

# Software Reliability Models: Time between failures and Accuracy estimation

Dalbir Kaur<sup>1</sup>, Monika Sharma<sup>2</sup>

M.E Scholar<sup>1</sup> UIET<sup>1</sup>, Supervisor<sup>2</sup> UIET<sup>2</sup>,

<sup>1,2</sup>Panjab University, Chandigarh, India

**Abstract**—For decide the quality of Software, Software Reliability is a vital and important factor. So before software is delivered to customer, Software should be thoroughly checked and all faults or errors should be removed. Most important fact for achieve this goal of success of any Software related project is achieving the most possible software reliability. Software Reliability is mathematical model which consider that software development are directly proportional to time between failures and accuracy for a particular reliable software. During different phases of Software Development Different types of SRMs are used. In this paper we will compare three SRMs models that is Generalized Goel-Okumoto Model, Goel-Okumoto Nonhomogeneous Poisson Model and Yamada Delayed S Model by using CASRE tool. It will provide ranking to these model from maximum to minimum values according to accuracy and time between failures (TBF).

**Keywords**—Software Reliability, SRGM, model criteria, survey, CASRE Tool, Time Between failures evaluation, accuracy evaluation, Ranking of models.

## I. INTRODUCTION

As the complexity and size of Software increases the concern with the Reliability concept is also grows. So there is most important requirement of software reliability model that give guaranty of failures free type of operations [1]. So we can say that the main important and basic goal of software development is to generate software of high quality with high reliability. As we know reliability is directly proportional to the time between failures and accuracy [16]. So we need software reliability models with maximum time between failures and accuracy for more reliable software. It is very vital and desirable to know the time between failures and accuracy to know how accurately the model give the results [23]. SRGM provide us those values of TBF and accuracy which explain how a particular software achieve reliability at the time when all faults and failures are detected and removed [22]. it tell us that when a software is ready for delivery to client and it also tell whenever it will achieve the level of expected reliability [21]. For estimate total number of expected defects and failures, many SRGM (Software reliability growth models) have been discovered [3]. Some known SRGMs are:-

- Generalized Goel- Okumoto Model
- Goel –Okumoto Nonhomogeneous Poisson Model
- Yamada Delayed S Model.

Every model have some shortcomings [27]. None of the reliability models are best for all types of dataset. They will unfit for some particular data set but fit for other types of data set. In this paper we will take three SRGM and predict

the TBF and accuracy by using CASRE tool and common data set for each model and will rank the model according to result.

## II. DIFFICULTY DURING SELECTION OF SGRMS

The parameters which we used can never be approximated accurately therefore the most of the empirical data is not satisfactory to develop a successful preferred model [2]. So it can be say that There are none model is universally authorized and none methodologies to pick the reliability models that correlate the exactly to the particular environment under which observation done [16].

## III. SGRMS

By the review study of all different software reliability Models we could be say that those failures which is a arbitrary type of operation are generally result of two different processes in which first process is say as fault introduction and second process is say as fault activation which we could say exist after the particular input election state. By nature of it could be say that it is an arbitrary type of process [2]. Diverse SRGMs (Software Reliability Growth models) have been classify, developed and the most approved the best model should be choose by proper noticed reliability may be disrobed as a one type of probability distribution curve of arbitrary process having value in specific time at every point. Failure of this probability distribution measurement out of all these models show a very vital role in the classification and development of SGRMs [21]. So we can analysed that whenever we chose the input state of SRGMs is activated and this is arbitrary natured process. In this paper we will describe following software reliability Models which will be explain below [27].

- Generalized Goel- Okumoto Model
- Goel –Okumoto Nonhomogeneous Poisson Model
- Yamada Delayed S Model

### A. Generalized Goel-Okumoto Model

If we consider perfect debugging, then in this model if we fix a defect, it may be inject new defects. So it is called error-prone because in this process activation of fix defect occurs [8]. Goel-Okumoto overcomes the limitations of this assumption because they purposed it as a debugging model which is imperfect [2]. The hazard function of the Goel-Okumoto model during time interval from the (m-1)st and the nth failures is given [3]-

$$Z(tm)=[X-p(m-1)]\lambda \quad (1)$$

where X is Fault number at time when testing start.

p is probability function of imperfect debugging.  
 $\lambda$  - Rate of failure at each fault.

Mean value Function-

$$m(t) = k(1 - \exp[-\lambda t]) \quad (2)$$

$k > 0, \lambda > 0$

**B. Goel-Okumoto Nonhomogeneous Poisson Model**

When the more concerned are given to the modelling of the observation to calculate how much failure in a given interval during testing is called NHPP (Non Homogeneous Poisson process) model [22]. So Goel and okumoto purpose the observation of the number of failure in a cumulative manner at time t, so X(t) can be modeled as a non-homogenous Poisson process(NHPP), because in which Poisson with failure rate are time dependent [8]. So Goel and okumoto called it is a type of exponential distribution of the failure rate which is time dependent in nature [3].

Mean value function-

$$m(t) = k(1 - \exp[-(\lambda t)^c]) \quad (3)$$

$k > 0, \lambda > 0, c > 0$

Where m (t) is observed failure which is expected at time t. Lambda density of failure function, k is the expected failure number and c is the detection rate of fault at each fault. So we can say that NHPP (non-homogenous Poisson process) is a straightforward application of the exponential form of model.

**C. Yamada Delayed Model**

In 1983, Yamada argue about defect detection nature of testing process. According to him, it is also defect isolation with defect detection [9]. So Delayed S shaped RG model is developed for such a process in which growth curve is observed. It is observed by cumulative number of the defects which is detected is S shaped. It is also a form of NHPP with having different value of mean function [9].

Mean value function-

$$m(t) = k(1 - (1 + \lambda t) * \exp[-\lambda t]) \quad (4)$$

$k > 0, \lambda > 0$

Where time is t

$\lambda$  is rate of error detection

K is the number of total defects.

**IV. COMPARISON OF SRGMS MODELS**

TABLE I. COMPARISON SUMMARY TABLE FOR SGRMS MODEL

Name of Model	Type of Model	MVF (mean value function)	Model selection criteria
1. Generalized Goel-Okumoto model	Concave	$m(t) = k(1 - \exp[-\lambda t])$ $k > 0, \lambda > 0$	If failure detection is an exponentially decaying rate function.
2. Goel-Okumoto Nonhomogeneous Poisson Model	Concave	$m(t) = k(1 - \exp[-(\lambda t)^c])$ $k > 0, \lambda > 0, c > 0$	If at the beginning the failure intensity of software slightly increases and then start to decrease.
3. The Yamada Delayed S Model-	S shaped	$m(t) = k(1 - (1 + \lambda t) * \exp[-\lambda t])$ $k > 0, \lambda > 0$	If the failure rate initially increase and later exponentially decays.

**V. TIME BETWEEN FAILURES AND ACCURACY EVALUATION**

For calculate (TBF) time between failure and accuracy for these three software reliability Models, CASRE tool was utilized. CASRE (Computer Aided Software Reliability Estimation) is a best type of software tool which considered as a measurement tool for software reliability measurement. CASRE grant the users to cache different types of models in collection as part of the tool's own configuration and explained them and run them most accurately by the same method as any other type component model do.

**VI. RESULTS**

Result for Following Three Models

- Generalized Goel- Okumoto Model
- Goel –Okumoto Nonhomogeneous Poisson Model
- Yamada Delayed S Model

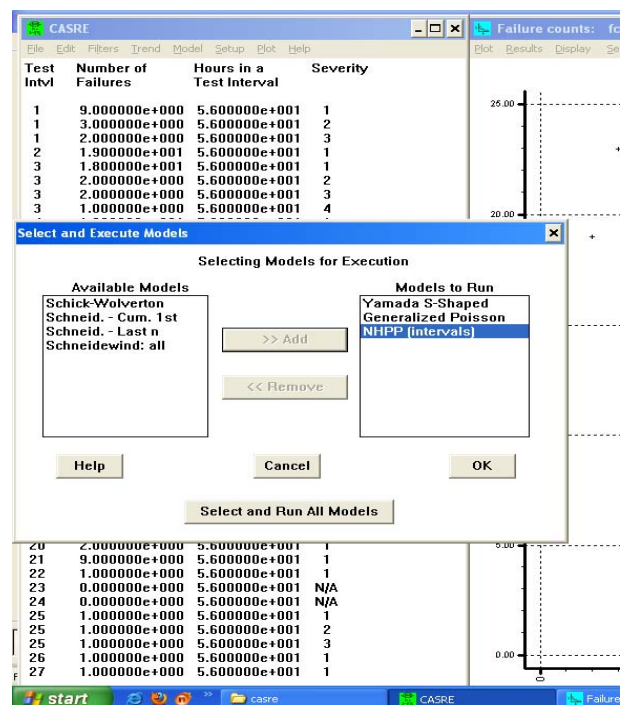


Fig.1 showing how to choose model to run

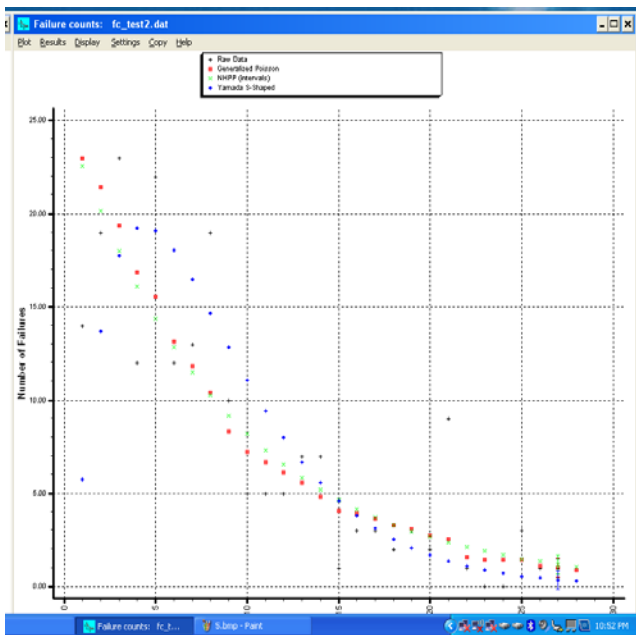


Fig. 2 showing display for failure data

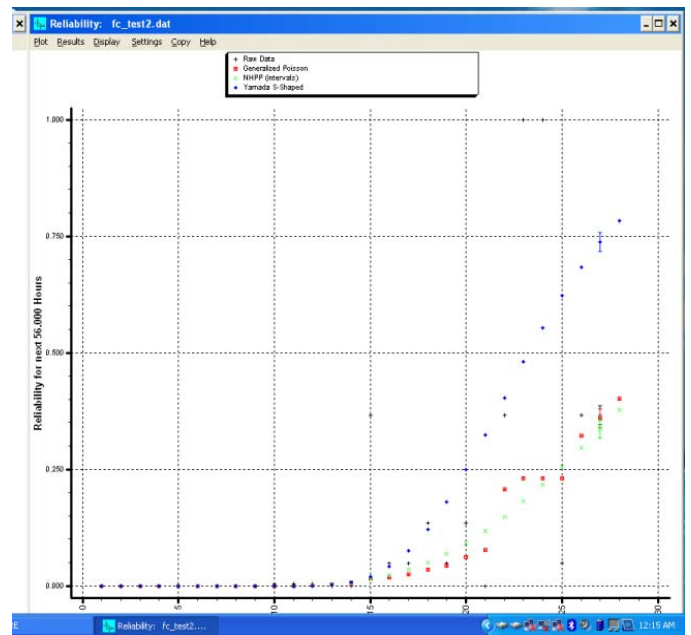


Fig 4 Showing Relative accuracy for each model

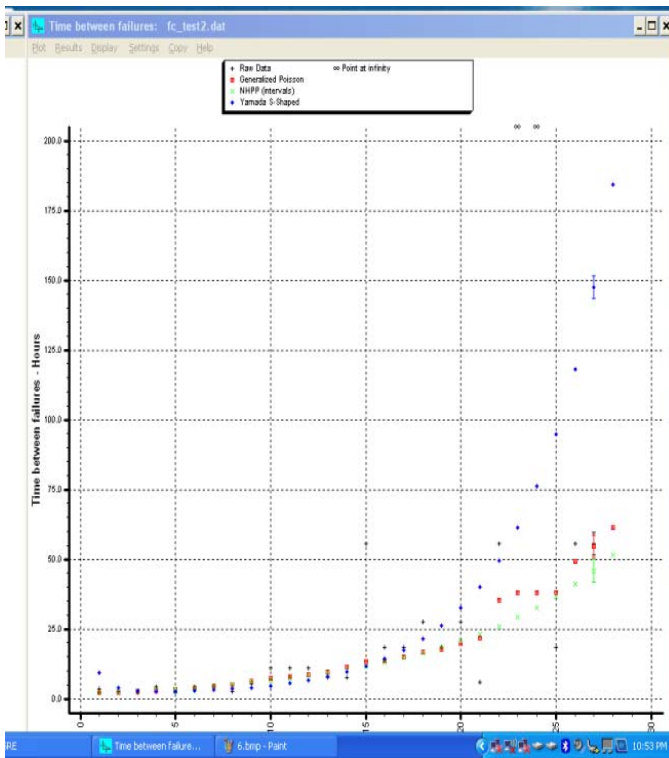


Fig 3 Showing time between failures

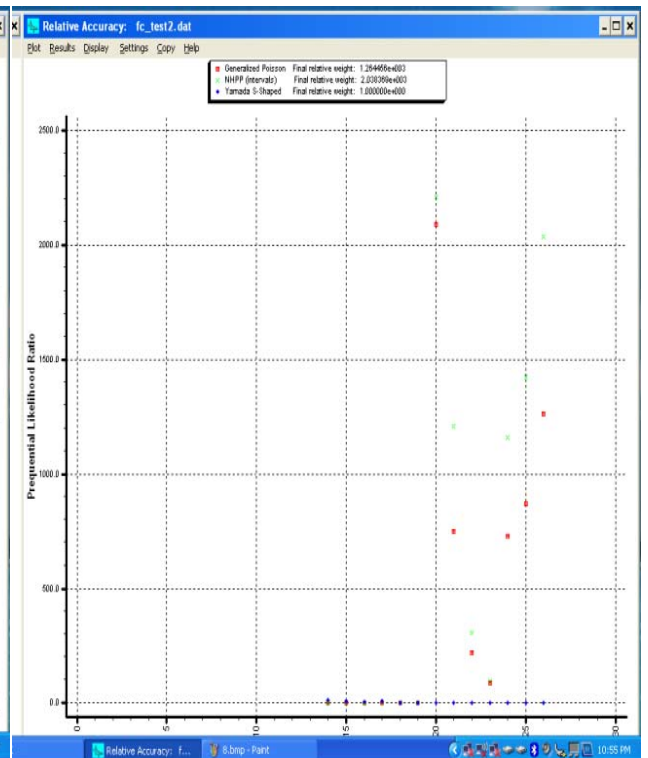


Fig. 5 Showing Reliability calculated by each model

TABLE 3. EVALUATED VALUES FOR MODELS

Model's Name	Reliability	Accuracy	Time B/w Failure (hour)
Yamada S- shaped	0.801	10	185
Generalized Poisson Goel Okumoto	0.40	2100	65
Goel-Okumoto NHPP(Interval)	0.36	2200	51

TABLE 4. RANKING OF MODELS

Model's Name	Rank according to accuracy	Rank according to TBF
Yamada S- shaped	3	1
Generalized Poisson Goel Okumoto	2	2
Goel-Okumoto NHPP(Interval)	1	3

## VII CONCLUSION

After studying three different software reliability model and evaluate TBF and accuracy using CASRE tool we analyzed and ranked them. Three Software Reliability Models were ranked according to time between failure and accuracy criteria. G-O NHPP model take minimum time between failure and having maximum accuracy and Yamada S shaped model take maximum time between failure and having minimum accuracy to evaluate reliability. Reliability is directly proportional to time between failure and accuracy. So rank of Yamada model is 1, Generalized Poisson (G-O) is 2, G-O NHPP(Interval) model is 3 according to time between failure and rank of Yamada model is 3, Generalized Poisson (G-O) is 2, G-O NHPP(Interval) model is 1 according to accuracy. So it concluded that no single model is universally applicable. Models are applied according to different conditions and environments in which they fit. On the basis of our experiment it has been concluded that if accuracy is the desired criteria, then Goel-Okumoto NHPP (Interval) will rank one and it will select among other models and if time between failure is the desired criteria, then Yamada S-shaped will rank one and it will be selected.

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