



Aspect Oriented Maintainability Metrics Validation-A Study on Philosophy

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Abstract: *Aspect Oriented Software Development is a new and emerging paradigm, which supports the separation of concerns that are scattered over the system. Since AOSD is an emerging approach compared to OOSD, its immaturity makes it a reason why software companies are disinclined to this new technology. If the maintainability in this approach could be proven to be better, then the approach may be adopted by the industry. The quality maintainability is indicated using metrics. This study aims at a systematic analysis of the literature to find the theoretical and empirical validation done on the aspect oriented software maintainability metrics.*

Keywords: *Aspect Oriented Maintenance metrics; Aspect Oriented Software Development; Crosscutting Concerns; Empirical validation; Separation of Concerns; Theoretical validation*

I. Introduction

Aspect-Oriented Software Development(AOSD) is a programming paradigm that overcomes the limitations of Object- Orientation (Programming) providing more suitable abstractions for modularizing crosscutting concerns[16,18] that cannot be decomposed from the rest of the software artifacts. AOP permits the modular realization of crosscutting concerns –concerns whose implementation is scattered throughout the system modules. AOSD concentrate on modularity problems that are not handled by other well known approaches such as Structured programming and Object Oriented Programming. Typical business and internet applications these days have to address “concerns” such as persistence, security, logging et al. It is observed that the basic abstraction of object oriented paradigm such as classes, objects and attributes are unable to capture all concerns in a software system. AOSD is a favorable model to support improved separation of concerns.

Maintainability is regarded a software attribute that plays a vital role in software quality level. If the software’s quality level is higher, the less effort/cost the software maintenance cycle requires. Aspect-Oriented Software Development (AOSD) is widely used software technology in academic scenarios [6]. Its acceptance by the industry may increase if studies, providing accurate information about its benefits and drawbacks are conducted. One approach to accomplish this is by showing the impact of the new method on the maintainability of the software is beneficial or not.

The maintenance cost can be controlled if software metrics is utilized during the development phase [13]. Studies [22] performed in the direction of Object Oriented software metrics have shown that metrics can be used as the predictors of maintenance efforts. As Aspect Oriented Software Development is an emerging paradigm a study on maintainability and its associated metrics need to be meticulously performed.

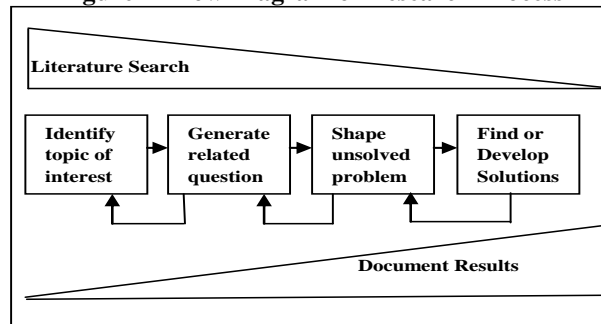
In this article an attempt is made to highlight the studies on aspect oriented maintainability metrics validation. The paper is organized as follows. Section 2 gives the methodology followed to carry out the study proposed by this paper. Section 3 presents the information compiled as part of following the methodology described. The results and evaluation of the study conducted is discussed in Section 4. The threats to validity are presented in Section 5. The paper is concluded in Section 6.

II. The Methodology

Lois Reed [17] suggests that literature search is very much significant once the topic of interest for research is recognized.

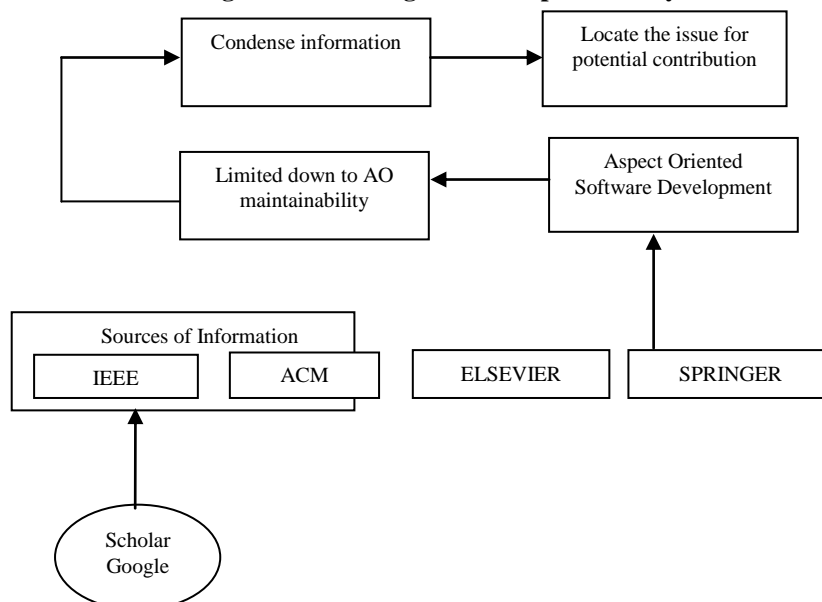
A flow diagram [17] of the research process shows how the literature search is related to the entire research process. This flow diagram is depicted in Fig. 1. As evident from the Fig. 1 a literature search obtains the topmost share of the research process. A search on the literature gives out three main functions [24]. A literature review helps [24] the researcher to realize the backdrop information relevant to the proposed area of the research, expound familiarity with research in own area and give clarity to the researcher about the contribution of the author to the proliferating knowledge base in the area.

Figure 1 Flow Diagram of Research Process



With the guidelines as given in [17] the methodology adopted for the literature search for the position paper is depicted in Fig. 2.

Figure 2 Flow Diagram of Proposed Study



A. Finding Sources

The sources of this study are secondary [20]. The sources are conference proceedings and journals. By keying in keywords in Scholar Google is one way of finding sources for this study. The list of references of some journals also provided a way of navigation for the study. A full record of the bibliographic information was maintained at this initial stage. As evident from the Fig. 2. IEEE Digital Library, ACM, Springer and Science Direct are databases which provided the secondary sources for the study.

B. The Search Strategy

The search approach for the selection of papers to be inclusive in the study is a two step process. Primarily, all the papers associated with aspect oriented software development selected were included on account of title, abstract and keywords. At this point resolution meeting with the experts clarified the inclusion/exclusion criteria of the papers and the area to be narrowed down. Saraiva [4] et al identified an Aspect Oriented Software Maintainability (AOSM) metrics for the use by AOSM research. The purpose of the mapping study is to identify the theoretical or empirical validation works on one or more of the metrics identified by Saraiva [4] et al. The papers that studied aspect oriented maintainability metrics was searched and collected.

C. Information Synthesis

The papers were critically scrutinized. The information was condensed to present an overview of what each paper proffer in terms of research problem and its solution. At the time of preparing summary about the work of others, the authors were mindful to include the reference for the works borrowed from other philosophers. The idea gathered at this juncture is outlined in the next section of this paper.

III. The Study

Validation of a metrics is essential to determine whether they measure what they claim to measure, before using them[23]. Briand,Emam and Morasca [19] identified two types of validation viz:theoretical and emperical. Even though in literature theoretical is often equated with internal and empirical with external, Meneely et al[2] views internal and external validation distinct from theoretical and empirical validation. Specifically internal

validation deals with how perfectly a metric measures an attribute whereas external validation associates a metric to quality factor. Theoretical validation uses logic to argue formally whether a metric is valid or not, while empirical validation employs analysis of data from experimentation or observation [2]. Briand, Emam and Morasca [19] suggest that theoretical validation answers whether the metrics is measuring the attribute it is purported to measure while empirical validation addresses the question, is the measure useful in the sense that it is related to other variables in expected ways.

Over the last few years, a range of research has been dedicated to aspect oriented metrics. In the subsequent section we discuss briefly some of the attempts to find out what are the works done on the aspect oriented software metrics and what metrics are accountable for the maintainability of the aspect oriented software artifact.

The study aims at finding the validation of metrics completed upon two dimensions namely development and evaluation [5]. Papers that are categorized in development are the one that accounts for a new/improved metric or set of metrics. Papers classified in evaluation are those validate existing metrics.

A. Papers Categorized in Development

E.K.Piveta et al [3] have performed an empirical study for the metrics specifically defined for aspect oriented software. The metrics under study are extended from the well known Chidamber and Kemerer [21] metrics suite proposed for object oriented software.

J Zhao and H Shen [8] have introduced a coupling metrics suite. The metrics suite makes use of common coupling metrics already in use of various coupling framework and introduce seven new coupling metrics.

Ceccato and Tonella [11] proposed a metrics suite that is a revised version of Chidamber and Kemerer’s [21] metrics used with OO paradigm. The work also collected the value for the metrics from software using the developed tool.

Sant’Anna et al [15] had presented a framework which is based on a suite of metrics and a quality model, to support the evaluation of aspect-oriented software in terms of reusability and maintainability.

Zhao and Xu2004 [12] in their paper had provided a theoretical validation for the measurement of cohesion for aspect oriented systems.

B. Papers Categorized in Evaluation

Kagiso Mguni and Yirsaw Ayalew [1] assessed the maintainability of AO systems based upon subset of metrics selected from the studies of different researchers. The study is an empirical validation for assessing the maintainability of aspect oriented system by using structural complexity and concern level metrics.

Bartsch and Harrison [7] have done with an empirical validation of aspect oriented coupling metrics. This work had used a subset of different coupling dimensions [10] and for each coupling measure a definition is also given.

Kulezsa et al [9] had done with an empirical study of the aspect oriented maintenance metrics already proposed by Sant’Anna et al [15].

IV. Results Discussion

This section presents the result initiated by the study. The results are depicted in a tabular manner and following this, a discussion of what is learnt from the study is elucidated.

A. Results

As mentioned earlier, the results are tabularized. Table I shows the topic type (Development/Evaluation) against paper types (Theoretical/Empirical).

Table I Main Topic against Paper Types

Topic	Paper Types		
	Empirical	Theoretical	Both
Development	3	1	1
Evaluation	3	0	0

As stated in section 2.B the study was aimed at finding out the validation of metrics identified by Saraiva et al [4]. Table II summarizes the empirical validation done on the metrics.

Table II Metrics of interest of study empirically validated

Metrics	Count of papers validating metrics	Authors
CDA	4	Piveta et al, Ceccato and Tonella, Kagiso and Yirsaw, Zhao and Shen
CAE	4	Piveta et al, Ceccato and Tonella, Kagiso and Yirsaw, Zhao and Shen
WOM	4	Piveta et al, Ceccato and Tonella, Kagiso and Yirsaw, Kulezsa et al
CDO	3	Kagiso and Yirsaw, Kulezsa et al, Sant’Anna et al
RFM	3	Ceccato and Tonella, Kagiso and Yirsaw, Zhao and Shen
CDLOC	2	Kulezsa et al, Sant’Anna et al

CIM	2	Ceccato and Tonella, Zhao and Shen
CFA	2	Kagiso and Yirsaw, Zhao and Shen
CBM	2	Kagiso and Yirsaw, Zhao and Shen
LCOO	2	Kulezsa et al, Sant'Anna et al
DOS	1	Kagiso and Yirsaw

B. Discussion

The study insinuates that AO metrics community is more or less influenced by the empirical validation of the metrics. Most of the studied papers are concentrated upon empirical validation of the metrics. From the study it is learnt theoretical studies of new metrics, framework and tool support are being overlooked by the AO metrics community.

B.1 Empirical validation studies

Empirical validation studies have a great influence on the metrics community. The validation works done by Ceccato and Tonella, Kagiso and Yirsaw, Kulezsa et al was to compare OO and AO versions of the same system. With the metrics value collected these studies established that AO version is more maintainable than OO version. The work done by Bartsch and Harrison confirms that maintenance effort is higher when source code of each aspect is large and coupling is higher. Zhao and Shen, in their study had developed a tool to calculate the metrics proposed by the authors. The work had given a theoretical validation of the metrics and also empirically validated the proposed metrics suite. In the study by Piveta et al the authors have performed a definition for the proposed metrics using set theory. The empirical data was collected from ten open source projects determining the value of the studied metrics for aspect oriented software. Sant'Anna et al proposed four set of metrics and an assessment framework to capture the understanding of the proposed metrics in terms of their usefulness as predictors of maintainability.

B.2 Conclusion for empirical validation studies

Most of the metrics used in empirical validation are extended from OO metrics suite. The empirical validation studies discussed in the position paper are re-engineering papers which is in favor of changing the design of application to optimize metrics. Also all the empirical validation studies are done on systems developed using AspectJ [14]. It is surprising that lot of empirical studies are being done on metrics that are theoretically not validated. So the authors feel that empirical validation is done on invalid metrics as long as they are not theoretically validated. Also it is found that most of the works lacks a tool support that aid in automated collection of metrics.

V. Threats to validity

The first threat to the validity is that the authors were very much biased towards the keyword maintainability metrics. This bias may have affected the study in such a way that, the papers that involved the studied metrics in some other quality attribute such as reusability is not considered. This also restricted the number of papers studied to be very less. The second threat observed is from the view point of data extraction. The study is performed by a two member group. The study would have benefitted more if the input from more researchers were present. This could have helped in categorizing more papers.

VI. Conclusion

Aspect Oriented Software Development (AOSD) aims at improving the modularity of software by providing structures which permit to modularize crosscutting concern whose representation in code cannot be isolated using traditional object oriented approach. Using object oriented approach for this purpose may lead to code cloning, which may give difficulty (again) to developers to identify all modules using the concern which may make maintenance difficult. In this scenario aspect orientation is a rewarding change. But the paradigm is at its burgeoning stage. Measurement of the object oriented paradigm was given a solid philosophical basis through Chidamber Kemerer and Li Henry. Aspect Orientation also needs to be matured on the lines of object oriented with respect to measurement and prediction features of metrics.

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