Software Reliability Models for Use During Proposal and Early Design Stages

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INTRODUCTION

Few software reliability models have been proposed for use during proposal or early design stages. The following model is proposed for use during these stages and is based on two simple and intuitive parameters. Since program development is a human activity and while there are major differences among projects, many of the development activities exhibit similar behavior. Values obtained from past projects can be used to predict software reliability in the early proposal and design stages with sufficient accuracy to serve as a guide for early project planning.

FUNDAMENTAL ASSUMPTIONS

The number of program errors present in a system at the beginning of integration test, ET, is the basis of many software reliability models. The number of such errors removed during integration (system) testing was found to be approximately 0.01 times the number of instructions, I. [Shooman 1983, p. 321-339]. Thus, ET=aI, where the parameter a can be roughly identified as the fraction of instructions which cause errors. Musa [1987, p. 116] found a range of values of a for the various phases of 36 projects on which he reports data. For the 25 projects reporting system test error removal data, the mean value of a = 0.0077 and the standard deviation is 0.0051, which agress well with Shooman's data. Thus a will be one model parameter.

The other model parameter is the growth factor, g, which measures the increase in the mean time between software failures (when the software is in operation) between the beginning and end of the integration test (system test) phase. Thus, g = MTBSF(end of system test)/ MTBSF(start of system test). It is postulated that the growth factor, g, is approximately the same for a range of different programs. This hypothesis is substantiated for the four sets of data in Table 1. In Table 1, we see that the growth ratio, g, varies from 10.75 to 17.43 for the 4 examples, the mean is 13.77 and the standard deviation is 2.83. More data must be taken for other projects to see if this ratio emerges as a characteristic of program development for various projects or classes of projects.

Table 1 Study of the Growth Ratio, g,for Four Programs

Source of Data	MTBSE(start)	MTBSE(release)	g
Shooman 1983, p. 360 Musa 1975 data	1.5 hr	18.5 hr	14.23
Shooman 1983, p. 359 Miyamoto 1975 data	1.75 days	30.5 days	17.43
Swedish Nuclear Software Data	6,369,427 hr	68,493,151 hr	10.75
Communications Software Kanoun data	88,180 h	1,115,421 hr	12.65

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SOFTWARE RELIABILITY MODEL

One can use the two parameters a and g to define a simple software reliability model. A generalized exponential reliability model has been developed by Shooman [1993,2000, AIAA 1993]. If the error removal rate is exponential this corresponds to Musa's exponential model [Musa 1975] and leads to a mean time between software failures expression

MTBSE(tau) = 1/[(KET) exp (-alpha x tau) (1)

where K and alpha are constants and tau is the development time variable, generally in months. If we know the constant a and the program size I, then ET = aI. Evaluating Eq. (1) at the start of integration test tau = 0, and the time of release taur, and computing the ratio yields

g = exp (+alpha x taur) (2)

Substitution of Eq.(2) into Eq.(1) yields the MTBSF(taur) at the release time

MTBSE((r) = 1/[KETg] (3)

PROJECT PLANNING

Assume that one wishes to use the above model during the proposal stage or early in software design and the values of a and g are selected from a table of past project data for the project which best matches the current project. Furthermore, we assume that the value of MTBSE(taur) is specified in the project requirements, then substitution of known values of ET=aI and g into Eq.(3) allows us to solve for K. Substitution of g in Eq. (2) allows us to solve for the product alpha x taur , which yields a hyperbola. Also, if a range of values is chosen for g, we can plot a family of hyperbolas with alpha plotted along the y axis and taur plotted along the x axis. This family of curves is very useful to project planners in performing a trade-off analysis between alpha and taur.

CONCLUSIONS

Further data must be studied to determine whether parameters a and g are repeatable characteristics of programs (or various classes of programs). Should this prove to be the case, then a data base of values for a and g would be of great help in project planning.

REFERENCES

AIAA/ANSI R-013-1992, "Recommended Practice Software Reliability, Feb. 23, 1993, p. 24-26.

Musa, John., "A Theory of Software Reliability and Its Application," IEEE Trans. on Soft. Eng., Sept. 1975, pp 312-327.

Musa, John et al., "Software Reliability ," McGraw-Hill, 1987

Shooman, Martin L., "Software Engineering", McGraw-Hill, 1983.

Shooman, Martin L., "Reliability of Fault-Tolerant Computer Systems and Networks", John Wiley and Sons., 2000.