Object oriented system reliability measurement techniques: A Review

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ABSTRACT

Reliability of a software system is a major factor to quantify the quality of a software system .In the competitive world of software industries one cannot compromise with the quality of the system, so the reliability .High reliable software product have been considered as the high quality product in the market. A lot of research work have been done in past decade to estimate the reliability of a software system .In this review paper, we present a systematic literature review on object oriented system reliability measurement techniques .In this paper, we aim to gather, study and present the various available reliability measurement techniques for object oriented software systems.

KEYWORDS

Object oriented software, reliability, reliability measurement techniques, quality, component

1. INTRODUCTION

"Quality is the totality of features and characteristics of a product or a service that bears on its ability to satisfy the given needs "[10]. Software quality is measured considering various factors, software reliability is one of the major factor that upgrade or degrade the software quality. Software reliability is the measure of degree of efficiency of system under certain conditions over a specific period of time. System reliability is directly proportional to system quality. Multiple models and techniques have been introduced by researchers to estimate the system reliability. System designed using object oriented approach, has different reliability estimation techniques. In this review paper we present some of the available techniques to measure the reliability of object oriented system having different methodology.

2. COMPLEXITY MATRIC BASED TECHNIQUE

The software size and complexity is the key concern in the field of software development. Based on various research works done in the field of software engineering, it is stated that, complexity of a system is directly related to system reliability. Highly complex system or system component will have low reliability, and hence the low quality. Metrics are the quantitative measure of the degree to which a software component posses a specified attribute [1]. Various object oriented reliability metrics can be used for calculating the reliability of a system. Dromey R.G., in one of his research paper introduced a generic model for reliability measurement. Based on this model, the researchers in paper [1] derived a relation between OOD attributes and reliability. Reliability metrics are helpful to know the possibility of software failure or the failure rate at which system errors will occur [2]. Derived model in [1] is based on following matrices :-

1. Inherited Complexity Metrics(ICM)
2. Cohesion Complexity Metrics(CCM)
3. Encapsulation Complexity Metrics(ECM)
4. Coupling Complexity Metrics(CM)

Using these matrices, a linear regression equation was established to calculate complexity

Y= a+b1X1+ b2X2…………………bnXn - (2.1)

Where, Y is the dependent variable

Xs are the independent variable.

a, b are the coefficients.

Complexity = a + b1(ICM) + b2(CCM) + b3(ECM)+ b4(CM) (2.2)

By using equation (2) values of coefficients a, b1, b2, b3, b4 was found to be, for example a=0.6234, b1=-0.3816, b2= 0.4563, b3=0.6480, b4=-0.5432.

Relation between reliability and complexity is represented using equation

Reliability=x+y(complexity) (2.3)

x and y are the model coefficients

Where, reliability is the dependent variable

Complexity is the independent variable.

Using SPSS author calculates the values of x and y, and calculates the reliability of the system using above equation.

2. COMPONENT BASED TECHNIQUE

Authors in [4], introduced a new technique to measure the system reliability from its components and connectors reliability. Many researchers find it infeasible to measure the system reliability from its components reliabilities, as software components are less independent as compared to hardware components. But according to the authors of [4], it is more efficient to calculate system reliability from existing estimated values of component and connector reliability. In paper [6], it is stated that a system can be divided in independent components if the individual system reliability is available then the overall system reliability can be calculate using Markov analysis techniques. But this technique does not include the connector reliability, which is found to affect the system reliability up to mark able extend. So, it is not a good idea to ignore the connector reliability while calculating the system reliability .In [4] author includes the connector reliability in the proposed technology.

2.1 Reliability Estimation

2.1.1 Assumption

1. System is composed of components and connectors.

2.1.2 Requirements

1. Reliability of each component.
2. Details about component interaction during system execution.

Individual component and connector reliability can be calculated using methods in [7].

2.1.3 Method

Let $C_1, C_2, C_3 \ldots\ldots C_n$ be the state of components in Markov model.

Reliability of individual component P_i is given by $P_i \in [1:n]$

$P_{ij,}$ is the transition probability.

P_{ij}, i, j ϵ [1:n] such that, P_{ij} is the probability that the system will execute component C_j ,given that it is currently executing component $C_{i.}$

$Q_{ij,}$ i, j € [1:n] is the probability of each connector between components C_i and C_j

Connectivity between i, j can be represented by

$l_{ij} = P_{ij} * Q_{ij}$

Semi Markov reliability model is given by….

$$\begin{pmatrix} C_{1n} \\ C_{2n} \\ C_{nm} \end{pmatrix} = \begin{pmatrix} L11 & L12\ldots & L1n \\ L21 & L22\ldots & L2n \\ Ln1 & Ln2\ldots & Lnn \end{pmatrix} \begin{pmatrix} C_{1n} \\ C_{2n} \\ C_{nm} \end{pmatrix}$$

$L_{ij} = l_{ij} * P_i(t)$

Where,

$Pi(t)=P\{Tn+1-Tn \leq t | Zn=i, Zn+1=j\}$ is reliability of state $C_{i..}$

3. ARCHITECTURE BASED TECHNIQUE

In architecture based technique, reliability is measured at design and analysis time using Use case, Sequence, Deployment diagrams etc. This method measures reliability of functional requirements. In [9], authors make use of system architecture, which can be represented using use case, sequence diagram, deployment diagram etc.. This method calculates system reliability at design and analysis phase at component level instead of calculating the overall system reliability.

3.1 Assumptions

1. In future COTS components would be sold with a specification sheet having their reliability details.
2. If any component fails system will fail.
3. Independence of failure among components.

Model in [9] makes use of Bayesian reliability prediction algorithm. It makes use of annotated UML diagrams for estimation .Paper proposed the annotated UML diagrams which are based on Bayesian approach to reliability modeling of component based system.

3.2 Method

1. Deriving equation from annotated use case diagrams.

Let there be m number of users and n number of use cases.

Probability of executing use case x can be written as

$$P(x) = \sum_{i=1}^{m} q_i \cdot p_{ix}$$

Where,

$q_{i,}$ is the probability that user u_i will use the system requesting some functionality.

p_{ix} is probability of i^{th} user requesting functionality in use case x.

There could be number of sequence diagrams in use case executing different scenario.

Probability of execution of k^{th} sequence diagram which refers to the j^{th} use case

$$P(k_j) = p(j).f_j(k) \qquad (3.1)$$

$f_j(k)$ is the frequency of execution of j^{th} use case.

2. Deriving equations from annotated sequence diagram

Sequence diagrams are the sequential representation of execution and interaction of components in a particular scenario.

If the failure probability Θ_i for every component is available to us, then the failure probability of component i in the scenario j is given by

Θ_{ij} = probability(failure of component c_i in scenario j)

$$= 1 – (1- \Theta_i)^{bp_{ij}} \qquad (3.2)$$

bp_{ij} of component i in scenario j, which could be easily counted manually from sequence diagram.

3. Deriving equations from deployment diagram

Each pair of components (l,m) interacting through connector I is subjected to a failure probability say Ψ_i

$$\Psi_{lmj} = (1- \Psi_i)^{(interact\ (lmj))} \qquad (3.3)$$

Where,

$\Psi_{lmj,}$ is the reliability of communication between the components.

|interact (lmj)| is the number of interactions the component l and m executing in the sequence diagram j.

Using the above derived equation reliability of whole system is given by

$$\Theta_s = 1 - \sum_{i=1}^{k} p_j \left(\prod^{n} (1- \Theta_i)^{bpij} \cdot \prod (1-\psi_{lij})^{(interact()lij)} \right) \qquad (3.4)$$

4. Conclusion

Many object oriented software reliability models and techniques have been proposed by the researchers in the past. The aim of this review paper is to summarize and explain the methodology used in some of the existing techniques and their approach and phase of software life cycle in which they are implemented. This could be a base for future research work in this area, for example automated software tools can be created for these techniques.

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