/3,1)
Slightly more Important	(3/2,2,5/2)	(2/5,1/2,2/3)
More Important	(2,5/2,3)	(1/3,2/5,1/2)
Significantly Important	(5/2,3,7/2)	(2/7,1/3,2/5)

The resulting matrix of pairwise comparison and questioning process may be as follows:

$$\begin{array}{c} \\ \textbf{C1} \\ \textbf{C2} \\ \textbf{C3} \end{array} \begin{array}{c} \begin{array}{ccc} \textbf{C1} & \textbf{C2} & \textbf{C3} \end{array} \\ \begin{bmatrix} (1, 1, 1) & (1/2, 2, 3/2) & (2/5, 1/2, 2/3) \\ (2/3, 1, 2) & (1, 1, 1) & (2, 5/2, 3) \\ (3/2, 2, 5/2) & (1/3, 2/5, 1/2) & (1, 1, 1) \end{bmatrix} \end{array} \quad (15)$$

Here the diagonal of the matrix is always one, as it shows the comparison of the component with itself. The elements in the matrix's lower triangle are the opposite of their respective counterparts in the upper triangle. Equation (5) can be used to calculate S_i using the technique described in Section 2 as follows:

SC_1=(1.9, 2.5, 3.16)*(1/11.98, 1/10.4,1/8.20)=(.16, .24, .38)
SC_2= (3.6, 4.5, 6)*(1/11.98, 1/10.4, 1/8.20) = (.30, .43, .73)
SC_3= (2.8, 3.4, 4)*(1/11.98, 1/10.4, 1/8.20) = (.23, .33, .49)

Now Equations (9) and (10) can be used to determine the degree of possibility ($S_i \geq S_j$) (i = j) as shown below:

$V(SC_1 \geq SC_2)=(0.30 - 0.38)/(0.24 - 0.38)-(0.43- 0.30)= 0.29$
$V(SC_1 \geq SC_3)=(0.23- 0.38)/(0.24-0.38)-(0.33- 0.23) = 0.625$
$V (SC_2 \geq SC_1) = 1$
$V (SC_2 \geq SC_3) = 1$
$V(SC_3 \geq SC_1)=(0.30-0.49)/ (0.33- 0.49) - (0.43- 0.30) =0.65$
$V (SF_3 \geq SF_2) = 1$

By applying equation (11):
$d'(C_1) = V(SC_1 \geq SC_2, SC_3)$ = min (.29, .625) = .29
$d''(C_2) = V(SC_2 \geq SC_1, SC_3)$ = min (1, 1) = 1
$d''(C_3) = V(SC_3 \geq SC_1, SC_2)$ = min (0.65, 1) = 0.65
Therefore W(C) = (.29, 1, 0.65).
Via normalization W(C) will be as follows:
W(C) = (0.15, 0.52, 0.33)

The reliability allocation $RC_i = RWC_i \forall$ (i = 1, 2. . . N). As a result, the function C1, C2, and C3's reliability allocation will be
$RC_1 = (R)^{WC1} = (0.94)^{0.15} = 0.99$
$RC_2 = (R)^{WC2} = (0.94)^{0.52} = 0.96$
$RC_3 = (R)^{WC3} = (0.94)^{0.33} = 0.97$

To meet the criteria of each component, relative weights of the components are estimated for reliability requirements. For component C_1, function F_1 and function F_2 are essential as indicated in figure 3. To calculate the reliability for “function 1”, the comparison matrix AF_1=

$$\begin{array}{c|cc} & F_1 & F_2 \\ F_1 & (1, 1, 1) & (1, 3/2, 2) \\ F_2 & (1/2, 2/3, 1) & (1, 1, 1) \end{array} \quad (16)$$

Using the matrix given in equation (16) and the methodology outlined in Section 2, the estimated relative weights are as follows:

$WF_1 = (WF_{11},WF_{12}) = (0.68, 0.32)$

Allocated reliability will be provided by:

$RF_{11}= (0.99)^{0.68} = 0.993$

$RF_{12}= (0.99)^{0.32} = 0.996$

For calculating reliability for “function 2”, pair wise comparison matrix may be:

$$AF_2 = F_2= (1, 1, 1) \quad (17)$$

$$WF_2 = (WF_{22}) = 1$$

$$RF_{22}= (RF_2)^{WF22}=(0.96)^1 = 0.96$$

For accomplishing function 3, pair wise comparison matrix AF_3 =

$$\begin{array}{c|cc} & F1 & F2 \\ F1 & (1, 1, 1) & (1/2, 1, 3/2) \\ F2 & (2/3, 1, 2) & (1, 1, 1) \end{array} \quad (18)$$

Using this matrix, the calculated relative weights are

$$WP_3 = (WP_{31},WP_{32}) = (0.5, 0.5)$$

$$RP_{31}= (RF_3)^{WP31}= (0.97)^{0.5} = 0.984$$

$$RP_{32}= (RF_3)^{WP32}= (0.97)^{0.5} = 0.984$$

Hence

RP_1=Maximum(RF_{11},RF_{12})=Maximum (0.993, 0.996) = 0.996

RP_2 = Maximum (RF_{12}, RF_{22}, RF_{32})

= Maximum (0.996, 0.960, 0.984) = 0.996

For the given reliability requirement .94, the reliability calculated value from the proposed method is .996. Before implementing the actual product, the reliability targets for all components of the component-based software are determined using this allocation technique. For these objectives to be realistic and meaningful, they must take into account regular user expectations as well as program reliability and architectural specifications. This strategy helps users, software managers, and programmers communicate more effectively.

6. Conclusion

It is essential to confirm the reliability and accuracy of software. The use of computer software in economic and defence systems is growing. It has taken a lot of money and research to discover the right principles for determining software reliability. It is crucial and vital to obtain a precise reliability apportionment early in the development process.

The component-based software reliability allocation problem has been investigated in the proposed research at the software planning and design stage. Together with the software engineer's and programmer's viewpoint on software in terms of components, the user's perspective on the components and their relative importance has been incorporated. To break down the hierarchy, a hierarchical structure has been established. The required parameters were then derived from this hierarchy using the fuzzy analytic hierarchy process (FAHP). The software system reliability aim is guaranteed by the reliability allocation methodology provided in this research. This strategy promotes user-to-user communication, according to software engineers.

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