# Bachelor's Project
# Statistical Models for Software Testing with Imperfect Debugging

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## 1 Introduction

In this bachelor's project you will learn about statistical models for software testing. During software testing, it is important to know when to stop testing. Software reliability growth models are a statistical tool to support such decisions based on the time profile of detected errors during testing. These models are a nice application of the theory that you learned in the courses on mathematical statistics (parameter estimation through Maximum Likelihood) and stochastic processes (Poisson processes). Although many papers have been written on this topic (mainly by computer scientists or software engineers), there are still many basic questions that have not yet been answered. There are also several cases in which wrong probabilistic methods (e.g., uses of the Central Limit Theorem when it is not valid) or numerically unstable implementations of statistical methods (simplistic ways to solve Maximum Likelihood equations) are being used.

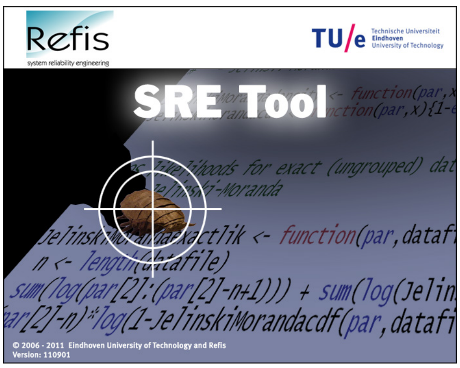
In order to provide software test engineers with sound statistical methods, The Probability and Statistics group has been developing a software tool (SREtool) to perform software reliability analyses. This is a joint project with the Refis company (`www.refis.nl`). The results of this project should result in an extension of the SRETool.

## 2 Project Goals

A popular class of stochastic models for software testing is the class of nonhomogeneous Poisson processes. Unlike the standard homogeneous Poisson process where the number of events in a time interval is Poisson distributed with mean proportional to the length of the interval, the nonhomogeneous Poisson process allows for means that are not necessarily proportional to the mean. The mean function (i.e, the function that describes the expected number of events in the interval $[0, t]$) can then be modelled in such a way that typical S-shaped forms appear that have shown to occur in practice (see e.g., Almering et al. (2007) ). These models are based on the unrealistic assumption that detected errors during testing are repaired with introducing new errors. To overcome this drawback, so-called imperfect debugging software reliability growth have been developed (see e.g., Chapter 3 of Kapur et al. (2011)).

The goal of this Bachelor's project is to present a complete overview of one or more of such imperfect debugging models based on a short literature review. You should select at least two models from the following list:

1. Yamada Imperfect Debugging Model 1 (see Yamada et al. (1984))
2. Yamada Imperfect Debugging Model 2 (see Yamada et al. (1984))
3. Pham Nordmann Zhang Model (see Pham et al. (1999)
4. Pham Exponential Imperfect Model (see p. 199 of Pham (2006))
5. Pham Zhang model (see Pham and Zhang (1997))



This overview should contain

1. a detailed mathematical description of the models (in terms of stochastic processes):
2. necessary and sufficient conditions for existence of Maximum Likelihood estimates of the parameters and possible interpretation in terms of reliability growth (see Meyfroyt (2012))
3. algorithms to compute the Maximum Likelihood and Least Squares estimates of the parameters (using the ideas of Knafl (1992) and Ishii et al. (2012))
4. how to estimate remaining number of errors, and the expected time to next error with confidence limits
5. implement the estimation procedures in the statistical software **R** (see `www.r-project.org`) so that they can included in the SREtool (both for grouped and ungrouped data)

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