A Generalized Software Reliability Model Considering Uncertainty and Dynamics in Development

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***Abstract*—Development environments have changed drastically in recent years. The development periods are shorter than ever and the number of team has increased. These changes have led to difficulties in controlling the development activities and predicting the end of developments. In order to assess recent software developments, we propose a generalized software reliability model based on a stochastic process, and simulate developments that include uncertainties and dynamics, such as unpredictable requirements changes, shortening of the development period, and decrease in the number of members.**

I. Introduction

The logistic curve and Gompertz curve[1] are well-known software reliability growth curves. However, these curves cannot account for the dynamics of software development. Developments are affected by various elements of the development environment, such as the skills of the development team and changing requirements. Examples of the types of software reliability models include "Times Between Failures Models" and "Failure Count Models." [2]

II. Generalized Software Reliability Model

For our software reliability model, we extend a non-linear differential equation that describes fault content as a logistic curve to an Ito type stochastic differential equation. We assume software development to have the following properties. 1) The total number of bugs is constant. 2) The number of bugs that can be found is variable depending on time. 3) The number of bugs that can be found contains uncertainty, which can be simulated with Gaussian white noise. Considering these properties, we extend Logistic equation to an Ito type stochastic differential equation with $a(t) = \alpha(t) + \sigma dw(t)$ as shown below.

$$dN(t) = (\alpha(t) + \sigma^2/2 + \beta N(t))N(t)dt + \gamma(t) \quad (1)$$

$N(t)$ is the number of tested cases at t, $\alpha(t)+\sigma^2/2+\sigma dw(t)$ is the differential of the number of tested cases per unit time, $\gamma(t) = N(t)\sigma dw(t)$ is the uncertainty term, σ is the dispersion, β is the carrying capacity term which is non-linear. We vary these two terms, $\alpha(t)$ and the coefficient of $dw(t)$, and simulate models using equation (1).

III. Simulation and Discussion

Three of the cases are modeled and plotted in Fig. 1. The difference between these three models is the parameter $\alpha(t)$. Based on **Model 1**, we defined that $a_2 = a_1$, $a_3 = 2a_1$ and $t_1 = t_{max}/2$ in **Model 2**, and $\alpha_3(t) = a_1 t$ in **Model 3**. The situation corresponding to **Model 2** is that at time t_1 the number of members of the development team doubles. The situation corresponding to **Model 3** is that the members' skills improve over time, effectively doubling the manpower by the time t_{max}.

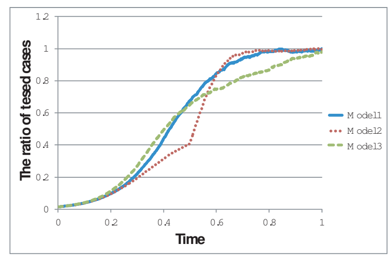

Fig. 1. The ratio of the total number of tested cases at time t to the total number of tested cases for the entire project is plotted.

IV. Conclusion and Feature Work

Using our model, we were able to simulate developments containing uncertainties and dynamic elements. We obtained the time-dependent logistic curve and growth curve, which was not possible using other models. Our model can be used to predict the end of projects where team members drastically change during development.

For future work, we will propose ways to quantitatively evaluate teams or team members taking uncertainties into account, and to optimize the teams to suit particular projects using our model.

V. List of our works

- K. Honda, et al., A generalized software reliability model considering uncertainty and dynamics in development. PROFES 2013
- K. Honda, et al. Predicting release time based on generalized software reliability model (gsrm). COMPSAC 2014
- K. Honda, et al., Predicting time range of development based on generalized software reliability model. APSEC 2014
- K. Honda, et al., Detection of Unexpected Situations by Applying Software Reliability Growth Models to Test Phases. ISSRE 2015

References

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