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Quantify Object Oriented Software Analyzability

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Abstract: Analyzability is one of the most important quality criteria for software development process. The majority of the software industries overdo 50 to 60 percent of resources for maintaining and correcting, the existing software. Nearly all of companies use over 60 % costs on testing and maintenance of the software to manage the quality. IEEE glossary of Software Engineering defines analyzability is "the ease with which a software system or component can be modified to correct faults, improve performance or other attributes, or adapt to a change environment". Software maintenance process required for additional effort, than any other software engineering development process. The analyzability criteria of software system are not feasible directly, although with the support of their internal uniqueness measurements. Early estimation of analyzability mainly at design phase helps to make use of its measurements more proficiently to enhance the quality of software product. The design stage estimation of analyzability is more practicable for software creation team and maintenance inexpensively. This paper proposes an analyzability measurement model. The proposed model for computing software analyzability point outs the possible influence of design properties and also talk about the impact of software analyzability computation with design stage complexity.

Keywords: Analyzability, Flexibility, Effectiveness, Analyzability Model.

I. INTRODUCTION

Quantifying analyzability of object oriented software early in the development process, particularly at design phase greatly reduce the overall development cost and effort, and in addition support the designers and developers for producing high quality maintainable and reliable software product within time and budget. To design and deliver quality products inside time and financial plan analyzability plays a very important role. The ISO/IEC 9126 (1) standard defines a model for product quality of the software that breaks down the overall view of quality into 6 key characteristics: namely analyzability, usability, efficiency, analyzability, analyzability and portability [3, 11].Analyzability estimation assists to examine the software maintenance effort and acceptance of software at design phase [12, 13]. This chapter shows the need and significance of analyzability at design phase and build up a multivariate linear model "Analyzability Quantification Model" for Object-Oriented Design. Developed model computes analyzability of product class diagrams in respect of their internal design properties.

In this chapter an endeavor has been made to establish a link among object oriented design properties and analyzability as a first contribution. Despite the fact that at the same time, in order to quantify class diagram's analyzability the study further developed multivariate models. Finally the proposed models have been validated using experimental tryout.

Software Engineering has turn into extremely essential discipline of study, practice and research. Everyone are working hard to decrease the problems and to meet the purpose of developing high-quality maintainable software that is delivered on time, within budget, and furthermore Satisfies the requirements [1,8]. Software has become significant to expansion in almost all areas of individual endeavor. The skill of software programming only is no longer enough to make large programs. There are serious problems in the timeliness, price, quality and maintenance of many software products [2, 9]. Software development process has the purpose of solving these challenges by producing feature- quality maintainable software within time, financial plan. To attain this goal, we encompass to centre in a closely controlled way on both the quality of the process and product use to develop the more acceptable product [4, 5, 6, 7].

II. OVERVIEW OF THE PROPOSED MODEL

Analyzability is strongly related to maintainability and continuously acts a major 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 enhanced design of the software at initial stage of software development life cycle that is to say at design phase that have positive impact on the overall analyzability quantification cost and effort [14, 15, 25]. We have developed an analyzability quantification model that demonstrates the quantification method of software analyzability [24, 26].

The proposed model is shown in Figure 1. The model establishes an appropriate impact relationship between analyzability 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 assessment of analyzability is extremely supportive to get analyzability indicator of software design for small cost analyzability quantification.

III.OOD CHARACTERISTICS

Object oriented technology have turn into the most accepted and recognizable concept in software industry. Object oriented notion is now broadly used by software industry. Despite the truth that technology is not grown-up

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enough from testing point of view [27, 28, 29], almost everybody speak about it, approximately everyone state to be doing it and nearly everyone says that it is superior than conventional function oriented design. For the reason that most of the center of the object oriented approach to software development has been on analysis and design phase, only a small research studies have been faithful to explore the concept of analyzability in object oriented system.

Object oriented ideology direct the designers what to carry and what to stay away from [16, 17, 18]. Numerous procedures have been explained so far to quantify object oriented design. There are various important idea of object orientation that are identified to be the foundation of inside quality of object oriented design and support in the perspective of measurement. These themes significantly take account of cohesion, coupling, inheritance, and encapsulation [31, 32].

Cohesion property refers to the internal Analyzability within the parts of the product design. A class diagram is cohesive when its parts are extremely correlated. It should be complicated to divide a cohesive class [19, 21 24]. Cohesion can be used to recognize the badly designed classes. Coupling indicates the association or interdependency among modules.
For illustration, object A is coupled to object B if and only if 'A' send a note to B that means the no. of association between classes or the number of messages passed between objects [22, 23, 30]. Coupling is a measure of interconnecting between modules in a software organization. Inheritance property is the sharing of quality and operations amongst classes.
It is a method whereby one diagram acquires uniqueness from one, or more other objects. Inheritance occurs in all levels of a class hierarchy.

Table 1: Metrics Description [19]

Metric	Definition
NC	The total number of classes
NA	The total number of attributes
NM	The total number of methods
NAssoc	The total number of associations
NAgg	The total number of aggregation relationships within a class diagram (each whole-part pair in an aggregation relationship)
NDep	The total number of dependency relationships
NGen	The total number of generalization relationships within a class diagram (each parent-child pair in a generalization relationship)
NAggH	The total number of aggregation hierarchies in a class diagram
NgenH	The total number of generalization hierarchies in a class diagram
Max Hagg	It is the maximum between the HAgg values obtained for each class of the class diagram. The HAgg value for a class within an aggregation hierarchy is the longest path from the class to the leaves.
Max DIT	It is the maximum between the DIT values obtained for each class of the class diagram. The DIT value for a class within a generalization hierarchy is the longest path from the class to the root of the hierarchy.

IV. CORRELATION ESTABLISHMENT

Correlation establishment is an important step between analyzability and its major identified factors. In this step the recognized software analyzability factors are to be correlated with the Object Oriented design properties.

A regression line will be established to quantify analyzability factors in terms of design characteristics with the help of design metrics.

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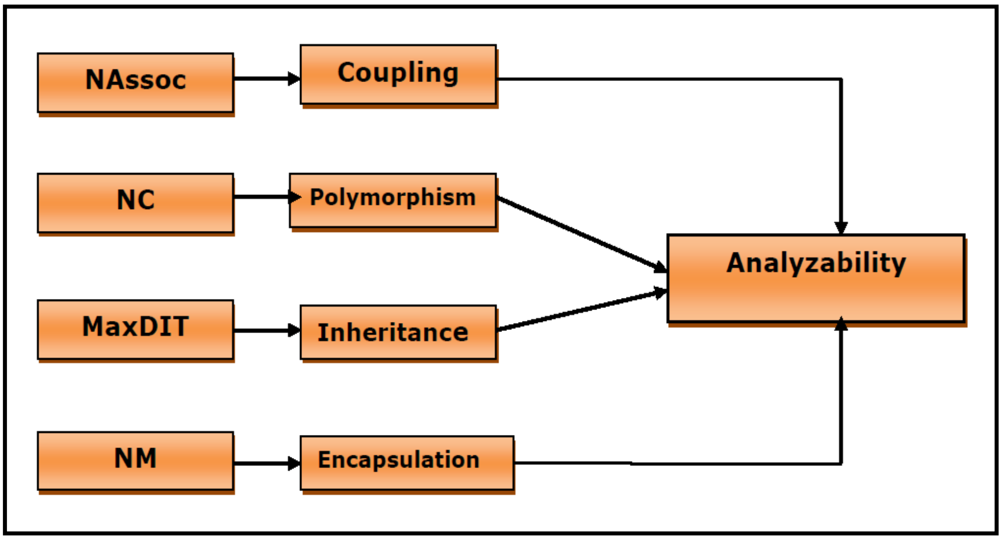

Fig. 1. Mapping among Object Oriented Design Properties and Analyzability

V. Model Development

In order to set up a model for analyzability, 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 analyzability model is taken from Genero (2001) that have been collected through commercial object oriented software. The relationship between analyzability and object oriented properties has been established as depicted in Figure 1. As per the mapping, Metrics 'NAssoc, NC, MaxDIT, NM' are selected from [10] as independent variable to build up the analyzability quantification model via SPSS, values of coefficient are calculated and analyzability model is formulated as given below.

Data values used during the study from Genero et al. [10]. It contains Analyzability data, collected through a controlled experiment. This dataset has used in regression analysis for establishing the analyzability model taking coupling, polymorphism, encapsulation and inheritance as independent variables, while analyzability as dependent variable.

VI. Analyzability Measurement Model

In order to create a multivariate measurement model for analyzability of class diagram, metrics listed in Genero (2001), will play the role of independent variables whereas analyzability will be in use as dependent variable. The data used for developing analyzability model is taken from [10] that have been composed during the controlled experiment. It comprises a set of 28 class diagrams (denoted as D0 to D27) and the metrics value of each diagram. In addition, the mean value of the expert's rating of analyzability of these diagrams is also known and termed as 'Known Value' in this chapter.

Analyzability = .398 + .236 x Coupling + .974 x Polymorphism + .272 x Inheritance -.162 x Encapsulation (2)

VII. Statistical Significance of Independent Variables

As long as statistical impact and importance of each independent variable in the Analyzability model (Eq. 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 for Analysability Model

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	.398	.745		.534	.647	-2.806	3.601
	Coupling	.236	.207	.388	1.137	.373	-.656	1.127

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	Polymorphism	.974	1.188	1.646	.820	.498	-4.136	6.084
	Inheritance	.272	.822	.178	.331	.772	-3.263	3.807
	Encapsulation	-.162	.280	-1.123	-.579	.621	-1.367	1.043
a. Dependent Variable: Analyzability								

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

Table3: Pearson Correlation for Analyzability Model						
		Analyzability	Coupling	Polymorphism	Inheritanc e	Encapsulation
Pearson Correlation	Analyzability	1.000	.607	.592	.764	.834
	Coupling	.607	1.000	.776	.596	.938
	Polymorphism	.592	.776	1.000	.658	.971
	Inheritance	.764	.596	.658	1.000	.763
	Encapsulation	.834	.938	.971	.763	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 analyzability by all the four metrics contributing in the model (2).

Table 4: Model summary for Analyzability Model									
Mod el	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.927[a]	.859	.576	.37598	.859	43.037	4	2	.263
a. Predictors: (Constant), Encapsulation, Inheritance, Coupling, Polymorphism									

ANOVA Table 4.5 shows the result of the ANOVA examination. In this table, we obtain F ratio of 43.037with (4, 2) degree of freedom. Obtained value is larger than the critical value of F is 6.94 for the 0.05 significance level. Analyzing the significance (p-value) for the F-test in the final column of the table, it can be concluded that the Analyzability model (2) is statistically significant at a confidence level of more than 95%.

Table 5: ANOVA for Analyzability Model						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1.717	4	.429	43.037	.263[A]
	Residual	.283	2	.141		
	Total	2.000	6			
a. Predictors: (Constant), Encapsulation, Inheritance, Coupling, Polymorphism						
b. Dependent Variable: Analyzability						

VIII. EMPIRICAL VALIDATION

Before This part of work paying attention how the above developed model is competent to conclude the analyzability of object oriented design at design phase. The empirical validation is an important stage of planned research to validate analyzability 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 analyzability quantification model has been executed using sample tryouts projects.

In order to validate proposed analyzability quantification model the value of metrics is available (Genero et al., 2001) data sets for given ten projects taken from [10]. The known analyzability rating for the given 10 Projects (P1-P10) is shown in Table 6.

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Table 6: Known Analyzability Value

P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
3	3	3	3	2	3	4	6	6	5

TABLE 7: KNOWN ANALYZABILITY RATING

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

Table 8: Calculated Analyzability Value

P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
4.72	5.696	2.202	3.5	1.6	4.146	6.044	10.47	11.72	8.128

Table 9: Calculated Analyzability Rating

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

TABLE 10: COMPUTED RANKING, ACTUAL RANKING AND THEIR RELATION

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

➔ **r_s >.781** means significant results.

Charles Speraman's rank Coefficient of Correlation [***rs***] was used to make sure the significance of correlation between calculated values of analyzability index via model and it's 'Known Values'. Rank correlation is the method of determining the degree of correlation 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 analyzability.
- n = number of projects (n=10) used in the experiment.

The correlation values between analyzability using developed model and known rating are shown in above Table. 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 analyzability quantification model is exceedingly truthful, essential and applicable in the analyzability perspective. However, the study needs to be standardized with a large experiment tryout for better acceptability and utility.

IX. CONCLUSION

This study shows the importance of analyzability in general and as a key factor to software analyzability for producing high class reliable software within time and budget. Analyzability is clearly highly appropriate and significant in the perspective of software analyzability. Analyzability 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. Analyzability quantification model has been validated contextually as well as empirically using experimental tryout. The practical validation on the software analyzability model concludes that proposed model is highly reliable, acceptable and extensive.

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REFERENCES

[1] IEEE Std. 65.12-1990. *Standard* Glossary of Software Engineering Terminology, IEEE Computer Society Press, Los Alamitos, CA, 1993.

[2] ISO, "International standard ISO/IEC 9126. Information technology: Software product evaluation: Quality characteristics and guidelines for their use." 1991.

[3] Abdullah, Dr, Reena Srivastava, and M. H. Khan. "Testability Estimation of Object Oriented Design: A Revisit". International Journal of Advanced Research in Computer and Communication Engineering Vol. 2, Issue 8, pages 3086-3090, August 2013.

[4] W. Li, S. Henry, "Object Oriented Metrics Which Predict Analyzability", Technical Report 93-05,

[5] A.Epping, C. M.Lott, "Does Software Design Complexity Affect AnalyzabilityEffort?", citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.6.5828, 19th Annual Software Engineering Workshop, 30 Nov–1 Dec 1994.

[6] 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.

[7] Dromey, R.G.: A Model for Software Product Quality. IEEE Transaction on Software Engineering 21(2), 146–162 (1995).

[8] Huda, M., Arya, Y.D.S. and Khan, M.H. (2015) Quantifying Reusability of Object Oriented Design: A Testability Perspective. *Journal of Software Engineering and Applications*, **8**, 175-183. http://dx.doi.org/10.4236/jsea.2015.84018

[9] L. Wang, E. Arisholm, "The Effect of Task Order on the Analyzability of Object Oriented Software", Information and Software Technology, Elsevier 2008, doi:10.1016/j.infsof2008.03.005

[10] Genero M., J. Olivas, M. Piattini and F. Romero, "A Controlled Experiment for Corroborating the Usefulness of Class Diagram Metrics at the early phases of Object Oriented Developments", Proceedings of ADIS 2001, Workshop on decision support in Software Engineering, 2001.

[11] Abdullah, Dr, Reena Srivastava, and M. H. Khan. "Modifiability: A Key Factor To Testability", International Journal of Advanced Information Science and Technology, Vol. 26, No.26, Pages 62-71 June 2014.

[12] J. Rumbaugh, M. Blaha, "Object Oriented Modeling and Design", ISBN: 81-7808-738-3, Pearson Education, 2003

[13] J.H. Hayes and L Zhao, "Maintainability Prediction: a Regression Analysis of Measures of Evolving Systems," *Proc. 21st IEEE International Conference on Software Maintenance*, 26 - 29 Sept. 2005, pp. 601 - 604, 2005.

[14] R. Pressman, "Software Engg: A Practitioner's Approach", Sixth Ed. Mcgraw-Hill, 2005.

[15] 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.

[16] Abdullah, Dr, M. H. Khan, and Reena Srivastava. "Testability Measurement Model for Object Oriented Design (TMM^{OOD})." International Journal of Computer Science & Information Technology (IJCSIT) Vol. 7, No 1, February 2015, DOI: 10.5121/ijcsit.2015.7115.

[17] Huda, M., Arya, Y.D.S. and Khan, M.H. (2015) Testability Quantification Framework of Object Oriented Software: A New Perspective. *International Journal of Advanced Research in Computer and Communication Engineering*,**4**,298-302. http://dx.doi.org/10.17148/IJARCCE.2015.4168

[18] Fu, J.P. and Lu, M.Y. (2009) Request-Oriented Method of Software Testability Measurement. *Proceedings of the ITCS* 2009 *International Conference on Information Technology and Computer Science*, Kiev, 25-26 July 2009, 77-80.

[19] Huda, M., Arya, Y.D.S. and Khan, M.H. (2015) Evaluating Effectiveness Factor of Object Oriented Design: A Testability Perspective. *International Journal of Software Engineering & Applications*(*IJSEA*),**6**,4149. http://dx.doi.org/10.5121/ijsea.2015.6104

[20] Lee, Ming-Chang. "Software Quality Factors and Software Quality Metrics to Enhance Software Quality Assurance." British Journal of Applied Science & Technology 4.21 (2014).

[21] Badri, M. and Toure, F. (2012) Empirical Analysis of Object-Oriented Design Metrics for Predicting Unit Testing Effort of Classes. *Journal of Software Engineering and Applications*, **5**, 513-526.http://dx.doi.org/10.4236/jsea.2012.57060

[22] Abdullah, Dr, M. H. Khan, and Reena Srivastava. "Flexibility: A Key Factor To Testability", International Journal of Software Engineering & Applications (IJSEA), Vol.6, No.1, January 2015. DOI: 10.5121/ijsea.2015.6108

[23] H. Zuse, "A Framework of Software Measurement" Walter de Gruyter, 1998. 44 ISO/IEC 9126-4:2004, "Software Engg. Product Quality-Quality in Use Metrics", ISO/IEC 2004.

[24] Huda, M., Arya, Y.D.S. and Khan, M.H. (2014) Measuring Testability of Object Oriented Design: A Systematic Review. *International Journal of Scientific Engineering and Technology* (*IJSET*), **3**, 1313-1319.

[25] Jungmayr, S. (2002) Testability during Design, Softwaretechnik-Trends. *Proceedings of the GI Working Group Test*, *Analysis and Verification of Software*, Potsdam, 20-21 June 2002, 10-11.

[26] Huda, M., Arya, Y.D.S. and Khan, M.H. (2015) Metric Based Testability Estimation Model for Object Oriented Design: Quality Perspective. *Journal of Software Engineering and Applications*, **8**, 234-243. http://dx.doi.org/10.4236/jsea.2015.84024

[27] M. Dagpinar and J. Jahnke, "Predicting Maintainability with Object- Oriented Metrics – an Empirical Comparison," *Proc. 5th Working Conference on Reverse Engineering (WCRE'03),* 13 - 17 Nov. 2003, pp. 155 - 164, 2003.

[28] Amin, A. and Moradi, S. (2013) A Hybrid Evaluation Framework of CMM and COBIT for Improving the Software Development Quality.

[29] Zheng, W.Q. and Bundell, G. (2008) Contract-Based Software Component Testing with UML Models. *International Symposium on Computer Science and Its Applications* (*CSA* '08), 978-0-7695, 13-15 October 2008, 83-102.

[30] S. Muthanna, K. Kontogiannis, K. Ponnambalaml and B. Stacey, "A Maintainability Model for Industrial Software Systems Using Design Level Metrics", In Working Conference on Reverse Engineering (WCRE'00), 2000

[31] S. Ghosh, S. K. Dubey, *et al.*, "Comparative Study of the Factors that Affect Maintainability," *International Journal on Computer Science and Engineering*, vol. 3, no. 12, pp. 3763-3769, 2011.

[32] S. W. A. Rizvi and R. A. Khan, "Maintainability Estimation Model for Object- Oriented Software in Design Phase (MEMOOD)," *COMPUTING*, vol. 2, no. 4, pp. 26-32.

[33] P. Oman and J. Hagemeister, "Metrics for assessing a software system's maintainability," *Software Maintenance*, 1992, pp. 337 - 344.

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