“Study of the Effect of Imperfect Debugging on Mathematics Development Cost “

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ABSTRACT

If we want to detect more additional faults in practice, it is advisable to introduce new test technologies: tools and test harnesses for developing and executing all kinds of manual and automated tests. These test technologies are different from the methods currently we use and they can help Mathematics developers get their product done quicker and more reliably. The benefit of these methods is that they can design (or propose) several testing programs (or automated testing tools) to test Mathematics for satisfying the client’s technical requirements, schedule, and budget. In addition, these methods can help engineers how to assessed Mathematics process by analyzing problem reports from earlier projects, to improve project planning with reliability receiving more precise and equal consideration, to achieved a fixed-percentage increase in testing efficiency or to highlight hard-to find problems in the code semantics and structure, etc. [Huensch et al., 1990; Huber,1999; Musa, 1999]. Hence, the cost trade-off of new test techniques can be considered in Mathematics cost model and viewed as the investment required improving the long-term competitiveness.All together, we wish that these new test techniques could greatly help us in detecting more faults that are difficult to find during regular testing and usage. Thus, the fault detection rate may not smooth and can be changed at some time moment called change point [Zhao, 1993; Chatman, 1995; Chang, 2001; Kwang, 2001; Shyur, 2003; Zou, 2003; Huang, in press].In addition to modeling the Mathematics fault detection process, we also address the problem faced by most Mathematics managers, namely, how to decide when to stop testing and release Mathematics. This is a problem of decision-making under uncertainly and involves a tradeoff between reliability and cost. Here we propose a new Mathematics cost model that can be used to formulate realistic total Mathematics cost projects discuss the optimal release policy based on cost and reliability considering testing-effort and efficiency. The cost model includes the testing cost, the debugging cost during testing phase, and the extra cost due to introduce new test techniques, etc.

Keywords – cost model, Effect, variants, testing , parameter, maximum, debugging.

INTRODUCTION-

It is widely recognized that the debugging processes are usually imperfect. Mathematics faults are not completely removed because of the difficulty in fixing them or because new faults might be introduced. Hence, it is of great importance to investigate the effect of imperfect debugging on Mathematics development cost. On the other hand, as the release time of the Mathematics is often determined by the minimum cost criterion, the imperfect debugging will affect the release time as well. In most of the existing imperfect debugging SRGMs, there is a parameter p, which is defined as the probability of perfect debugging, termed as testing level here indicates “how perfect” the testing process is. The parameter p is usually influenced by a number of factors, such as the experience of the testing personnel, the testing strategy adopted, and the number of reviews in debugging. However it is expensive to be increased but manageable to a certain extent with additional resources. It is important to get the optimal values of both the testing level and the release time, which result in the lowest Mathematics cost, a model incorporating this situation is presented. Then, the formulation and the solution of the optimal testing level and release time problem are presented.

Notations

a : initial error content.

b : proportionality constant (fault removal rate per remaining fault).

p : testing level (probability ofperfect debugging).

C_1 : expected cost ofremoving afault during the testing phase.

C_2 : expected cost ofremoving afault during the operation phase, $c_2 > c_1$. C_3 : expected cost perunit time oftesting.

T : release time ofthe Mathematics.

$\mathrm{m(t)}$: mean number offailures detected in $(0, \mathrm{t}]$.

The Effect of Imperfect Debugging on Mathematics Cost

When the failure process is modeled by non-homogeneous Poisson process (NHPP) with mean value function $\mathrm{m(t)}$, acommonly used cost model [M.Xie,1991] is:

$$C = C_1 m(T) + C_2[m(\infty) - m(T)] + C_3 T$$

For example, using the Goel-Okumoto NHPP [Goel,1985] model, for which the mean value function is

$$4t) = a(1 - e^{-bt})$$

The optimal release time that minimizes the Mathematics cost given by is

$$T^* = \frac{1}{b} ln \frac{ab(C_2 - C_1)}{C_3}$$

For the Mathematics failure data cited in [Zhang and Pham,1998], the maximum likelihood estimates (MLE) of a and b are obtained as $\hat{a} = 142.32$ and $\hat{b} = 0.1246$ .Assuming $C1$=\$200, $C2$=\$1,500, and $C3$=\$10, then, from , the optimal release time is calculated as 62.14 and the Mathematics cost is found to be at its minimum of\$29,166. However, this assumesa perfect debugging and it would be of interest to study how much the cost will change when we have an imperfect debugging case.

A simple imperfect debugging model proposed by [Obha and Chou,1989] and used by many others has the following mean value function:

$m(t) = \frac{a}{p}(1 - e^{-bpt})$.

If the release time remains at 62.14, the Mathematics cost under different probabilities of perfect debugging or testing levels is calculated and summarized. It is clear that the Mathematics cost changes significantly as the testing level, p, changes. Obviously, if the management has not taken into consideration the effect of imperfect debugging on Mathematics cost, the budget for testing will be insufficient and the profit of the product will be lower.Change of Mathematics Cost with Testing level p

p	$C(\$10^3)$
0.50	65.878
0.55	57.891
0.60	51.954
0.65	47.422
0.70	43.904
0.75	41.179
0.80	39.159
0.85	37.931
0.90	38.034
0.95	42.514
1.00	∞

Mathematics Cost Model

Total expected Mathematics cost includes cost of testing and the cost of flexing a fault during testing and operation phase for perfect and imperfect debugging Cost of flexing an error is different for both perfect and imperfect debugging Also the cost of testing is a function of perfect debugging probability p Since the testing cost parameter C_3 depends on the testing team composition and testing strategy used if the probability of perfect debugging is to be increased it is expected that extra financial resources will be needed to engage more experienced testing personnel ,and this will result in an increase of C_3Inotherwords C_3 shouldbe a functionof the testing leveldenoted by $C_3(p)$ and hence this function should posses s the following two properties:

1. $C_3(p)$ isamonotonousincreasingfunctionof$p$.
2. When p→1, $C_3(p) \to \infty$.

The first property is justified because if is decided to improve the testing process, the cost of testing will go up Hence $C_3(p)$ increasesThesecondpropertyisdueto the factthat completely perfectdebugging isimpossible in practiceorthe cost of achievingit isextremelyhigh. Although there are many cost functions that can satisfy these conditions, a simple, but reasonable function that meets the two properties above is the following:

$$C_3(p) = c/(1-p)$$

Using this function of $C_3(p)$, the cost model can be modified as

$$C(T,p) = C_1 m(T) + C_2\big(m(\infty) - m(T)\big) + \frac{c}{1-p}T$$

From the above, we cannot only solve the problem of optimal release time, but also determine the optimal testing level so that the developer can decide the team composition and testing strategy and so on. The cost function is simple but useful for illustrative purposes.

Conclusion

We have discussed two models based on NHPP with imperfect debugging and discussed optimal release policies based on cost-reliability criterion. Cost also includes the cost incurred on those failures which could not be fixed during the development and operational phases. Next we have discussed a model which allows for imperfect debugging and three different error types. This is done within the framework of NHPP. The three error types are categorized by the difficulty of removal and detection. Minor errors (Type 3) are easily detected and removed; major errors (Type 2) are more difficult to detect and remove; critical errors (Type 1) are very difficult to detect and remove. We also presented an SRGM which incorporates the possibility of introducing new faults (i.e. secondary faults) into a Mathematics system due to the imperfect debugging of the original faults (i.e. primary faults) in the system. These new faults are assumed to occur in a delayed sense. Further we discussed the cost model with multiple failures, imperfect debugging as well as random life cycle in which cost also includes the penalty cost. The probability of perfect debugging can usually be increased with additional cost and, hence, it has a strong influence on total Mathematics development cost. A concept of testing level is introduced here. To achieve the lowest Mathematics cost, the management can use the proposed cost model to formulate the optimal testing level and release time problem by considering the effect of imperfect debugging. Our problem formulation and the proposed solution is useful in practice as the imperfect debugging probability can be managed by using test engineers with proper experience, by selecting testing strategy or even by including a suitable number of review staff.

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