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Reliability Measurement of Object Oriented Design: Complexity Perspective

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Abstract: Object oriented design and development are well-known conceptions in today's software development environment. Object oriented design supports number of design properties such as coupling, cohesion, inheritance and encapsulation. The proposed study will deliver a method for reliability measurement of object oriented design in term of complexity perspective. The four metrics namely Inherited Complexity Metric, Cohesion Complexity Metric , Encapsulation Complexity Metric ,Coupling Metric, are identified for each of object oriented design properties such as inheritance, cohesion coupling, and encapsulation respectively. Complexity and reliability measurement approach is presented in this research paper. On the basis of identified metrics a multiple linear regression equation has been established for measuring the complexity of design structure. Complexity is directly affects reliability of object oriented designs in opposite direction. Finally a multiple regression equation has been applied to measure reliability with respect to complexity. Comparative analysis between metric values, reliability and complexity has been done in this study.

Keywords: Complexity, Reliability, Design Phase, Measurement.

I. INTRODUCTION

There are numerous approaches to makes the system very much reliable. Among several available methods object oriented design is one of the important method to measures reliability with respect to complexity perspective [1, 2]. Object oriented design signed itself as an essential approach for resolving mainly of the software problems [3, 4]. In an object oriented approach, the data is considered as the most significant element and it cannot move freely around the system [16]. Increase in the size of program, increases needless effort and complexity. Software complexity always increases with error handling functions. Software with high complexity generally produces software with faults [5]. High complexity always decreases reliability of software. Though, software faults vary noticeably with respect to their severity. A failure occurred by a fault may go ahead to a complete system crash or an incapability to open a file [12, 13].

Therefore, there is an urgent need to develop a model that can be applied to identify those classes that are prone to have serious faults. From the abovementioned discussion, it appears that reducing unwanted complexity early in the development process leads to the development of high quality reliable end products. A metric based model may be used to quantify complexities and their expansion for object oriented design. On the basis of the model, reliability of the object oriented software at an initial stage of development life cycle can be improved. None of such a model is presented to be used near the beginning of development cycle and there is in big demand to produce a complexity perspective model for object oriented software to be used in design stage. These object oriented concepts have an ability to adjust complexity of object oriented design by maintaining software reliability [6,7].

The proposed research work provides a model for reliability measurement of object oriented design with respect to complexity perspective. Complexity of design can be maintained by adjusting object oriented properties such as coupling, cohesion, inheritance and encapsulation. Reliability of a software design increases by developing the system less complex. In section 2 studies identified four metrics. Complexity measurement and reliability measurement model is covered in section 3 and 4 respectively. In section 5 Comparative analysis is performed. Findings and significance are incorporated in section 6.At final study is concluded in section 7.

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II. IDENTIFIED METRICS

An A lot of metrics were proposed by number of researchers and practitioners for object oriented software. Metrics are the quantitative measure of the degree to which a software component possesses a specified attribute [8, 9, 11]. The ultimate objective of object oriented metrics is the identification and measurement of the essential parameters that affects software development process. Object oriented metrics are broadly classified into product metrics and process metrics [14, 15, 17].

Object oriented metrics are the rank of quantifiable measurement for which a system element possess a given software measurement. Object oriented reliability metrics are used for software reliability ranking and self-assurance and they are very significant for software reliability for the reason that quantification, reliability, forecasting, validation, cost and schedule [16,18] Reliability metrics are helpful to know the possibility of software failure or the failure rate at which system errors will occurs [19]. The following metrics are identified during the research work:

1. Inherited Complexity Metric.
2. Cohesion Complexity Metric.
3. Encapsulation Complexity Metric.
4. Coupling Metric.

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III. COMPLEXITY MEASUREMENTS

The generic quality model [10, 20] has been considered as a source to develop the Complexity Measurements model for OOD.This model used the design metrics namely Inherited Complexity Metric. Cohesion Complexity Metric. Encapsulation Complexity Metric. Coupling Metric. In order to establish a relationship between reliability attribute complexity and design properties, the relevant influence of design properties on software complexity and reliability are being examined on the basis of relevant literature survey [20]. It was observed from literature survey that each of the design properties affects software complexity and complexity affects software reliability of object oriented design. The wide-ranging review of object oriented development literature discloses that object oriented properties positively or negatively affects software complexity and complexity always negatively affects overall software reliability. Object oriented design properties such as high coupling and inheritance, negatively affects software reliability and positively affects software complexity [21, 22]. In same approach high encapsulation and cohesion increases software reliability and decreases software complexity. The identified relevant metrics are being used for measuring complexity of object oriented design. A multiple regression equation has been developed to get model coefficients. Thus, the multiple linear regression equation takes the following form:

$Y= \alpha 0+\beta 1X1+ \beta 2X2\ldots\ldots\ldots\ldots\ldots\ldots \beta nXn$ (1)

Where

1. Y is the dependent variable
2. Xs are independent variables.
3. α and β are the coefficients,

Putting equation 1, 2, 3 and 4in equation 5 the generated equation will be as follows:

$$\text{Complexity} = \alpha+\beta\ (\text{ICM}) +\lambda\ (\text{CCM}) +\gamma\ (\text{ECM}) +\delta\ (\text{CM}) \quad (2)$$

Where, complexity is dependent variable, Inherited Complexity Metric (ICM), Cohesion Complexity Metric (CCM) , Encapsulation Complexity Metric(ECM) ,Coupling Metric(CM) are the Object oriented metrics which are treated as independent variables and α, β, λ, δ ,γ are considered as model coefficients. Complexity mainly depends on design properties such as coupling, cohesion inheritance and encapsulation. Five different equations are put for five different case studies. After applying these case studies model coefficients for object oriented design properties such as inheritance, cohesion, encapsulation and coupling are calculated as:

α=0.4734, β=-0.1869, γ= 0.9506, δ=0.5790, λ=-0.3266 respectively. Putting values of α, β, γ, δ, λ in equation 2, following equation will be generated

Complexity = 0.4734 -0.1869 (ICM) +0.9506 (CCM) +0.5790 (ECM) -0.3266 (CM) ---------- (3)

IV. RELIABILITY MEASUREMENT

In order to establish a relationship between reliability and complexity, the respective influence of relationship between complexity and reliability are being examined on the basis of relevant literature survey. It was observed from literature survey that complexity and reliability closely associated to each other and complexity affects software reliability negatively .Studies use the complexity of system design to measure reliability of software. Software complexity constantly decreases the reliability of object oriented design [23, 24]. The developed model 1 is being applied for measuring reliability of object oriented design. Using SPSS the model's coefficients are calculated. Thus, the multiple regression equation takes the following form:

$Z= \lambda 0+\Gamma\ 1X1+ \Gamma 2X2\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \Gamma nXn$ (4)

Where

- Z is the dependent variable.
- Xs are independent variables

λ and Γ are the regression coefficients.

Reliability = α+β (Complexity)

Where reliability is dependent variable and complexity worked as independent variables and α, β is considered as regression coefficients in model 5. Reliability highly depends on complexity. Five different equations are put for five different case studies. After applying these case studies model coefficients for complexity are calculated as:

α=0.232, β= 0.866. Putting values of α, β, in equation 5, following equation will be generated

Reliability = 0.232+0.866(Complexity) (5)

V. COMPARATIVE ANALYSIS

Comparative analysis among identified object oriented metrics, reliability and complexity is shown in given bellow tables and figures:

Examination of object oriented metrics, complexity and reliability values for the designs before complexity minimization.

Table 1: Metric, complexity and reliability values for the designs

Metric → / Designs↓	ICM	CM	CCM	ECM	Complexity	Reliability
Design 1	1.168	3.831	0.990	1.367	0.925	0.5093
Design 2	0.825	4.06	1.776	1.067	0.976	0.7346
Design 3	0.7695	3.926	0.853	1.145	0.919	0.367
Design 4	0.806	2.768	0.721	2.92	1.258	0.821
Design 5	0.612	0.542	1.990	1.870	1.413	1.379

Analysis of metrics, complexity and reliability values after complexity minimization

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Table-2: Metrics, complexity and reliability comparison after Complexity minimization

Metric → / Designs ↓	ICM	CM	CCM	ECM	Complexity	Reliability
Design 1	0.886	3.138	0.505	1.020	0.355	0.549
Design 2	0.285	1.510	1.410	0.870	0.770	0.899
Design 3	0.636	3.009	0.470	0.980	0.385	0.566
Design 4	0.268	2.275	0.5625	1.08	0.8403	0.959
Design 5	0.523	0.427	1.880	1.082	1.349	1.400

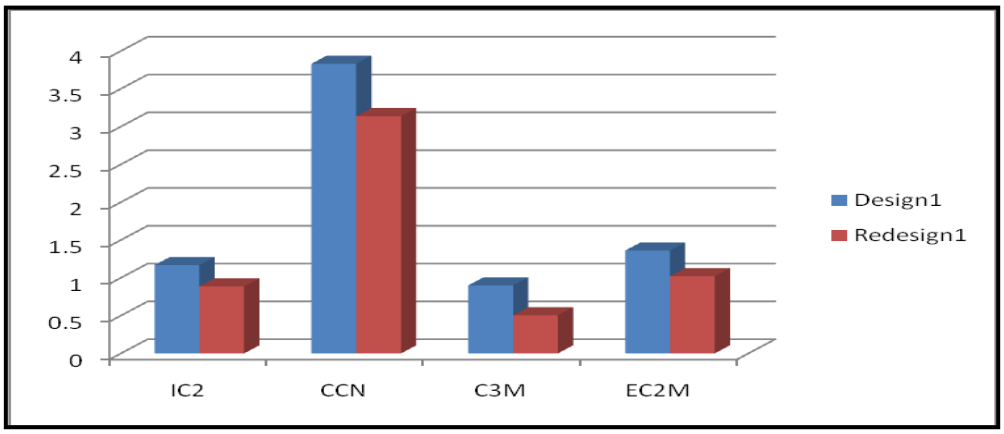

Fig 1: Comparing metric values after complexity minimization for design 1

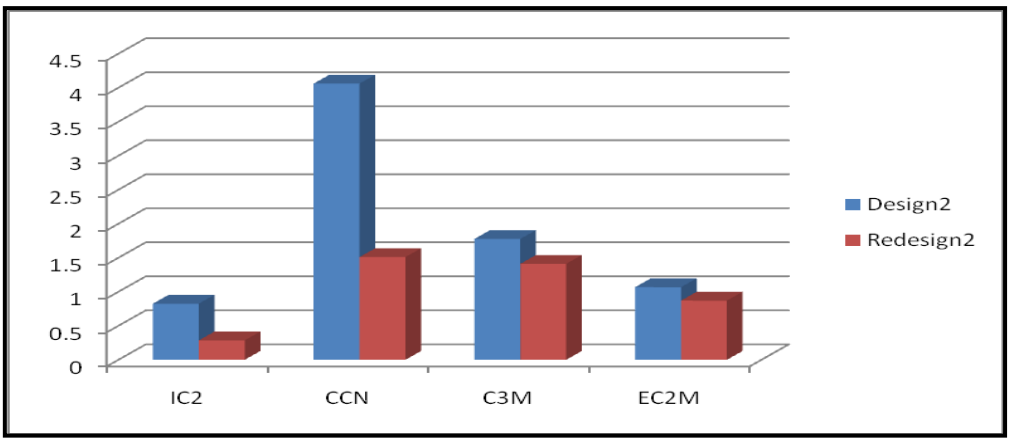

Fig 2: Comparing metric values after complexity minimization for design 2

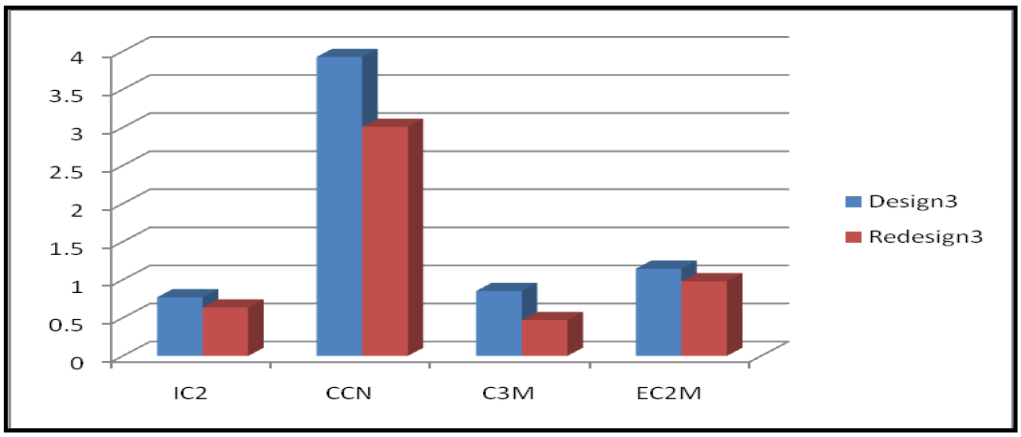

Fig 3: Comparing metric values after complexity minimization for design 3

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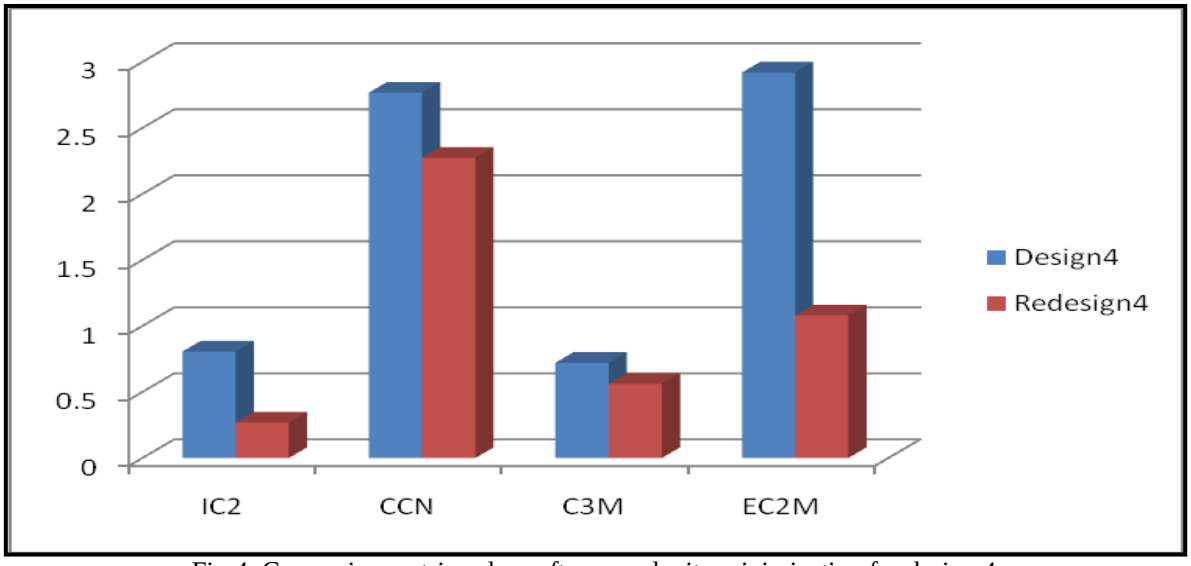

Fig 4: Comparing metric values after complexity minimization for design 4

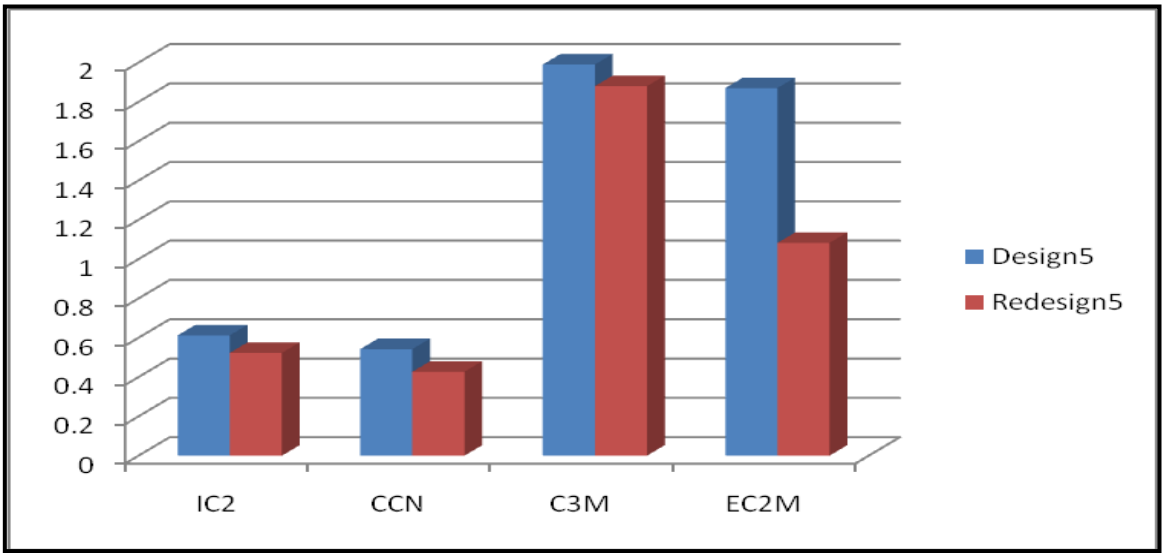

Fig 5: Comparing metric values after complexity minimization for design 5

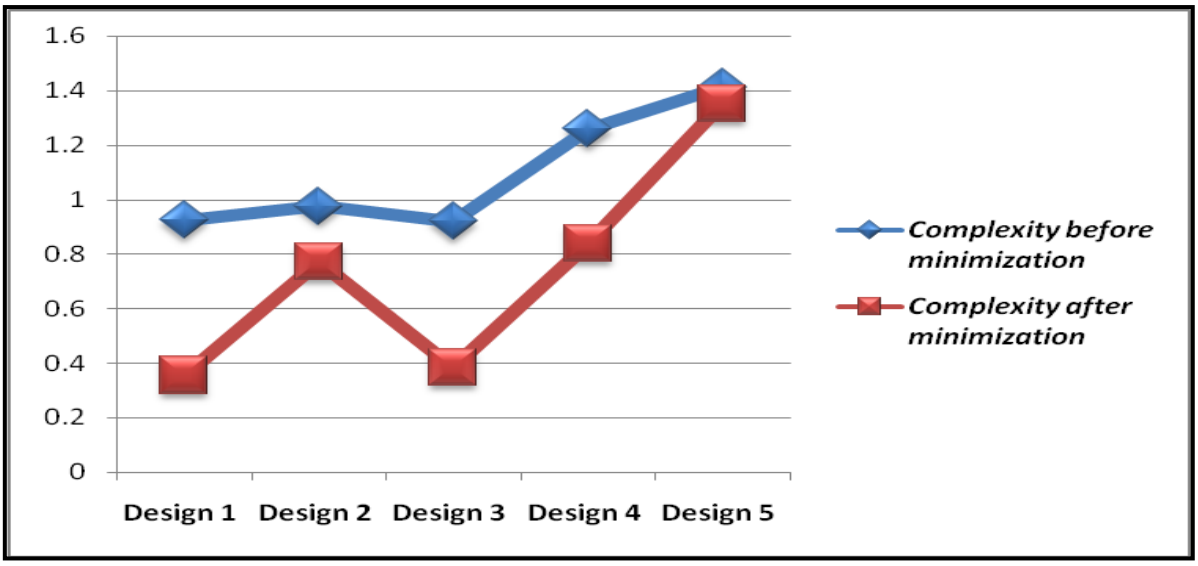

Fig 6: Line graph for complexity analysis after before complexity minimization

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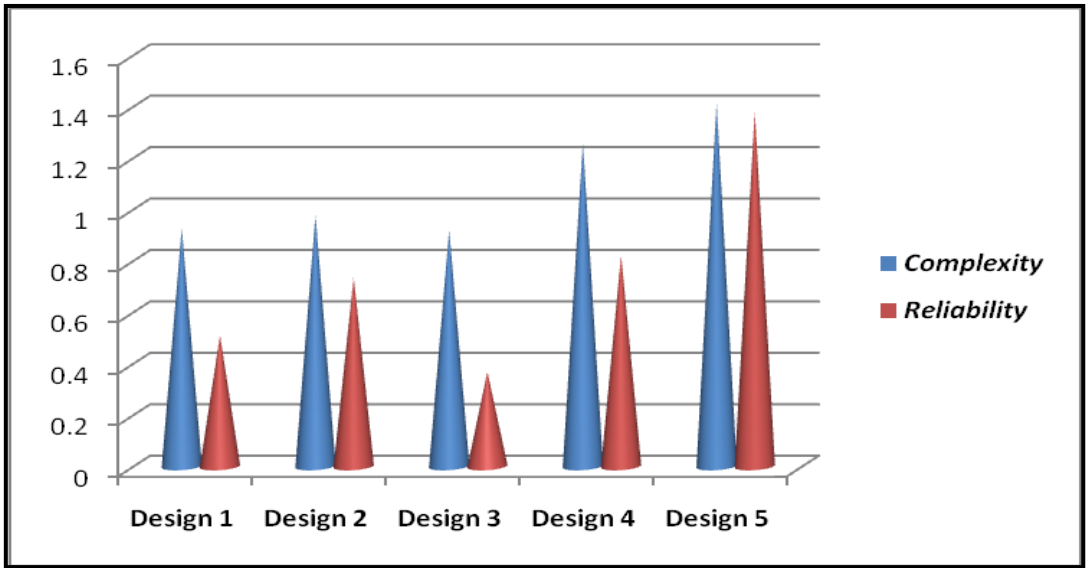

Fig 7: Complexity and reliability analysis before complexity minimization

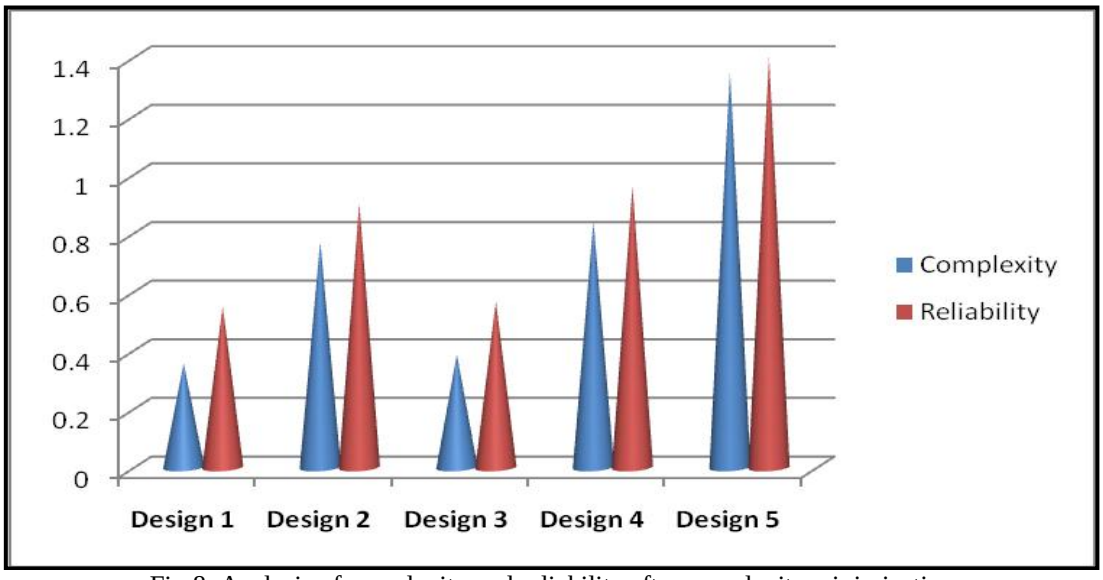

Fig 8: Analysis of complexity and reliability after complexity minimization

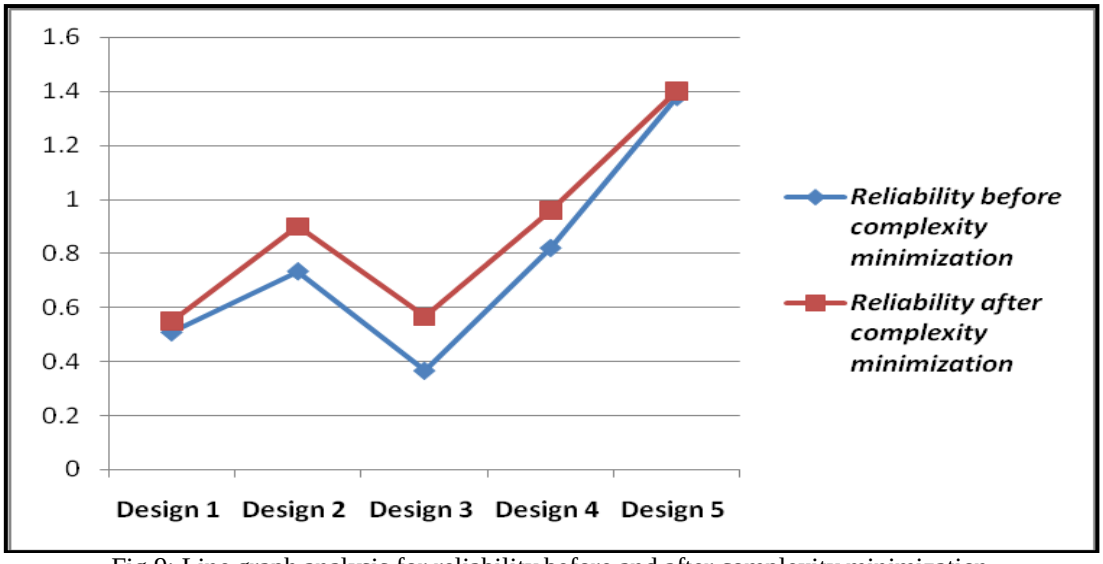

Fig 9: Line graph analysis for reliability before and after complexity minimization

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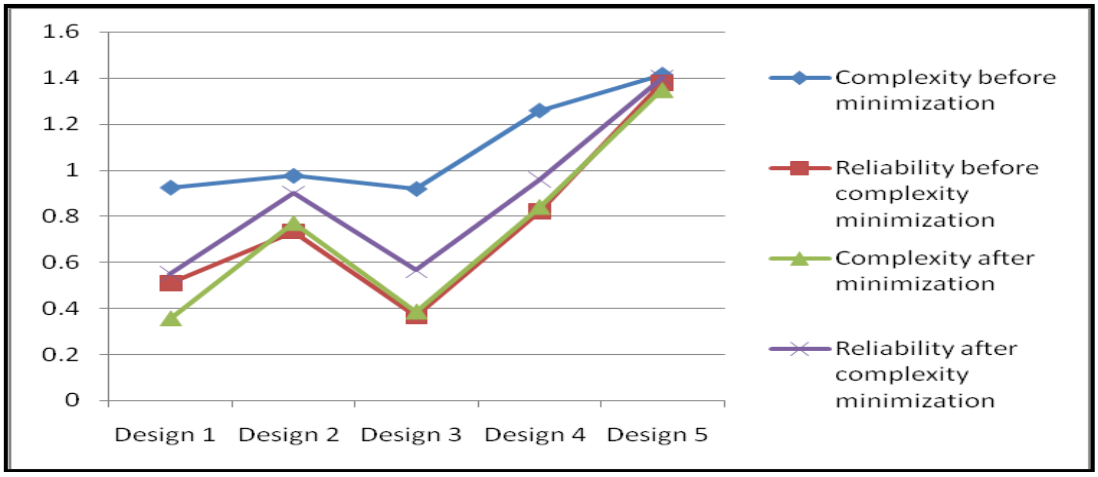

Fig 10: Line graph analysis for reliability and complexity before and after complexity minimization

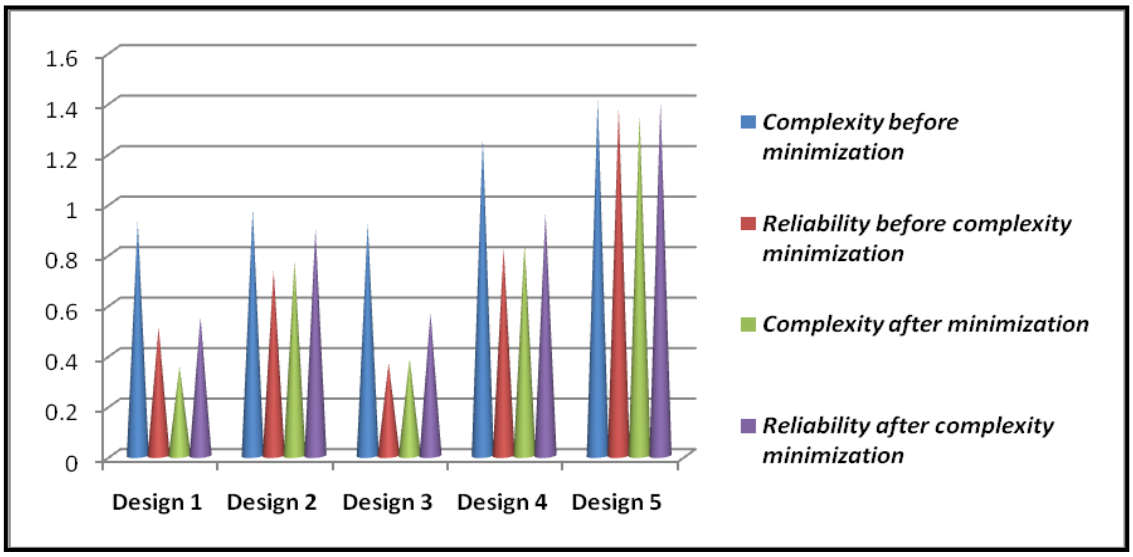

Fig 11: Analysis for reliability and complexity before and after complexity minimization

VI. FINDINGS

- Complexity is an important factor for reliability measurement. High complex software frequently decreases the software reliability. Some of the important and key findings are as listed below:
- Inherited Complexity Metric, Cohesion Complexity Metric, Encapsulation Complexity Metric, Coupling Metric, are identified for each of object oriented design properties such as inheritance, cohesion coupling, and encapsulation respectively.
- Complexity and reliability measurement models have been developed.
- Comparative analysis among identified object oriented metrics, reliability and complexity is the major part of the proposed research work has been done.
- It if found after study of object oriented metrics, complexity and reliability values for the designs before design complexity minimization is that high values of complexity and decreases the values of reliability. Therefore, higher the complexity value, lower is the reliability of object oriented design.
- It if found after study of object oriented metrics, complexity and reliability values after design complexity minimization is that complexity has lesser values than reliability. For this reason, smaller the complexity value, greater the reliability of object oriented design.
- Object oriented Metrics values are compared with each other before and after complexity minimization for all five design case studies. It is recognized that values of design complexity before complexity minimization has greater
- Values than after complexity minimization for the designs. Hence, complexity values are minimized for five designs shown in tables and figures.

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- Complexity has been examined for five design case studies, after and before complexity minimization for the designs shown in table 8 and figures 6 and 7.

- It is found that before design complexity minimization that reliability is smaller than complexity values. Hence, greater the complexity smaller is the reliability of designs. Table 9 and figure 8 depict the comparative analysis between them.

- It is found that after design complexity minimization, complexity values are smaller than the values of reliability. Hence, smaller the complexity greater is the reliability of the designs. Table 10 and figure 9 depict the analysis after complexity minimization for the designs.

- Reliability study after design complexity minimization is shown in table 11 and represented in figure 10. It is found that reliability values are high after complexity minimization.

- Reliability and complexity study before & after complexity minimization for the designs are given in table 12 and figure 12 and 13. It is found that design complexity decreases and reliability of designs increases.

VII. CONCLUSION

The four metrics namely Inherited Complexity Metric (ICM), Cohesion Complexity Metric (CCM), Encapsulation Complexity Metric (ECM), Coupling Metric (CM), are identified for each of object oriented design properties such as inheritance, cohesion coupling, and encapsulation respectively. Complexity and reliability measurement models have been developed to measure the complexity and reliability of software design. Comparative analysis among identified object oriented metrics, reliability and complexity is the major part of the proposed research work has been done.

It if found after study of object oriented metrics, complexity and reliability values for the designs before design complexity minimization is that high values of complexity and decreases the values of reliability. Therefore, higher the complexity value, lower is the reliability of object oriented design. Hence above tables and graphical illustration shows the systematic comparative analysis between complexity and reliability after and before complexity minimization.

REFERENCES

[1] 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.

[2] Natasha Sharygina , James C. Browne, and Robert P. Kurshan, "A Formal Object-Oriented Analysis for Software Reliability: Design for Verification", 2011, pp:1-15.

[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] 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.

[5] Marian Cristescu, Laurenţiu Ciovica, "Estimation of the Reliability of Distributed Applications", Informatica Economică vol. 14, no. 4/2010, pp: 19-29.

[6] Stephanie Gaudan , Gilles Motet and Guillaume Auriol , "A new structural complexity metrics applied to Object Oriented design reliability assessment", http://www.lesia.insa-toulouse.fr/~motet/papers/2007_ISSRE_GMA.pdf.

[7] Everald E. Mills, "Software Metrics", SEI Curriculum Module SEI-CM-12-1.1, Software Engineering Institute, Dec 1988, pp: 1-43.

[8] 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.

[9] Offutt, J. and R. Alexander, (2001): A fault Model for Subtype Inheritance and Polymorphism. In 12th International Symposium, Software Reliability Engineering, Nov 27-30, 2001, IEEE, pp. 84-93.

[10] 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.

[11] 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.

[12] 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.

[13] Jagdish Bansiya, "A Hierarchical Model for Object Oriented Design Quality Assessment", IEEE Transaction of Software Engineering, Volume 28, No. 1, January 2002, and pp: 4-17.

[14] Mahfuzul Huda, Dr.Y.D.S.Arya, and Dr. M. H. Khan. "Evaluating Effectiveness Factor of Object Oriented Design: A Testability Perspective." International Journal of Software Engineering & Applications (IJSEA), Vol.6, No.1, January 2015, DOI:10.5121/ijsea.2015.6104.

[15] Yong Cao Qingxin Zhu. Improved metrics for encapsulation based on information hiding. DOI: 10.1109/ICYCS.2008.76, The 9th International Conference for Young Computer Scientists, IEEE computer society 2008, p: 742-724.

[16] Sch aril N., Black Andrew P., Ducasse S. Object oriented Encapsulation for Dynamically Typed Languages. OOPSLA 2004, ACM, pp: 130–139.

[17] 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.

[18] 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.

[19] 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.

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

[21] Mahfuzul Huda, Dr.Y.D.S.Arya, and Dr. M. H. Khan. "Testability Quantification Framework of Object Oriented Software: A New Perspective." International Journal of Advanced Research in Computer and Communication Engineering, Vol. 4, Issue 1, Jan, 2015, DOI: 10.17148/IJARCCE.2015.4168.

[22] Fiondella, L.; Gokhale, S.S., "Software reliability model with bathtub-shaped fault detection rate" Reliability and Maintainability Symposium (RAMS), 2011 Proceedings - Annual , 24-27 Jan. 2011,pp: 1 – 6, ISBN: 978-1-4244-8857-5.

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology
Vol. 2, Issue 4, April 2015

[23] Mahfuzul Huda, Dr.Y.D.S.Arya, and Dr.M. H. Khan. "Measuring Testability of Object Oriented Design: A Systematic Review." International Journal of Scientific Engineering and Technology, Vol. 3, Issue 10, pp: 1313-1319 Oct, 2014.

[24] Mohan, K.K.; Verma, A.K.; Srividya, A., "Software reliability estimation through black box and white box testing at prototype level ", 2nd International Conference on Reliability, Safety and Hazard (ICRESH), 14-16 Dec. 2010, pp: 517 - 522, ISBN: 978-1-4244-8344-0.