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COMPARATIVE ANALYSIS OF BURR TYPE III WITH PARETO TYPE II MODEL USING SPRT: ORDER STATISTICS

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ABSTRACT

In modern technologies computer software has turned out to be an essential component. The failure of this component leads to high penalty costs. To overcome this, software reliability has to be assessed. The Software reliability engineering helps in maintaining software quality. Many mechanisms do exist to detect whether the software is reliable or not.. Sequential Analysis of Statistical Science with order statistics is one of the mechanisms to make decision quickly. Order statistics deals with applications of ordered random variables and functions of these variables. In this paper we present a software reliability growth (SRGM) models comparison using Sequential Probability Ratio Test (SPRT) control mechanism on ordered time domain failure data using mean value function of Burr Type III and Pareto Type II distributions, which are based on Non Homogenous Poisson Process (NHPP).

Keywords: Burr Type III, NHPP, Order Statistics, Pareto Type II, SPRT

1. INTRODUCTION

The important quality characteristic of software is software reliability, which can evaluate and estimate the operational quality of a software system during its development.[1] Software Reliability is the probability of failure free operation of software in a specified environment for a specified period of time. Software reliability growth Model (SRGM) is a mathematical model of how the software reliability improves as faults are detected and required [1][2]. Among all SRGMs developed so far a large family of stochastic reliability models based on a Non-Homogeneous Poisson Process known as NHPP reliability model has been widely used. There is several software reliability growth models exist, one can predict the reliability of software and the number of errors in the software systems. During the past three decades research on software reliability engineering has been conducted and developed numerous statistical models for estimating software reliability. Most existing models for predicting software reliability are based purely on the observation of software product failures where they require a considerable amount of failure data to obtain an accurate reliability prediction.

The Software reliability probability ratio test was initially developed by Wald (1947) for quality control problems during World War II. It has many extensions and applications: such as in clinical trial and in quality control. The original development of the SPRT is used as a statistical device to decide which of two simple hypotheses is more correct. Wald’s SPRT is currently the only Bayesian Statistical procedure in SISA. What is required in Bayesian statistics is quite a detailed description of the expectations of the outcome under the model prior to executing the data collection. In Wald’s SPRT, if certain conditions are met during the data collection decisions are taken with regard to continuing the data collection andthe interpretation of the gathered data. [16]

Wald's procedure is particularly relevant if the data is collected sequentially. Sequential Analysis is different from Classical Hypothesis Testing were the number of cases tested or collected is fixed at the beginning of the experiment. In Classical Hypothesis Testing the data collection is executed without analysis and Consideration of

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the data. After all data is collected the analysis is done and conclusions are drawn. However, in Sequential Analysis every case is analyzed directly after being collected, the data collected up to that moment is then compared with certain threshold values, incorporating the new information obtained from the freshly collected case. This approach allows one to draw conclusions during the data collection, and a final conclusion can possibly be reached at a much earlier stage as is the case in Classical Hypothesis Testing. The advantages of Sequential Analysis are easy to see. As data collection can be terminated after fewer cases and decisions taken earlier, the savings in terms of human life and misery, and financial savings, might be considerable. In the analysis of software failure data we often deal with either Time between Failures or failure count in a given time interval. If it is further assumed that the average number of recorded failures in a given time interval is directly proportional to the length of the interval and the random number of failure occurrences in the interval is explained by a Poisson process then we know that the probability equation of the stochastic process representing the failure occurrences is given by a homogeneous Poisson process with the expression.

$$P[N(t)=n]=\frac{[\lambda t]^n}{n!}e^{-\lambda(t)} \qquad (1)$$

[6] observes that if classical testing strategies are used, the application of software reliability growth models may be difficult and reliability predictions can be misleading. However, he observes that statistical methods can be successfully applied to the failure data. He demonstrated his observation by applying the well known sequential probability ratio test of[16] for a software failure data to detect unreliable software components and compare the reliability of different software versions.

This paper describes a method for detecting reliable software based on the SPRT, using Maximum Likelihood Estimation (MLE) of parameter estimation. The Wald's SPRT procedure can be used to distinguish the software under test into one of the two categories like reliable/unreliable, pass/fail and certified/uncertified. SPRT is the optimal statistical test that makes the correct decision in the shortest time among all tests that are subject to the same level of decision errors. SPRT is used to detect the fault based on the calculated likelihood of the hypotheses. We considered two of the popular software reliability growth models Burr Type III and pareto Type II for which the principle of Stieber has been adopted and helped in detecting whether the software is reliable or unreliable in order to accept or reject the developed software, later two of the model results are compared in order to decide which model has better performance .

The theory proposed by Cohen on order statistics is described in section 2. The theory proposed by Stieber is described in section 3 Implementation of SPRT for the proposed Burr type III and Pareto Type II Software Reliability Growth Model are illustrated in section 4. Result analysis and comparison of both models is given in section 5.

2. ORDER STATISTICS

Order statistics deals with properties and applications of ordered random variables and of functions of these variables. The use of order statistics is significant when failures are frequent or inter failure time is less. Let X denote a continuous random variable with probability density function f(x) and cumulative distribution function F(x), and let (X_1 , X_2 , …, X_n)denote a random sample of size n drawn on X. The original sample observations may be unordered with respect to magnitude. A transformation is required to produce a corresponding ordered sample. Let (X(1) , X(2) , …, X(n)) denote the ordered random sample such that X(1) < X(2) < … < X(n); then (X(1), X(2), …, X(n)) are collectively known as the order statistics derived from the parent X. The various distributional characteristics can be known from Balakrishnan and Cohen .The inter-failure time data is grouped into non overlapping successive sub groups of size 4 or 5 and add the failure times within each sub group. The probability distribution of such a time lapse would be that of the rth ordered statistics in a subgroup of size r, which would be equal to power of the distribution function of the original variable [m(t)]. The order statistics is preferable when the failure data set is large. We implemented the Burr Type III model for 4th order and 5th order statistics.[5]

3 WALD'S SEQUENTIAL PROBABILITY RATIO TEST FOR POISSON PROCESS

The Sequential Probability Ratio Test (SPRT) was developed by Abraham Wald at Columbia University in 1943[5]. The SPRT procedure is used for quality control studies during the manufacturing of software products. The tests can be performed on fixed sample size sets with fewer observations. The SPRT methodology for Homogeneous Poisson Process is described below.

Let {N(t), t ≥ 0} be a homogeneous Poisson process with rate 'λ'. In this case, N(t) = number of failures up to time 't' and 'λ' is the failure rate (failures per unit time). If the system is put on test and that if we want to estimate its failure rate 'λ'. We cannot expect to estimate 'λ' precisely. But we want to reject the system with a high probability if the data suggest that the failure rate is larger than $\lambda_1$and accept it with a high probability, if it is smaller than λ_0. Here we have to specify two (small) numbers 'α' and 'β', where 'α' is the probability of falsely rejecting the system. That is rejecting the system even if $\lambda \leq \lambda_0$. This is the "producer's" risk. 'β' is the probability of falsely accepting the system. That is accepting the system even if $\lambda \leq \lambda_1$. This is the "consumer's" risk. Wald's classical SPRT is very sensitive to the choice of relative risk required in the specification of the alternative hypothesis. With the classical SPRT, tests are performed continuously at every time point as t > 0 additional data are collected. With specified choices of λ_0 and λ_1 such that $0 < \lambda_0 < \lambda_1$, the probability of finding N(t) failures in the time span (0, t) with λ_1, λ_0 as the failure rates are respectively given by

$$P_1 = \frac{e^{-\lambda_1 t}\left[\lambda_1 t\right]^{N(t)}}{N(t)!} \quad (2)$$

$$P_0 = \frac{e^{-\lambda_0 t}\left[\lambda_0 t\right]^{N(t)}}{N(t)!} \quad (3)$$

The ratio $\frac{p_1}{p_0}$ at any time 't' is considered as a measure of deciding the truth towards λ_0 or, λ_1 given a sequence of time instants say $t_1 < t_2 < \ldots\ldots < t_k$ and the corresponding realizations $N(t_1) < N(t_2) < \ldots.. < N(t_K)$ of N(t). Simplification of $\frac{p_1}{p_0}$ gives

$$\frac{P_1}{P_0} = \exp(\lambda_0 - \lambda_1)t + \left(\frac{\lambda_1}{\lambda_0}\right)^{N(t)}$$

The decision rule of SPRT is to decide in favor of λ_0 in favor of λ_1 or to continue by observing the number of failures at a later time than 't' according as $\frac{p_1}{p_0}$ is greater than or equal to a constant say A, less than or equal to a constant say B or in between the constants A and B. That is, we decide the given software product as unreliable, reliable or continue [11] the test process with one more observation in failure data, according to

$$\frac{P_1}{P_0} \geq A \quad (4)$$

$$\frac{P_1}{P_0} \leq B \quad (5)$$

$$B < \frac{P_1}{P_0} < A \quad (6)$$

The approximate values of the constants A and B are taken as

$$A \cong \frac{1-\beta}{\alpha}, B \cong \frac{\beta}{1-\alpha}$$

Where 'α' and 'β' are the risk probabilities as defined earlier. A simplified version of the above decision processes is

To reject the system as unreliable if N(t) falls for the first time above the line

$$N_U(t) = a.t + b_2 \quad (7)$$

To accept the system to be reliable if N(t) falls for the first time below the line

$$N_L(t) = a.t - b_1 \quad (8)$$

To continue the test with one more observation on (t, N(t)) as the random graph of [t, N(t)] is between the two linear boundaries given by equations (7) and (8) where

$$a = \frac{\lambda_1 - \lambda_0}{\log\left(\frac{\lambda_1}{\lambda_0}\right)} \quad (9)$$

$$b_1 = \frac{\log\left[\frac{1-\alpha}{\beta}\right]}{\log\left(\frac{\lambda_1}{\lambda_0}\right)} \qquad (10)$$

$$b_2 = \frac{\log\left[\frac{1-\beta}{\alpha}\right]}{\log\left(\frac{\lambda_1}{\lambda_0}\right)} \qquad (11)$$

The parameters 'α', 'β', 'λ_0' and 'λ_1' can be chosen in several ways. One way suggested by Stieber is

$$\lambda_0 = \frac{\lambda.\log(q)}{q-1}, \lambda_1 = q\frac{\lambda.\log(q)}{q-1}, \quad where\ q = \frac{\lambda_1}{\lambda_0}$$

If λ_0 and λ_1 are chosen in this way, the slope of $N_U(t)$ and $N_L(t)$ equals λ. The other two ways of choosing λ_0 and λ_1 are from past projects (for a comparison of the projects) and from part of the data to compare the reliability of different functional areas (components).[6]

4. SEQUENTIAL TEST FOR SOFTWARE RELIABILITY GROWTH MODELS

We know that for any Poisson process, the expected value of N(t) = λ(t) called the average number of failures experienced in time 't'. Which is also called the mean value function of the Poisson process. On the other hand if we consider a Poisson process with a general function (not necessarily linear) m(t) as its mean value function the probability equation of a such a process is

$$P\left[N(t)=Y\right] = \frac{\left[m(t)\right]^y}{y!}.e^{-m(t)}, y = 0,1,2,----$$

Depending on the forms of m(t) we get various Poisson processes called NHPP, for the Burr Type III model and Pareto Type II model. The mean value functions are given as

$$m(t) = a\left[1+t^{-c}\right]^{-b} \quad , \quad m(t) = a\left[1-\frac{c^b}{(t+c)^b}\right]$$

$$P_1 = \frac{e^{-m_1(t)}.\left[m_1(t)\right]^{N(t)}}{N(t)!}$$

$$P_0 = \frac{e^{-m_0(t)}.\left[m_0(t)\right]^{N(t)}}{N(t)!}$$

Where $m_1(t)$, $m_0(t)$ represents the mean value function of stated parameters indicating reliable software and unreliable software respectively. The mean value function m(t) comprises the parameters 'a', 'b' and 'c'. The two specifications of NHPP for b are considered as b_0, b_1 where ($b_0 < b_1$) and two specifications of c say c_0, c_1 where ($c_0 < c_1$). For our proposed model, m(t) at b_1 is said to be greater than b_0 and m(t) at c_1 is said to be greater than c_0. The same can be denoted symbolically as $m_0(t) < m_1(t)$. The implementation of SPRT procedure is illustrated below.

System is said to be reliable and can be accepted if

$$\frac{P_1}{P_0} \le B$$

i.e., $$\frac{e^{-m_1(t)}.\left[m_1(t)\right]^{N(t)}}{e^{-m_0(t)}.\left[m_0(t)\right]^{N(t)}} \le B$$

i.e., $$N(t) \le \frac{\log\left(\frac{\beta}{1-\alpha}\right) + m_1(t) - m_0(t)}{\log m_1(t) - \log m_0(t)} \tag{12}$$

System is said to be unreliable and rejected if

$$\frac{P_1}{P_0} \ge A$$

i.e., $$N(t) \ge \frac{\log\left(\frac{1-\beta}{\alpha}\right) + m_1(t) - m_0(t)}{\log m_1(t) - \log m_0(t)} \tag{13}$$

Continue the test procedure as long as

i.e., $$\frac{\log\left(\frac{\beta}{1-\alpha}\right) + m_1(t) - m_0(t)}{\log m_1(t) - \log m_0(t)} < N(t) < \frac{\log\left(\frac{1-\beta}{\alpha}\right) + m_1(t) - m_0(t)}{\log m_1(t) - \log m_0(t)} \tag{14}$$

Substituting the appropriate expressions of the respective mean value function, we get the respective decision rules and are given in followings lines.

Acceptance Region Burr Type III:

$$N(t) \le \frac{\log\left(\frac{\beta}{1-\alpha}\right) + a\left(\left(1+t^{-c_1}\right)^{-b_1} - \left(1+t^{-c_0}\right)^{-b_0}\right)}{\log\left[\frac{\left(1+t^{-c_1}\right)^{-b_1}}{\left(1+t^{-c_0}\right)^{-b_0}}\right]} \tag{15}$$

Rejection Region Burr Type III:

$$N(t) \ge \frac{\log\left(\frac{1-\beta}{\alpha}\right) + a\left(\left(1+t^{-c_1}\right)^{-b_1} - \left(1+t^{-c_0}\right)^{-b_0}\right)}{\log\left[\frac{\left(1+t^{-c_1}\right)^{-b_1}}{\left(1+t^{-c_0}\right)^{-b_0}}\right]} \tag{16}$$

Continuation Region Burr Type III:

$$\frac{\log\left(\frac{\beta}{1-\alpha}\right) + a\left(\left(1+t^{-c_1}\right)^{-b_1} - \left(1+t^{-c_0}\right)^{-b_0}\right)}{\log\left[\frac{\left(1+t^{-c_1}\right)^{-b_1}}{\left(1+t^{-c_0}\right)^{-b_0}}\right]} < N(t) < \frac{\log\left(\frac{1-\beta}{\alpha}\right) + a\left(\left(1+t^{-c_1}\right)^{-b_1} - \left(1+t^{-c_0}\right)^{-b_0}\right)}{\log\left[\frac{\left(1+t^{-c_1}\right)^{-b_1}}{\left(1+t^{-c_0}\right)^{-b_0}}\right]} \tag{17}$$

Acceptance Region Pareto Type II:

$$N(t) \leq \frac{\log\left(\frac{\beta}{1-\alpha}\right) + a\left[\frac{c_0^{\,b_0}}{(t+c_0)^{b_0}} - \frac{c_1^{\,b_1}}{(t+c_1)^{b_1}}\right]}{\log\left[\frac{1-\frac{c_1^{\,b_1}}{(t+c_1)^{b_1}}}{1-\frac{c_0^{\,b_0}}{(t+c_0)^{b_0}}}\right]} \quad (18)$$

Rejection Region Pareto Type II:

$$N(t) \leq \frac{\log\left(\frac{1-\beta}{\alpha}\right) + a\left[\frac{c_0^{\,b_0}}{(t+c_0)^{b_0}} - \frac{c_1^{\,b_1}}{(t+c_1)^{b_1}}\right]}{\log\left[\frac{1-\frac{c_1^{\,b_1}}{(t+c_1)^{b_1}}}{1-\frac{c_0^{\,b_0}}{(t+c_0)^{b_0}}}\right]} \quad (19)$$

Continuation Region Pareto Type II:

$$\frac{\log\left(\frac{\beta}{1-\alpha}\right) + a\left[\frac{c_0^{\,b_0}}{(t+c_0)^{b_0}} - \frac{c_1^{\,b_1}}{(t+c_1)^{b_1}}\right]}{\log\left[\frac{1-\frac{c_1^{\,b_1}}{(t+c_1)^{b_1}}}{1-\frac{c_0^{\,b_0}}{(t+c_0)^{b_0}}}\right]} < N(t) < \frac{\log\left(\frac{1-\beta}{\alpha}\right) + a\left[\frac{c_0^{\,b_0}}{(t+c_0)^{b_0}} - \frac{c_1^{\,b_1}}{(t+c_1)^{b_1}}\right]}{\log\left[\frac{1-\frac{c_1^{\,b_1}}{(t+c_1)^{b_1}}}{1-\frac{c_0^{\,b_0}}{(t+c_0)^{b_0}}}\right]} \quad (20)$$

For the specified model, it may be observed that the decision rules are exclusively based on the strength of the sequential procedure (α, β) and the value of the mean value functions namely $m_0(t)$ $m_1(t)$. As described by Stieber, these decision rules become decision lines if the mean value function is linear in passing through origin, that is $m(t) = \lambda t$. The equations (12) and (13) are considered as generalizations for the decision procedure of Stieber. SPRT procedure is applied on live software failure data sets and the results that were analyzed are illustrated in Section 5.[14][15]

5. RESULTS AND ANALYSIS

In this section, the SPRT methodology is applied on two different data sets for 4th ordered and 5th ordered statistics referred from (LYU 1996)] and the decisions are evaluated on the mean value function of Burr Type III . The specifications for parameters b_0,b_1 and c_0,c_1 are chosen on the parameter estimates b and c as $b_0 = b - \delta$, $b_1 = b + \delta$ and $c_0 = c - \delta$, $c_1 = c + \delta$, and apply SPRT such that $b_0 < b < b_1$ and $c_0 < c < c_1$. Assuming the δ value of 0.0125 the choices are given in Table 1.

Table 1: Estimates of a, b, c & specifications of b_0, b_1, c_0, c_1

Data sets	Order	Estimate of 'a'	Estimate of 'b'	b_0	b_1	Estimate of 'c'	c_0	c_1
CSR2	4	8.92826	0.099999	0.087499	0.112499	0.101418	0.088918	0.113918
	5	5.702856	0.099998	0.087498	0.112498	0.106519	0.094019	0.119019
SYS2	4	5.858959	0.099999	0.087499	0.112499	0.100322	0.087822	0.113918
	5	3.873422	0.099999	0.087499	0.112499	0.105221	0.094019	0.119019

Using the specification b0, b1, and c0, c1 the mean value functions $m_0(t)$ and $m_1(t)$ are computed for each 't'. Later the decisions are made based on the decision rules specified by the equations (15), (16), (17) for the data sets. At each 't' of the data set, the strengths (α, β) are considered as (0.6, 0.6). SPRT procedure is applied on two different data sets and the necessary calculations are given in Table 2 and Table 3.

Table 2: SPRT Analysis for 4th Order data sets for Burr Type III

Data Set	T	N(t)	R.H.S. of equation (3.4) Acceptance region (≤)	R.H.S. of equation (3.5) Rejection region (≥)	Decision
CSR2	1557	1	-7.43086	8.737562	REJECT
	1639	2	-7.48319	8.776151	
	1973	3	-7.67517	8.918006	
	2183	4	-7.7818	8.996983	
	2714	5	-8.01605	9.170961	
	3455	6	-8.28354	9.370387	
	5045	7	-8.72012	9.697572	
	5087	8	-8.72992	9.704941	
	5222	9	-8.76095	9.72828	
	5608	10	-8.84599	9.792279	
SYS2	1576	1	-6.21469	8.445398	REJECT
	4149	2	-7.05728	9.121103	
	5827	3	-7.3793	9.38095	
	10071	4	-7.92966	9.826981	
	11836	5	-8.09994	9.965455	
	15280	6	-8.37693	10.19115	
	16860	7	-8.48622	10.28036	
	19572	8	-8.65469	10.41803	
	23827	9	-8.88216	10.60423	
	28257	10	-9.08434	10.77001	
	31886	11	-9.23047	10.89001	

Table 3: SPRT Analysis for 5th Order data sets of Burr Type III

Data Set	T	N(t)	R.H.S. of equation (3.4) Acceptence region (≤)	R.H.S. of equation (3.5) Rjection region (≥)	Decision
CSR2	1579	1	-6.53061	8.765538	REJECT
	1738	2	-6.61658	8.835579	
	2030	3	-6.75817	8.951058	
	2714	4	-7.03115	9.174181	
	3491	5	-7.27683	9.375512	
	5054	6	-7.6538	9.685355	
	5222	7	-7.68806	9.713568	
	5608	8	-7.76331	9.775576	
	6602	9	-7.93837	9.919968	
	7233	10	-8.03805	10.00229	
	7603	11	-8.09307	10.04776	
SYS2	2610	1	-12.9566	15.54412	CONTINUE
	4436	2	-13.9495	16.4418	
	8163	3	-15.2031	17.57807	
	11836	4	-16.0317	18.33066	
	15685	5	-16.6951	18.93413	
	17995	6	-17.0305	19.23954	
	22226	7	-17.5618	19.72358	
	28257	8	-18.1897	20.29631	
	32346	9	-18.5549	20.62965	
	39856	10	-19.1364	21.16074	
	46147	11	-19.5574	21.54566	
	53223	12	-19.978	21.93028	
	58996	13	-20.2882	22.2142	
	67374	14	-20.6968	22.58828	
	80106	15	-21.2442	23.0898	
	91190	16	-21.6653	23.47592	
	98692	17	-21.9272	23.71607	

We also compare the SPRT methodology on two different data sets for 4th ordered and 5th ordered statistics referred from (LYU 1996)] and the decisions are evaluated on the mean value function of Pareto Type II. The specifications for parameters b_0,b_1 and c_0,c_1 are chosen on the parameter estimates b and c as $b_0 = b - \delta$, $b_1 = b + \delta$ and $c_0 = c - \delta$, $c_1 = c + \delta$, and apply SPRT such that $b_0 < b < b_1$ and $c_0 < c < c_1$. Assuming the δ value of 0.0125 the choices are given in Table 4.[14]

Table 4: Estimates of a, b, c & specifications of b_0, b_1, c_0, c_1

Data sets	Order	Estimate of 'a'	Estimate of 'b'	b0	b1	Estimate of 'c'	c0	c1
CSR2	4	32.007075	0.999752	0.649752	1.349752	4.890103	4.640103	5.140103
	5	25.007721	1.000377	0.65038	1.35038	4.883801	4.6338	5.1338
SYS2	4	21.000000	4.748504	4.395804	5.098504	5.051261	4.801261	5.301261
	5	17.000000	4.312880	3.96288	4.66288	5.054862	4.80486	5.30486

Using the specification b_0, b_1, and c_0, c_1 the mean value functions $m_0(t)$ and $m_1(t)$ are computed for each 't'. Later the decisions are made based on the decision rules specified by the equations (18), (19), (20) for the data sets. At each 't' of the data set, the strengths (α, β) are considered as (0.05,0.2). SPRT procedure is applied on two different data sets and the necessary calculations are given in Table 5 and Table 6.

Table 5: SPRT Analysis for 4th Order data sets of Pareto Type II

Data Set	T	N(t)	R.H.S. of equation (3.4) Acceptance region (≤)	R.H.S. of equation (3.5) Rejection region (≥)	Decision
CSR2	1557	1	-1.521980456	60.40735943	CONTINUE
	1639	2	-2.363664708	61.19302918	
	1973	3	-5.602221781	64.19955817	
	2183	4	-7.505588675	65.95636072	
	2714	5	-11.95893562	70.04422893	
	3455	6	-17.51898409	75.11493547	
	5045	7	-27.74940129	84.38301639	
	5087	8	-27.99628871	84.60596339	
	5222	9	-28.78314626	85.31633798	
	5608	10	-30.97939179	87.29771755	
	6599	11	-36.29872995	92.08922517	
	7042	12	-38.54832807	94.11288595	
	7565	13	-41.11601258	96.42099482	
	7612	14	-41.34240155	96.62441697	
	8496	15	-45.47844618	100.338781	
	9356	16	-49.3022912	103.7696182	
	10662	17	-54.79021776	108.6890393	
	12523	18	-62.06280593	115.2015831	
	13656	19	-66.22896226	118.9295173	
	24480	20	-99.5717941	148.7164213	
	26136	21	-103.9571962	152.6296836	
	31174	22	-116.5080636	163.825532	
	34077	23	-123.2820175	169.8661884	

	35422	24	-126.3226574	172.5772865	
	37476	25	130.8570432	176.6198361	
	39336	26	-134.857272	180.185794	
	47688	27	-151.7528155	195.2438059	
	50119	28	-156.3869831	199.3731567	
	58707	29	-171.9191153	213.2112304	
	69259	30	-189.5210589	228.8901434	
	78723	31	-204.1975401	241.961117	
	88694	32	-218.7346684	254.9064607	
SYS2	1576	1	-6442026.289	5731564.611	CONTINUE
	4149	2	-72085685.61	64135279.97	
	5827	3	-168312027.3	149748664.8	
	10071	4	--660009377.1	587215929.1	
	11836	5	-987913656.4	878955122.1	
	15280	6	-1869716572	1663502587	
	16572	7	-2289983140	2037417284	
	16860	8	-2390691963	2127018770	
	23827	9	-5672327868	5046711814	
	29257	10	-9473258650	8428437873	
	32886	11	-12687098419	11287818124	
	35467	12	-15322798642	13632822762	
	41151	13	-22213406419	19763454409	
	48662	14	-33768970062	30044536494	
	53623	15	-43037470210	38290798967	
	56483	16	-49003893338	43599175765	
	61888	17	-61572191482	54781296246	
	70138	18	-84170079399	74886827035	
	83146	19	-1.28752E+11	1.14552E+11	
	91514	20	- 1.63611E+11	1.45566E+11	
	98022	21	-1.94244E+11	1.72821E+11	

Table 6: SPRT Analysis for 5th Order data sets of Pareto Type II

Data Set	T	N(t)	R.H.S. of equation (3.4) Acceptence region (≤)	R.H.S. of equation (3.5) Rjection region (≥)	Decision
CSR2	1579	1	-7.561305554	52.84022539	CONTINUE
	1738	2	-9.125044688	54.28592842	
	2030	3	-11.82847923	56.77376905	
	2714	4	-17.50705839	61.9637791	

	3491	5	-23.16671186	67.1030995	
	5054	6	-32.92437338	75.91492717	
	5222	7	-33.87844045	76.7741518	
	5608	8	-36.01484645	78.69698421	
	6602	9	-41.20397052	83.36134978	
	7233	10	-44.29930882	86.14023478	
	7603	11	-46.05241999	87.7131417	
	8496	12	-50.11722526	91.35773735	
	9632	13	-54.99351438	95.72612833	
	11629	14	-62.91915039	102.8191299	
	12793	15	-67.22823924	106.6725145	
	24480	16	-102.7292559	138.3688006	
	26809	17	-108.6901104	143.6850387	
	31869	18	-120.8088953	154.490045	
	35386	19	-128.6738583	161.5004524	
	37476	20	-133.1636927	165.5018759	
	47320	21	-152.8016038	182.9995211	
	49620	22	-157.0866688	186.8168374	
	58648	23	-173.0169432	201.0063531	
	69259	24	-190.246013	216.3500391	
	78785	25	-204.6200376	229.1494057	
SYS2	2610	1	-396372600	352656065.4	CONTINUE
	4436	2	-1904736682	1694660266	
	8163	3	-11589772426	10311517959	
	11836	4	-34830986458	30989421399	
	15685	5	-80197251654	71352168796	
	17995	6	-1.20476E+11	1.07189E+11	
	23226	7	-2.25215E+11	2.00376E+11	
	28257	8	-5.08423E+11	4.52349E+11	
	32346	9	-7.49067E+11	6.66451E+11	
	39856	10	-1.36735E+12	1.21655E+12	
	46147	11	-2.08971E+12	1.85924E+12	
	53223	12	-3.16093E+12	2.8123E+12	
	58996	13	-4.26841E+12	3.79764E+12	
	67374	14	-6.28787E+12	5.59437E+12	
	80106	15	-1.04114E+13	9.26308E+12	
	91190	16	- 1.52549E+13	1.35724E+13	
	98692	17	1.91728E+13	1.70582E+13	

6. CONCLUSION

In this paper we compared Burr Type III and Pareto Type II models using Sequential Probability Ratio Test (SPRT) based on the cumulative quantity between observations of ordered time domain failure data based on Non Homogenous Poisson Process (NHPP)**.**The experimental result shows that the CSR2 and SYS2 data sets of Burr type III with 4th and 5th order statistics can detect the reliability of software at earlier stage compared with Order Pareto Type II model. Hence, we may conclude that Burr Type III model with order statistics using SPRT can come to an early conclusion of reliable/unreliable of software.

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