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OPTIMAL RELEASE POLICY OF SOFTWARE WITH IMPERFECT DEBUGGING AND TESTING EFFORT UNDER FUZZY ENVIRONMENT

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Abstract: **The major three problems observed in the development process of software include the cost of software development, quality of software and the target. Each software organization has a tendency to release the software and updates related to it in a timely manner. The release of the software is dependent on various factors, the optimal release is decided after the evaluation of level of software reliability, the cost that is needed to be spent on software for its development, the manpower required etc. To optimize the date of software release we need fuzzy techniques as these factors doesn't have values that are accurate and crisp. The objective of the paper is to use fuzzy environment to find the time that is appropriate to release the software. To optimize the release time of the software, software reliability growth model is used with learning function. Numerically illustrated results and with the help of fuzzy optimization problem we can solve the problem related to software release and decide the best possible time for its release.**

Keywords: **Software Release Time Problem (SRTP), Software Development Life Cycle (SDLC), Software Reliability Growth Model (SRGM), Membership Function, Reliability Function.**

I. INTRODUCTION

Three main issues observed in the development process of the software include the cost of software development, quality of software and the target. The main aim of software organization is to develop high quality invention of software with lower cost and timely delivery. To increase the hold in the market share, gain of trust of the consumers and their confidence with timely release of software and updates related to it is highly important [7].

Various factors such as software size, reliability of software to the desired level, cost of the software and efficiency of the developer contribute to the minimum amount of time required for testing of software with minimum faults before its release. The SRTP related problem is related to release of the software in a timely manner with the minimum amount of cost. In past many authors discussed the various SRTP. To reduce the amount of cost during the testing of software and debugging of software during SDLC or to increase the reliability of the software at considering the cost constraints SRTP is used. Various optimal techniques are used to find out the minimum cost and optimal time for the software release. Optimizing methods of calculus are used in case of reliability of the software whenever crisp values are given, soft values can also be considered. Optimizing methods such as fuzzy logic etc are used to solve the problem of optimization using soft values [4].

In this paper authors used the optimizing methods of fuzzy logic to minimize the cost of the software by releasing it using the proposed SRGM. Problem is solved by using fuzzy logic optimization technique, the transformation of the fuzzy problem first into crisp values of mathematical problem, which are later solved by using the optimization techniques.

The content of the paper are organized in such a manner

- Section II: discusses the literature of already proposed SRGM [7].
- Section III: discusses on the concepts of fuzzy sets, fuzzy numbers and formulation of fuzzy cost problem.

- Section IV: discusses the approach of the mathematical fuzzy programming and solution for the proposed fuzzy cost model.
- Section V: conclusion and future prospects.

II. SOFTWARE RELIABILITY GROWTH MODEL

To envisage the reliability of the software most of the SRGMs follow NHPP. All the SRGMs use mean value function $m_r(t)$ to detect the remaining faults in the software and to check its reliability. For model developments following assumptions are made:

A. *Assumptions:*

1. Removal of software faults and observation of failure trail NHPP.
2. During the running of software error present in software leads to software failure.
3. After the observations of failure instanteous effort are prepared to isolate the root of failure and to take away it, various efforts are initiated.
4. Rate of failure of software is directly proportional to the remaining faults dormant in the software.
5. Elimination of faults is assumed to be intelligent function which explains experience of developers of software. It includes the experience of debugging team.

B. *Notations:*

$m_r(t)$: removal of mean no. of faults in time t.
a : initial number of faults.
b(t) : detection rate of faults as a function of testing time.
b : constant detection rate of faults.
α, β : constants.
γ : rate of error generation
p : probability of imperfect debugging
w(t) : testing effort by time t.
W(t) : cumulative testing effort in the time interval(0,t), $\frac{d}{dt}W(t)=w(t)$
T_W : duration of warranty.
Co_1 : incurred Cost during testing of software per unit time
Co_2 : incurred cost in fault removal before software release.
Co_3 : incurred cost in removal of faults after software release

Function of intelligence is embedded in the modeling; the removal of faults from software with the help of learning can be described by the differential equation described below:

$$\frac{dm_r(t)}{dt}\times\frac{1}{w(t)}=pb(t)(a(t)-m_r(t))$$

Where, $b(t)=\frac{\alpha+\beta W(t)}{1+bW(t)}$ and $a(t)=a+\gamma m_r(t)$

We can write above equation as:

$$\frac{dm_r(t)}{dt}\times\frac{1}{w(t)}=p\frac{\alpha+\beta W(t)}{1+bW(t)}((a+\gamma m_r(t)-m_r(t))$$

For $m_r(t=0)=0$ and $W(t=0)=0$, the above equation reduced to

$$m_r(t)=\frac{a}{(1-\gamma)}\left(\begin{array}{l}1-\left(1+bW(t)\right)^{p(1-\gamma)(\frac{\beta}{b^2}-\frac{\alpha}{b})}\\ e^{-p(1-\gamma)\frac{\beta}{b}W(t)}\end{array}\right) \quad (1)$$

This is the mean value function given by Khatri.et al. [7]

Software reliability for specified time Tw is given as:

$$R((T+Tw)\,|T)=e^{-(mf(T+Tw)-mf(T))} \quad (2)$$

III. FORMULATION OF THE FUZZY PROBLEM

A. *Fuzzy number:*

Fuzzy numbers were introduced by B .Hutton and S.E. Rodabaugh. A fuzzy number is a convex, normalized fuzzy set $A\subseteq R$ whose membership function is piecewise continuous. Here the condition of normalization implies it has at least one element having membership value $\mu_A(x)=1$.The convex condition is that the line by α-cut of A must be a closed interval for $\alpha \in (0, 1]$. So, an approximate number can be represented by a fuzzy set and it is referred as a fuzzy number. The fuzzy set for a given fuzzy number is not unique.

Using Zimmermann's approach for solving the mathematical fuzzy problems. In Zimmermann's approach fuzzifier objective function value is taken minimum which is first understood and then expressed as C_0 in restriction satisfaction level. Using various membership functions are explained for different fuzzy inequalities then using the principle given by Bellman and Zadeh [2]. We convert fuzzy decision into the crisp values of mathematical programming problem, further it can be resolved using algorithm for crisp mathematical problem.

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B. Formulation of Problem:

The formulation of optimal release time problem is given in this section and its solution obtained in section IV. The minimum expected incurred cost on the testing of software and its removal of its faults keeping reliability of software in mind, gives the optimal time for the release of the software.

C. The Cost Function:

The function for cost includes the cost incurred due to dependent faults as well as cost incurred due to the independent faults. The model for the cost is designed in such a way that it includes the incurred risk cost due to field failure. Measurement of the risk is given by the non reliability of software. Therefore including the incurred cost in the model deals with the reliability of the software as objective, also the quality of software from the view point of users.

Function for the cost is derived with the help of mean value function of the failure phenomenon that explains the total incurred cost for debugging and testing of software and removal of its faults. The factors on which the total cost is dependent on

- Co_1: Incurred cost during testing of software per unit time
- Co_2: Incurred cost in fault removal before software release.
- Co_3: Incurred cost in removal of faults after software release

The function of cost can be given by

$$Co\,(W\,(T)) = Co_1 W\,(T) + Co_2 m\,(T) + Co_3\,(m\,(T+T_w) - m\,(T)) \tag{3}$$

The coefficients of cost functions Co_i, where i=1, 2, 3 is dependent on various factors such as strategy for testing the software environment, team dealing with the testing and debugging of software, infrastructure etc. These factor my change while testing as they are not static.

The optimal time problem for the release of the software can be written as, from equation (3) using cost function

$$\textbf{Minimize}\quad \textbf{Co}\,(W(T))$$

$$\begin{aligned} \text{s.t.}\quad & R\,(T_w|T) \gtrsim R_0 \\ & W(T) \lesssim W_0 \\ & T \geq 0 \end{aligned} \tag{4}$$

The major purpose of the proposed problem is to reduce the cost of developing software and inequalities given by reliability function in fuzzy environment, when the constraints for cost are non-specific. Reliability constraints values determine the software quality which is specified by the developer, while level of constraints is determined by the management. The sign $\gtrsim$ represent the fuzzy "greater or equal" to while the sign $\lesssim$ represent the "fuzzy less of equal to". The optimization crisp problems using the approach of mathematical problem are solved. There exist no accurate mechanisms in crisp optimizations method that can deal with the uncertainties in formulation of problems. Therefore to solve the problem related to the fuzzy optimization techniques like mathematical programming under fuzzy environment.

IV. PROBLEM SOLUTION FOR THE TIME OF RELEASE UNDER FUZZY OPTIMIZATION ENVIRONMENT

Under this division, we confer on solving the problem related to the software release time under fuzzy conditions that is prepared by means of Zimmermann's approach [13] under section III of this paper. The initial step is to state the problem using minimum objective function with fuzzifier and as constrain for restriction. The problem given in (4) can also be written as:

$$\begin{aligned} \textbf{Find}\quad & \textbf{T} \\ \textbf{s. t.}\quad & Co\,(W\,(T)) \leq Co_0 \\ & R\,(T_w\,|T) \geq R_0 \\ & W\,(T) \leq W_0 \\ & T \geq 0 \end{aligned} \tag{5}$$

For every fuzzy inequalities declared in the problem, we likewise describe fuzzy membership functions $\mu i(T)$, i=1, 2, 3.

$$\mu_1(T) = \begin{cases} 1 & ; Co(W(T)) \leq Co_0 \\ \dfrac{Co^* - Co(W(T))}{Co^* - Co_0} & ; Co_0 < Co(W(T)) \leq Co^* \\ 0 & ; Co(W(T)) > Co^* \end{cases}$$

$$\mu_2(T) = \begin{cases} 1 & ; R(T_w)\,|\,T) \geq R_0 \\ \dfrac{R(T_w\,|\,T) - R^*}{R_{0\,-}\,R^*} & ; R^* \leq R(T_w\,|\,T) < R_0 \\ 0 & ; R(T_w\,|\,T) < R^* \end{cases}$$

$$\mu_3(T)=\begin{cases}1 & ;W(T)\le W_0\\ \dfrac{W^*-W(T)}{W^*-W_0} & ;W_0<W(T)\le W^*\\ 0 & ;W(T)>W^*\end{cases} \tag{6}$$

Here Co* represent the cost tolerance, whereas R* and W* denote the desired level of reliability and efforts required for testing respectively. To solve the inequalities of fuzzy system that corresponds to the problem (5) using the fuzzy decision, we have use Bellman and Zadeh's principle [2], the resulting problem of crisp optimization can be written as:

Max α

Subject to

$$\mu_i \ge \alpha \quad \iota = 1,2,3 \quad ;\alpha \ge 0,\ T \ge 0 \tag{7}$$

Optimal for problem (7) can be originated using the crisp mathematical programming if feasible. After the incorporation of different parameter values in the problem (7), it can be solved using the approach of mathematical programming.

V. NUMERICAL EXAMPLE

This is accepted that values of the parameters a and b for the reliability model have as of now been predicted from the testing information set gathered by Obha[10]. The predicted parameter values are a=332, b=0.008, α=0.01989, β=0.00263, p=0.99173 and γ=0.001.Further it is assumed that values of Co_1, Co_2, Co_3 and T_w are already known. Here we can have $Co_1=12$, $Co_2=30$, $Co_3=50$, $T_w=5$. The problem of release time could be analyzed based on the assumed data. Further total budget to be had by the management is $Co_0=11000$, requirement of the reliability by the time of release is $R_0=0.89$ and testing effort required is $W_0=70$ with tolerance levels on cost and reliability Co*=13000, R*=0.999 and W*= 150. (From the various literature values have been assumed these values, in practice though these values should be determined by the management on basis of their experience). Using values for different constants and parameters given above, using method of fuzzy optimization technique, we can solve the problem and find its solution. The mean value function for failure and its function of reliability are specified as:

m_r (t) = (((332/(1-0.001))*(1-((1+(0.008*w))**(0.99173*(1-0.001)*((0.00263/(0.008**2))-(0.01989/0.008))))*exp(-0.99173*(1-0.001)*(0.00263/0.008)*w)))

And m_r (t + t_w) = (((332/(1-0.001))*(1-((1+(0.008*(w+5)))**(0.99173*(1-0.001)*((0.00263/(0.008**2))-(0.01989/0.008))))*exp(-0.99173*(1-0.001)*(0.00263/0.008)*(w+5))))

And $R\,((T+Tw)\,|T) = e^{-(mf(T+Ts)-mf(T))}$

The membership functions of fuzzy for cost and reliability constraints are given as

$$\mu 1(T)=\frac{13000-(12W+30m(T)+50(m(T+Tw)-m(T))}{13000-11000}\quad ;\ 11000<Co(T)\le 13000$$

$$\mu 2(T)=\frac{e^{-(mf(T+Tw)-mf(T))}-0.89}{0.999-0.89}\quad ;\quad 0.89\le e^{-(mf(T+Tw)-mf(T))}<0.999$$

$$\mu 3(T)=\frac{150-W(T)}{150-70}\quad ;\quad 70<W(T)\le 150 \tag{8}$$

The cost, reliability and testing effort membership functions are plotted on cost and reliability scales respectively, given away in figures 1, 2 and 3 respectively.

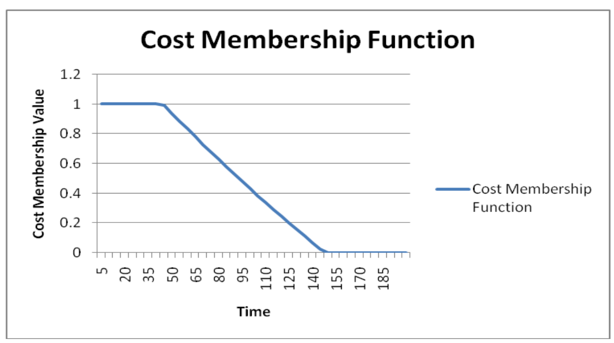

Fig. 1. Cost Membership Function

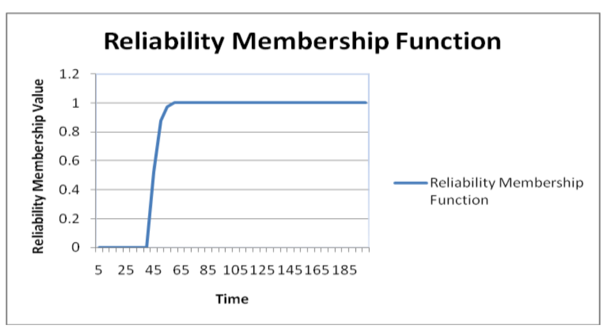

Fig 2. Reliability Membership Function

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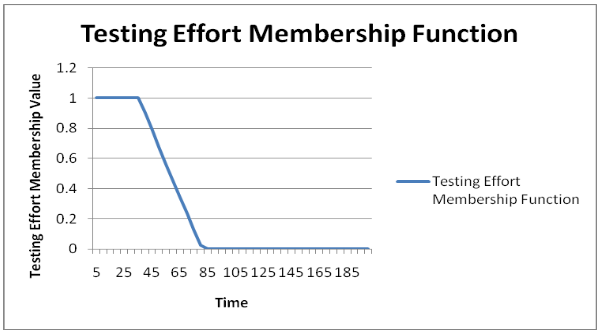

Fig. 3. Testing Effort Membership Function

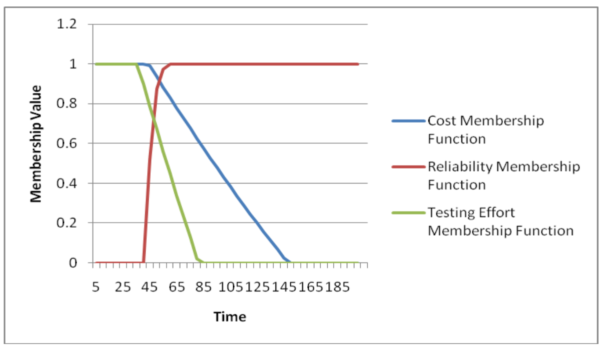

Fig. 4. Cost Membership Value Vs Reliability Membership Value

Above Fig. 4 can be obtained after solving problem (8). We find that optimal release time is T=54 and α=0.9734.

VI. CONCLUSION

In this paper discussion on software release time problem using fuzzy optimization under constraints for the objective cost minimization in relation with the software reliability and its testing effort. We have also discussed a mathematical example and its solution to explain the various steps involved for solving the problem of fuzzy optimization. In this paper objective function is taken as only cost but today is the generation of great competition where the developers of software consider various things simultaneously such as low cost and increased software reliability or very less time of delivery. In fuzzy optimization in which the objective function uses two constraints is known as bi-criterion, whereas the objective function using more than two constraints is called multi-criterion optimization problem. Further, bi-criterion software time release related problems will be discussed in future under fuzzy environment.

VII. REFERENCES

[1] Bector CR and Suresh C, "Fuzzy Mathematical Programming and Fuzzy Matrix Games", Springer-VerlagnBerlin Heidelberg, 2005.
[2] Bellman RE and Zadeh LA, "Decision making in a fuzzy environment", Management Science, 17,141-164,1973.
[3] Goel AL, Okumoto K. "Time dependent error detection rate model for software reliability and other performance measures" IEEE Transactions on Reliability; R-28(3): 206-211, 1979.
[4] Jha P. C., Kumar Deepak, Kapur P. K. "Fuzzy Release Time Problem" Proceedings of 3rd International Conference in Quality,Reliability and Infocomm Technology (ICQRIT'2006) pp. 304-310, 2006.
[5] Kapur PK, Jha PC, Gupta D,Yadav K,"Identification of different stages in the testing phase of a software reliability growthmodel", Advances in performance and safety of complex systems;A.K.Verma, P.K. Kapur and S.G. Ghadge(Eds.), Macmillan Advance Research Series, 850-861, 2008.
[6] Kapur PK, Garg RB, Kumar S. "Contributions to hardware and software reliability"; Singapore: World Scientific Publishing Co. Ltd., 1999;
[7] Khatri SK,Kumar Deepak, Dwivedi A, Mrinal N, :Software Reliability Growth Model with Testing Efforts using Learning Function"IEEE explore digital library, Proceedings of International Conference on Software Engineering (Conseg 2012), Devi Ahilya Vishwavidhylaya,Indore,India, 1-5,2012
[8] Kumar Deepak, Sharma S. G., Saini S., Mrinal N." Development of Software Reliability S-shaped Models", Review of Business and Technology Research Vol. 6, No. 1, pp. 101- 110, 2012.
[9] Ohba M. "Software reliability analysis models" IBM Journal of Research and Development; 28: 428-443, 1984.
[10] Obha M. "Inflection S-shaped Software Reliability Growth Model", Lecture notes in *Economics and Mathematical Systems* Ed. S. Osaki and Y.Hotoyama, Springer Verlag, 1984.
[11] Pham H., "System software Reliability", Springer, Reliability Engineering Series, 2006
[12]Okumoto K, Goel AL."Optimal release time for computer software", IEEE Transactions on Software Engineering, SE-9 (3): 323-327, 1985.