Correlation Between Coupling Metrics Values and Number of Classes in Multimedia Java Projects: A Case Study

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***Abstract* — Coupling is an interdependence relationship between the modules of object-oriented software. It is a property with the most influence on quality attributes of the object-oriented software. Coupling with high values results in complex software design hence software professionals try to keep the coupling as low as possible. The values of coupling metrics are dependent on the type of input source code. Reusability is the main feature of object-oriented languages, so coupling occurs due to reuse of code modules. This paper investigates a correlation between the values of coupling metrics and the number of classes in the multimedia Java code. Here, a case study of a banking multimedia Java project with its forty different versions is conducted to comments on this correlation. The analysis of the results shows that, if the input source code is with a large number of classes then it results in high coupling values.**

***Keywords* — Coupling, Object-oriented, Metrics, Classes, Software.**

I. Introduction

Software coupling is an important metrics from the quality point of view. Software professionals need to evaluate continuously and study relations and correlations of all attributes and factors that can affect their developed software products [1]. Software metrics values are the indicators of one or more software quality attributes. Coupling metrics values are also the indicators different quality attributes like reliability, efficiency, integrity, maintainability, flexibility, portability, reusability, and interoperability, etc. [2], [3], [4].

In this paper, we focused on studying the correlation between coupling metrics values and the total number of classes in multimedia Java projects. The focus of this study is to monitor the behavior of coupling values with raise in numbers of classes of multimedia Java projects. The study considers banking software named *Cyclos* with its forty different versions downloaded from the open source repository sourceforge.net. The versions of *Cyclos* taken into account for this study possess the different number of classes and coupling values.

The rest of the paper is organized as follows. In section 2 data collection for the case study is given. Section 3 provides detailed of results and analysis. The correlation analysis between coupling metrics values and number of classes in input multimedia Java code is provided in section 4. Section 5 concludes the paper.

II. Data Collection for the Case Study

This section gives details of input multimedia Java projects, selection of coupling metrics, coupling data collection procedure used in the work.

A. Input multimedia Java projects

This study considers the projects developed in multimedia Java programming language. The requirement of the input multimedia Java projects is a folder containing .java files. The multimedia Java project folders with .exe or .jar files are not useful for this study. This study referred the open-source repository sourceforge.net to download the multimedia Java projects. The sourceforge.net repository has ten different category projects. This study selected the projects only from the *Banking* category. The *Banking* project *Cyclos* with its **forty different versions** is considered for this case study. *Cyclos* offers a complete on-line banking system with additional modules such as e-commerce and communication tools. *Cyclos* is used for Microfinance institutions, local banks (in developing countries) and complementary currency systems like LETS, Barter networks, and Timebanks. The detailed listing of forty versions of *Cyclos* is given in Table II.

TABLE I
COUPLING METRICS

Sr. No.	Coupling Metrics	Type of interactions	Coupling Mechanisms	Source
1	Parameter coupling	Method-Method,	The method of one class invokes method/passes parameter/passes message to methods of another class or to make a call to the constructor of another class.	[5]
2	Inheritance coupling	Class-Class	One class is a superclass of another class (Inheritance).	[5, 6, 7, 8]
3	Global coupling	Method-Attribute/Class-Attribute (Friend)	The method of one class can directly access parts of the internal structure, of another class method (friend). Also to access common, shared, non-local variables of another class.	[5]
4	Data Abstraction Coupling	Class-Method/Class-Attribute	One class is used in the implementation of methods of another class. One class is the domain of the instance variable, the local variable of another class.	[8]
5	Import Coupling	ALL	All type of coupling due to any import mechanism.	[9]
6	Export Coupling	ALL	All type of coupling due to an export mechanism.	[9]
7	External coupling	Sharing of global devices.	Sharing an external device like the printer, HDD, external file by the two classes.	[9]

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TABLE II
COUPLING VALUES OBTAINED FROM JCMT

Project Name	Number of Classes in Project	Parameter coupling	Inheritance Coupling	Global Coupling	Data Abstraction Coupling	Import Coupling	Export Coupling	External Coupling
cyclos_3.0	1095	6884	1902	10	4004	4684	4680	22
cyclos_3.0.1	1096	6888	1904	10	4007	4688	4684	22
cyclos_3.0.2	1095	6862	1904	10	3995	4665	4661	22
cyclos_3.0.3	1097	6916	1907	10	4011	4684	4680	22
cyclos_3.0.4	1098	6937	1907	10	4018	4706	4702	22
cyclos_3.0.5	1098	6937	1907	10	4018	4706	4702	22
cyclos_3.0.6	1098	6950	1907	10	4022	4716	4712	22
cyclos_3.0.7	1098	7004	1907	10	4024	4732	4728	22
cyclos_3.0.8	1098	7008	1909	10	4029	4741	4737	22
cyclos_3.0.9	1099	7026	1909	10	4032	4758	4754	22
cyclos_3.0.10	1098	7027	1909	10	4031	4759	4755	22
cyclos_3.0.11	1098	7029	1909	10	4032	4760	4756	22
cyclos_3.0.B1	990	5624	1716	10	3526	3853	3849	21
cyclos_3.0.B2	1040	6254	1799	10	3748	4285	4281	21
cyclos_3.5	1809	14438	3232	77	7442	9946	9953	28
cyclos_3.5.1	1809	14449	3232	77	7449	9959	9966	28
cyclos_3.5.2	1812	14485	3238	79	7475	9985	9992	28
cyclos_3.5.3	1812	14546	3238	80	7486	10019	10026	28
cyclos_3.5.4	1819	14608	3253	81	7524	10079	10086	28
cyclos_3.5.5	1820	14631	3255	81	7531	10091	10098	28
cyclos_3.5.6	1821	14633	3256	81	7531	10093	10100	28
cyclos_3.5.beta1	1698	12975	3010	62	6886	8914	8925	29
cyclos_3.5.beta2	1699	13065	3011	62	6906	8992	9003	29
cyclos_3.5.beta3	1750	13531	3113	63	7105	9368	9379	29
cyclos_3.5.beta4	1756	13701	3127	65	7154	9461	9472	29
cyclos_3.5.RC1	1755	13726	3126	65	7162	9474	9485	29
cyclos_3.5.RC1a	1754	13725	3126	65	7161	9473	9484	29
cyclos_3.5.RC2	1768	14111	3154	67	7303	9669	9678	29
cyclos_3.6	2357	16615	4459	109	8937	11544	11573	30
cyclos_3.6.1	2367	16711	4466	111	9026	11637	11666	29
cyclos_3.6.beta1	1936	15714	3487	106	8107	10889	10897	28
cyclos_3.6.beta2	1935	15718	3485	106	8110	10911	10919	28
cyclos_3.6.beta3	1936	15617	3491	107	8069	10840	10848	28
cyclos_3.6.RC1	2035	16978	3659	110	8558	11873	11899	29
cyclos_3.6.RC2	2357	16615	4460	109	8944	11561	11590	30
cyclos_3.7	2435	17275	4602	123	9552	12018	12062	30
cyclos_3.7.1	2438	17320	4606	125	9569	12057	12101	30
cyclos_3.7.2	2443	17405	4615	125	9600	12113	12157	30
cyclos_3.7.3	2443	17403	4617	125	9602	12109	12153	30
cyclos_3.7_RC1	2431	17253	4599	123	9537	11994	12038	30

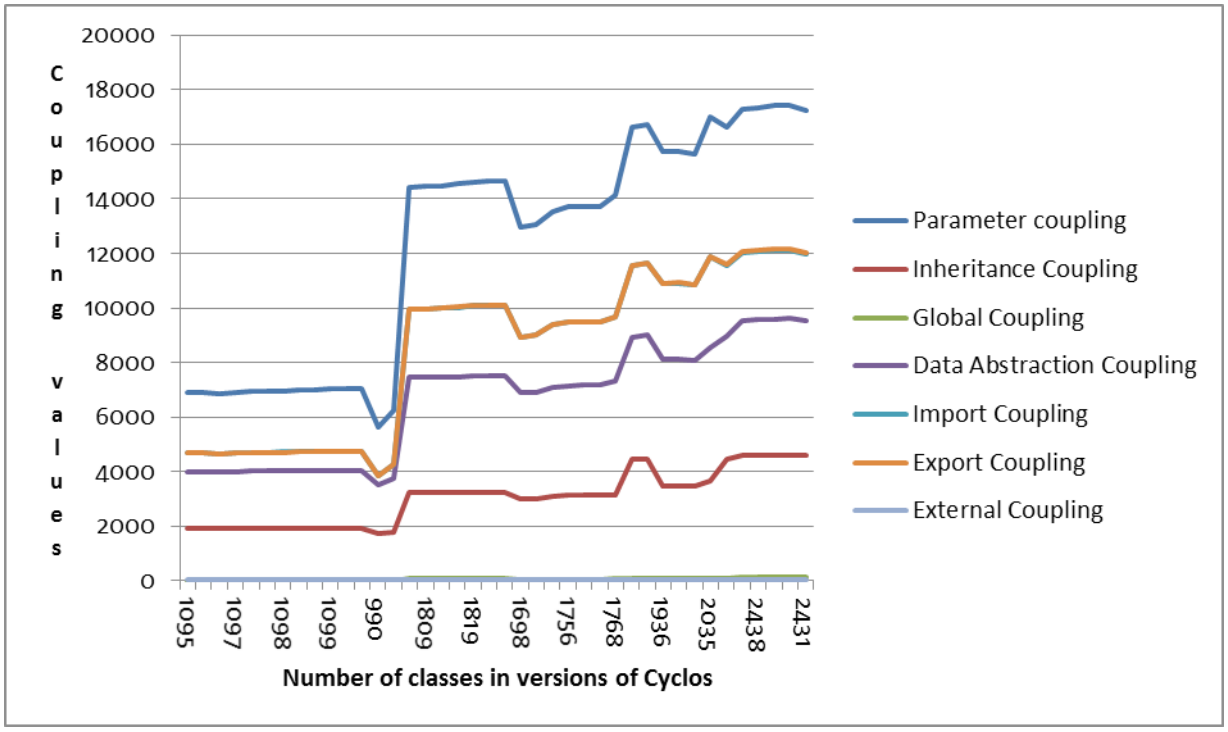

Fig. 1 Behavior of coupling values of forty versions of Cyclos

B. *Selection of coupling metrics*

So far, there are many coupling metrics described in the literature by various authors. Every author has a diverse set of coupling metrics focusing on different aspects of coupling measurement. In this study, we considered seven coupling metrics as given in Table I. The metrics selected in this study are comprehensive and considers all aspects of coupling measurement. Every coupling metric chosen for the study have the entirely different type of coupling interactions and mechanisms. The coupling metrics considered is a part of our previous study.

C. *Coupling data collection*

The authors have developed a specific tool named Java Coupling Measurement Tool (JCMT) to compute coupling between all pairs of classes of the input multimedia Java source code. The multimedia Java project folder possessing .java files is an input required to the JCMT tool. The JCMT calculates the seven types of couplings described in Table I.

III. Results and Analysis

In this study, forty different versions of a Banking project Cyclos are evaluated using JCMT to compute values of coupling metrics described in Table I. The sum of the coupling values of all classes belonging to a project is calculated for each coupling metrics by JCMT. The coupling values of forty versions of banking software Cyclos are computed using JCMT and specified in Table II.

The behavior of the coupling values of all forty versions of Cyclos project is plotted using a graph shown in figure 1.

In figure 1, X-axis represents the number of classes and Y-axis represents the coupling values of the different versions of Cyclos project. The curves of import and export couplings are overlapped in figure 1 because of the minor difference in their coupling values. Similarly, the curves of global and external couplings are also overlapped and are near to X axis because of their smaller coupling values. Primarily from figure 1, it is observed that every coupling metrics has a different range of values but a geometrically similar behavior. Secondly, it seems that the behavior of coupling values is changing as per the number of classes of a project. If the numbers of classes in project increases then coupling metrics values are also increases.

IV. Correlation Analysis

The correlation analysis aims to determine the relationship between the number of classes and coupling metrics values of a project. The goal of this correlation analysis is to answer the following questions.

Q1. Is there a correlation between the number of classes and coupling metrics values of a project?

Q2. Which correlation exists between the number of classes and coupling metrics values of a project?

To answer the above questions, data of Table II is sorted as per the ascending order of the number of classes in the projects.

The graph is plotted for the values of Table III and presented in figure 2. In figure 2 X-axis represents the number of classes in the project and y-axis represents coupling metrics values of the Cyclos project.

From the figure 2 following observations are made,

1. **As the number of classes in the project increases the coupling values also increases.** For e.g. in the version cyclos_3.0.B1, the numbers of classes are 990 means the lowest number of classes, so the project has lowest coupling values. Where, in subsequent projects numbers of classes are increased, so coupling values are also increased. There are some exceptions to this rule, in cyclos_3.0.9 the total classes are increased by one than its earlier version cyclos_3.0.11 in Table II, but the coupling values of cyclos_3.0.9 are smaller or same as compared to its earlier version cyclos_3.0.11. These exceptions happen when there is very small rise in the total number of classes i.e. rise of one to five classes or no rise. If

TABLE III
DATA OF TABLE 2 SORTED AS PER ASCENDING ORDER OF NUMBER OF CLASSES

Project Name	Number of Classes in project	Parameter coupling	Inheritance Coupling	Global Coupling	Data Abstraction Coupling	Import Coupling	Export Coupling	External Coupling
cyclos_3.0.B1	990	5624	1716	10	3526	3853	3849	21
cyclos_3.0.B2	1040	6254	1799	10	3748	4285	4281	21
cyclos_3.0	1095	6884	1902	10	4004	4684	4680	22
cyclos_3.0.2	1095	6862	1904	10	3995	4665	4661	22
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cyclos_3.5.6	1821	14633	3256	81	7531	10093	10100	28
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cyclos_3.6.RC1	2035	16978	3659	110	8558	11873	11899	29
cyclos_3.6	2357	16615	4459	109	8937	11544	11573	30
cyclos_3.6.RC2	2357	16615	4460	109	8944	11561	11590	30
cyclos_3.6.1	2367	16711	4466	111	9026	11637	11666	29
cyclos_3.7_RC1	2431	17253	4599	123	9537	11994	12038	30
cyclos_3.7	2435	17275	4602	123	9552	12018	12062	30
cyclos_3.7.1	2438	17320	4606	125	9569	12057	12101	30
cyclos_3.7.2	2443	17405	4615	125	9600	12113	12157	30
cyclos_3.7.3	2443	17403	4617	125	9602	12109	12153	30

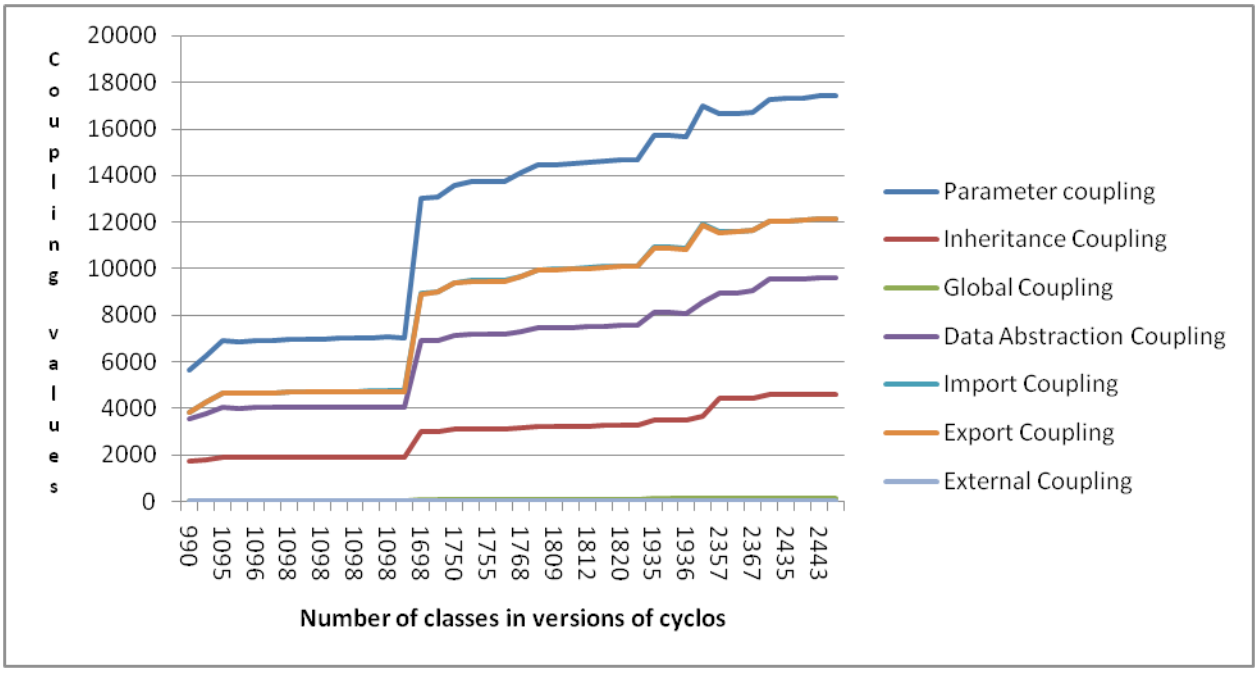

Fig. 2 Behavior of coupling values of forty versions of Cyclos after sorting

there is a major rise (i.e. rise of more than five) in the number of classes of the project, then the coupling values of the projects are increased. It means if there is a major rise in the number of classes of the project the coupling values also increases.

2. **Even if the numbers of classes are stable, the coupling values are not stable.** From the versions cyclos_3.0.4 to cyclos_3.0.11 it is observed that even if the number of classes is same for multiple versions, the coupling values can differ. This is due to changes in the software as per requirements.

Answer 1. With the above observations, the questions can be answered as below.

Answer 2. The correlation exists between the number of classes and coupling values of the projects.

(1) The second question is answered in two parts.

(2) Numbers of classes in the project are directly proportional to the coupling values of the project in case of the significant rise in the number of classes.

If the numbers of classes are stable for many versions then coupling values of the versions may differ.

V. Conclusion

In this paper, a case study is used to find the correlation between the numbers of classes and coupling values of the multimedia Java projects. Results showed that the numbers of classes in the project are directly proportional to the coupling values of the project in case of the major (more than five) rise in the number of classes. Also, if the numbers of classes are stable for many versions, then coupling values of the versions may differ.

References

[1] Arwa Abuasad, Izzat M. Alsmadi, "Evaluating the Correlation Between Software Defect and Design Coupling Metrics", 2012 International Conference on Computer, Information and Telecommunication Systems, CITS 2012, Amman, Jordan. 978-1-4673-1550.

[2] Lucas Batista Leite de Souza, Marcelo de Almeida Maia, "Do Software Categories Impact Coupling Metrics?", Proceedings of the Working Conference on Mining Software Repositories, pp. 217–220. IEEE 2013.

[3] Marcio F. S. Oliveira, Ricardo Miotto Redin, Luigi Carro, Luis da Cunha Lamb, Flavio Rech Wagner, "Software quality metrics and their impact on embedded software", In 5th International Workshop on Model-based Methodologies for Pervasive and Embedded Software (MOMPES), pages 68–77, 2008.

[4] Yeresime Suresh, Jayadeep Pati, Santanu Ku Rath, "Effectiveness of software metrics for the object-oriented system." Procedia Technology 6 (2012): 420-427.

[5] Jeff Offutt, Aynur Abdurazik, and Steve Schach, "Quantitatively Measuring Object-Oriented Couplings", Springer's Software Quality Journal, 6(4):489-517, December 2008.

[6] J. Eder, G. Kappel, M. Schrefl, "Coupling and Cohesion in Object-Oriented Systems", Technical Report, University of Klagenfurt, 1994.

[7] Huan Li, "A Novel Coupling Metric for Object –Oriented Software Systems", IEEE International Symposium on International Journal of Computer Applications (0975 – 8887) Volume 27– No.10, August 2011Knowledge Acquisition and Modeling Workshop, pp. 609-612, 2008.

[8] Husein Sukainah, Oxley Alan, "A Coupling and Cohesion Metrics Suite for Object-Oriented Software", International Conference on Computer Technology and Development, vol.1, no., pp.421-425, 13-15 Nov. 2009.

[9] Briand, Lionel C., John W. Daly, and Jurgen K. Wust, "A unified framework for coupling measurement in object-oriented systems." Software Engineering, IEEE Transactions on 25.1 (1999):91-121.

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