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Reliability Quantification of Object Oriented Software: Functionality Perspective

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Abstract: Object oriented design and development are well-liked and accepted conceptions in today's software development circumstances. Object oriented design supports design principal such as inheritance, coupling, cohesion and encapsulation. The planned research work will deliver a method for reliability estimation of object oriented design in respect of functionality perspective. To design and deliver quality products within time and budget functionality plays a vital job. Functionality and reliability quantification approach is presented in this paper. This paper appreciates the need and importance of functionality at design phase and the statistical conclusion establishes functionality as an influencing factor for software reliability. On the basis of proposed mapping among object oriented design properties and functionality a multiple regression equation has been established for computing the functionality of design hierarchies. Functionality is positively affects reliability of object oriented designs. Once more a multiple regression equation has been established to calculate reliability in respect of functionality. At last the proposed model has been validated using experimental tryout.

Keywords: Software reliability, reliability quantification, Functionality, Object Oriented Design, Software Quality.

I. Introduction

Software is often the costliest item in a computer based application. Center of attention on software price tag and feature is a branch of engineering (analysis and design) and not of production. Furthermore, price of software is not dependent on quantity of production. Like any product, software is designed based on some software specification; it is developed under formalized product reviews (quality assurance) and formalized testing procedures [1, 2]. It requires huge amount of effort, time and funds to design and develop high quality reliable and testable software. Successful software testing will extensively make a contribution to the delivery of better-quality software products, pleased customers and will provide accurate and consistent results [3,4]. Software testing is an essential and expensive movement of development life cycle that is used for determining whether a program has errors or not. Any procedure that improves a software design at an early stage of development life cycle can have highly advantageous impact on the final testing cost and functionality.

There are severe problems in the cost, timeliness, maintenance and reliability of many software products. Software engineering has the intention of solving these problems by producing feature- quality reliable software in time, economic plan. Software reliability is the possibility that the software will work without failure for a particular stage of time. Software reliability is a key attribute to software quality [3]. Reliability is the property of referring 'how well software meets its requirements' & also 'the probability of failure free operation for the specified period of time in a specified environment [5]. Software reliability describes as the failure free operation of computer program in a specified environment for a specified time [6, 7, 8, 9].

Reliability is one of the decidedly important quality indicators of object oriented software. Its accurate measurement or estimation, continually make easy and improve the software development process. On the other hand, reliability has always been an unexplained theory and its honest measurement or evaluation is a hard exercise [10, 11]. Quality controllers and industry personals have constantly argued that reliability should be considered as a key feature in order to promise the quality software. A perfect measure of software quality completely depends on reliability measurement, and as a result estimating reliability is a complex problem attracting significant research consideration [12, 13].

II. Overview of The Proposed Model

Functionality Quality factor

Functionality is strongly related to reliability and constantly plays a key role to deliver high class maintainable and reliable software within time and financial plan. It is one of the most important concepts in design and testing of software programs and components. It always supports for improved software design at early stage of software development life cycle that is to say at design phase that have positive impact on the overall reliability quantification cost and effort [10, 14, 15].

Functionality Quantification Model

We have developed a functionality quantification model that demonstrates the quantification method of software functionality. The proposed model is shown in Figure 1. The model establishes an appropriate impact relationship between functionality and object oriented design constructs and the associated metrics. The values of these metrics can be effortlessly identified with the help of class diagram. The quantifiable evaluation of functionality is very supportive to get reliability index of software design for low cost reliability quantification.

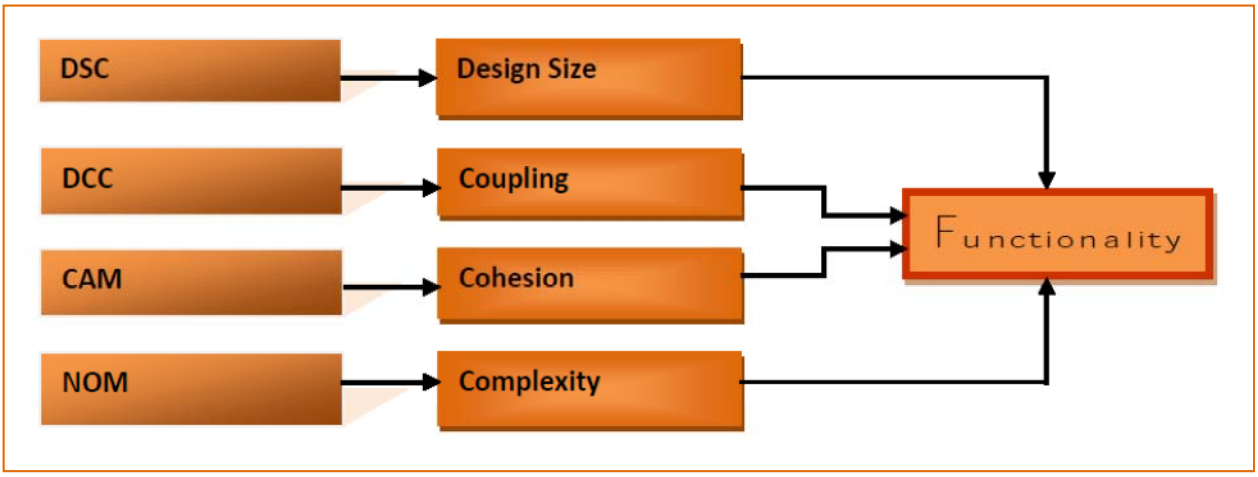

Figure 1: Mapping among Object Oriented Design Properties and Functionality

Table 1: Metrics explanation

Metric	Description
DSC	Design Size in Classes
DCC	Direct Class Coupling
CAM	Cohesion Among Methods of Class
NOM	Number of Methods

III. Model Development

In order to set up a model for functionality, multiple linear regression method has been used. Multivariate linear model is given below in *Eq* (1) which is as follows.

$Y=a_0+a1X1+a2X2+a3X3+\text{-------}+anXn$ **Eq (1)**

Where,

- Y is dependent variable.
- X1, X2, X3--------Xn (be independent variables) associated to Y.
- a1, a2, a3--------an., are the coefficient of the exacting independent variables.
- a_0 is the intercept.

The data used for establishing functionality model is taken from [19] that have been collected through large commercial object oriented systems. The relationship between reliability factor functionality and object oriented properties has been established as depicted in Figure 1. As per the mapping, Metrics 'DSC, DCC, CAM, NOM' are selected from [33] as independent variable to build up the functionality quantification model via SPSS, values of coefficient are calculated and functionality model is formulated as given below.

Functionality=.339 + .374 x Design Size + .104 x Coupling + .153 x Cohesion + .367 x Functionality ***Eq (2)***

IV. STATISTICAL SIGNIFICANCE OF INDEPENDENT VARIABLES

As long as statistical impact and importance of each independent variable in the functionality model (2) is apprehension. It can be noticed from the last column of Table 2, (p value for 't' test) that all of the four metrics participating in the model is statistically considerable at a significance level of 0.05 (equal to a confidence level of 95%).

Table 2. Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.339	.359		.944	.518
	Designsize	.374	.038	.539	9.778	.065
	Coupling	.104	.044	.147	2.387	.253
	Cohesion	.153	.040	.186	3.835	.162
	Functionality	.367	.041	.490	8.962	.071

Pearson's coefficient of correlation technique was used for estimating the degree of correlation among variables. The value of corelation 'r' lies between ±1, positive value of 'r' in Table 2 is a sign of positive corelation between the two variables.

Table 3. Pearson Correlation

Correlations						
		Functionality	Designsize	Coupling	Cohesion	Functionality
Pearson Correlation	Functionality	1.000	.803	.739	.495	.744
	Designsize	.803	1.000	.519	.339	.254
	Coupling	.739	.519	1.000	.219	.553
	Cohesion	.495	.339	.219	1.000	.192
	Functionality	.744	.254	.553	.192	1.000

Moreover the evaluation of R2 (Coefficient of Determination) and adjusted R2 in the Table 4, is to very encouraged. As, it refers to the percentage of the whole variance in functionality by all the four metrics contributing in the model (2).

Table 4. Model Summary

Model Summary									
Model	R	R Square	Adjusted R Square	Std. Error of the Quantify	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.999[a]	.998	.990	.32624	.998	121.706	4	1	.068
a. Predictors: (Constant), Functionality, Cohesion, Designsize, Coupling									

Table 5. ANOVA

ANOVA[b]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	51.814	4	12.954	121.706	.068[a]
	Residual	.106	1	.106		
	Total	51.921	5			
a. Predictors: (Constant), Functionality, Cohesion, Designsize, Coupling						
b. Dependent Variable: Functionality						

V. Reliability Quantification

In order to establish a correlation among reliability and functionality, the relevant influence of correlation between functionality and reliability are being examined on the basis of literature review [16, 17, 18, 19]. It was observed that functionality and reliability are strongly associated with each other and functionality positively affects reliability of object oriented software [20]. Researcher uses the functionality of object oriented design to quantify reliability of software. Highly functional software increases the reliability of object oriented design [19]. The developed equation 1 is being used for quantifying reliability of object oriented design. The multiple linear regressions set up a relationship between dependent variable and multiple independent variables [5]. As a consequence, the multiple regression equation takes the form as follows:

$$Z=ß0 + ß1Y1 + ß2Y2 + ß3Y3 + \text{-------} + ßn\ Yn \qquad Eq\ (3)$$

Where Z is the dependent variable *ß0* and *ß1, ß2, ßn* are the regression coefficients, and Ys are independent variables.

$$R= \alpha+\beta\ (F) \qquad Eq\ (4)$$

- Where R is reliability which is dependent variable,
- F is functionality which worked as independent variables
- And α, β is treated as regression coefficients.

Reliability depends on functionality. The value of metrics is available (Bansiya et al., 2002) data sets for projects taken from [19]. On the basis of these projects data, regression coefficients for functionality are computed as α=-0.884, β= 1.030. Putting values of α, β, in equation 4, following equation will be generated

$$R= -0.884+1.030\ (F) \qquad Eq\ (5)$$

VI. Empirical Validation

This part of work paying attention how the above developed model is competent to conclude the reliability of object oriented design at design phase. The empirical validation is an important stage of planned research to validate reliability quantification model for high and enhanced level acceptability. Empirical validation is the approved approach and practice to say the model acceptance. Keeping view of this truth, practical validation of the reliability quantification model has been performed using sample tryouts.

In order to validate proposed reliability quantification model the value of metrics is available (Bansiya et al., 2002) data sets for given ten projects taken from [19].

The known Reliability rating for the given 10 Projects (P1-P10) is shown in Table 6.

Table 6. Known Reliability Value

P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
6.294	3.696	9.758	8.026	2.83	7.16	5.428	11.49	12.356	10.624

Table 7.Known Reliability Rating

P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
4	2	7	6	1	5	3	9	10	8

Table 8. Calculated Reliability Value

P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
5.61	3.90	7.70	7.06	7.25	10.14	8.51	10.13	9.11	8.17

Table 9. Calculated Reliability Rating

P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
2	1	5	3	4	10	7	9	8	6

Table 10. Computed Ranking, Actual Ranking and their Relation

Projects ➔ Reliability Ranking 🡻	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
Computed Ranking	2	1	5	3	4	10	7	9	8	6
Known Ranking	4	2	7	6	1	5	3	9	10	8
Σd^2	4	1	4	9	9	25	16	0	4	4
rs	0.98	0.99	0.98	0.95	0.95	0.85	0.90	1.00	0.98	0.98
rs >.781	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

r_s >.781 means significant results.

Charles Speraman's Coefficient of Correlation ***rs*** was used to check the significance of correlation between calculated values of reliability via model and it's 'Known Values'. Rank corelation is the method of determining the degree of corelation between two variables. The ' ***rs***' was computed using the formula given as under:

Speraman's Coefficient of Correlation (rs) =

$$r_s = 1 - \frac{6\sum d^2}{n(n^2-1)} \qquad -1.0 \le r_s \le +1.0$$

- 'd' = difference between 'Calculated Values' and 'Known Values' of reliability.
- n = number of projects (n=10) used in the experiment.

The correlation values between reliability using model and known ranking are shown in Table above. Pairs of these values with correlation values ***rs*** above [±.781] are checked in Table 10.The correlation are up to standard with high degree of confidence, i.e.at the 99%. As a result we can conclude without any loss of generality that reliability quantification model is exceedingly truthful, essential and applicable in the functionality perspective. However, the study needs to be standardized with a large experiment tryout for better acceptability and utility.

VII. Conclusion

This study shows the importance of functionality in general and as a key factor to software reliability for producing high class reliable software within time and budget. Functionality is clearly highly appropriate and significant in the perspective of software reliability. Reliability model is developed with the help of multiple linear regression method on object oriented design properties. Statistical test shows that this model is statistically very much significance and acceptable. Reliability quantification model has been validated theoretically as well as empirically using experimental try-out. The applied validation on the reliability model concludes that proposed model is highly reliable, acceptable and extensive.

References

1. Michael R.Lyu., Software Reliability Engineering: A Roadmap", Future of software engineering, 23-25 May 2007, pp: 153-170, ISBN: 0-7695-2829-5, DOI: 10.1109/FOSE.2007.24.
2. Zainab Al-Rahamneh, Mohammad Reyalat, Alaa F. Sheta, Sulieman Bani-Ahmad, Saleh Al-Oqeili,, "A New Software Reliability Growth Model: Genetic-Programming-Based Approach", Journal of Software Engineering and Applications, 2011, Vol: 4, PP:476-481 doi:10.4236/jsea.2011.48054.
3. Deepak Arora, Pooja Khanna and Alpika Tripathi, Shipra Sharma† and Sanchika Shukla, "Software Quality Estimation through Object Oriented Design Metrics", IJCSNS International Journal of Computer Science and Network Security, VOL.11 No.4, April 2011,pp:100-104.
4. R.A Khan, K. Mustafa and S.I Ahson, "Operation Profile-A key Factor for Reliability Estimation", Universities press, Gautam Das & V P Gulati, CIT, 2004, pp 347-354.
5. Abdullah, Dr, Reena Srivastava, and Dr. M. H. Khan. "Modifiability: A key factor to testability", International Journal of Advanced Information Science and Technology, Volume 26, Issue 26, Pages 62-71,2014
6. Jintao zeng, Jinzhong Li, Xiaohui Zeng, Wenlang Luo "A Prototype System of Software Reliability Prediction and Estimation". IITSI 2010.
7. J. Peter Rooney, "Customer Satisfactions", In Proceedings of annual Reliability and Maintainability Symposium, 24- 27 Jan. 1994 pp.376 – 381.
8. J. D. Musa and K. Okumoto, "A Logarithmic Poisson Execution Time Model for Software Reliability, Measurement", Bell Lab, IEEE, 1984, pp. 230-238.
9. M. L. Shooman, "Yes, Software Reliability Can be Measured and Predicted", Division of Computer Science, Polytechnic University, 1987, pp.121-122.
10. Abdullah, Dr, Reena Srivastava, and M. H. Khan. "Testability Measurement Framework: Design Phase Perspective.", International Journal of Advanced Research in Computer and Communication Engineering Vol. 3, Issue 11, Pages 8573-8576 November 2014
11. Natasha Sharygina , James C. Browne, and Robert P. Kurshan, "A Formal Object-Oriented Analysis for Software Reliability: Design for Verification", 2011, pp:1-15.
12. Weber Philippe, Jouffe Lionel, "Complex system reliability modelling with Dynamic Object Oriented Bayesian Networks (DOOBN)", Reliability Engineering and System Safety 91/2, (2006) 149-162,pp:1-15.
13. Nikolaos Tsantalis, Alexander Chatzigeorgiou, "Predicting the Probability of Change in Object-Oriented Systems", IEEE Transactions on Software Engineering, VOL. 31, NO. 7, July 2005, pp: 601-614.
14. Marian Cristescu, Laurențiu Ciovica, "Estimation of the Reliability of Distributed Applications", Informatica Economică vol. 14, no. 4/2010, pp: 19-29.
15. Abdullah, Dr, Reena Srivastava, and Dr. M. H. Khan. "Testability Estimation of Object Oriented Design: A Revisit."International Journal of Advanced Research in Computer and Communication Engineering, Volume 2, Issue 8, Pages 3086 -3090, 2013.
16. A.Yadav & R.A Khan, "Reliability Estimation of Object Oriented Design", IUP Journal of System Management, Volume IX, No.2, May 2011, pp: 28-41, ISSN: 0972-6896.
17. Usha Chhillar, Shuchita Bhasin , " A New Weighted Composite Complexity Measure for Object-Oriented Systems", International Journal of Information and Communication Technology Research Volume 1 No. 3, July 2011,pp: 101-108, ISSN-2223-4985.
18. Haifeng Li Minyan Lu Qiuying Li , "Software Reliability Metrics Selecting Method Based on Analytic Hierarchy Process", Sixth International Conference on Quality Software, 2006. QSIC 2006, 27-28 Oct. 2006, pp: 337 – 346, ISSN: 1550-6002, ISBN: 0-7695-2718-3.
19. Bansiya, Jagdish, and Carl G. Davis. "A hierarchical model for object-oriented design quality assessment." Software Engineering, IEEE Transactions on 28.1 (2002): 4-17
20. F. Li., T.Yi, "Apply Page Rank Algorithm to Measuring Relationship's Complexity", IEEE, DOI 10.1109/ PACIIA.2008.309, pp. 914-917, 2008, ISBN: 9780769534909.

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