FAEMM-A PROTOTYPE MODEL TO ASSESS MAINTENANCE OF ASPECT ORIENTED SYSTEM

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Abstract:

As per ISO standards, maintainability of the software is one of the essential qualities that software must have. Aspect-oriented software's Software Maintainability Assessment (SMA) has been the subject of research. Software maintainability has been evaluated using statistical and machine learning techniques. An alternate method to SMA in aspect-oriented systems is fuzzy logic. Fuzzy logic has become a vital tool for utilization in many different areas, from the creation of automated intelligence systems to the engineering of control systems. Fuzzy logic doesn't quite depend on historic data and is capable of handling uncertainty and multivalued data. This feature of data-free model construction improves the potential of applying fuzzy logic for software metrics. The paper presents a fuzzy logic-based prototype for SMA of aspect-oriented systems.

Keywords: *Aspect Oriented Software Metrics, Concern Modularization, Fuzzy logic, Fuzzy Inference system, Model for Maintainability, Quality Estimation, Software Quality*

1. INTRODUCTION

Information and communication technology (ICT) plays an indispensable role in day to day life shifting thewhole world into a global village. The three factors that constitute the ICT viz: software and services, Information Technology Enabled Services (ITES) and the hardware segments. The aforementioned three factors have immensely contributed to the development of economy of many nations including India. Indian software industry contributes substantially towards the EDP [1, 2] and employment opportunity for the Indian youth. Even though software industry enjoys many positive sides, there exist a flip sidesuch as cost overrun, low reliability and high maintenance efforts. In this regard approaches should be introduced that can realize the introduction of maintainable software systems.

Aspect Oriented Software Development (AOSD) is the programming approach that succeeds object oriented programming by supporting separation of concerns. A concern is core business logic of the like security, persistence and logging et al. Many studies [3] in the domain of object-oriented software development had shown the usage of metrics at the developmental phase aid in the development of better maintainable software. The work focuses on the development of metrics based maintainability model for aspect oriented systems.

Of the total software development cost, the major share is consumed by maintenance efforts. The developmental cost of the software could be cut down by developing better maintainable software. It is by now proven [3] that software metrics are capable of predicting maintainability of software. A thorough skim through the literature revealed that much work has not been devoted in identifying a whole suit of aspect oriented metrics capable of influencing maintainability with empirical evaluation. In addition a metrics based maintainability model, is dexterous of identifying those elements which deteriorate the maintainability factors of software. Once these factors are identified guidelines can be formulated for the fabrication of aspect oriented software that abides by the quality factormaintainability. To make it concise the work was influenced by the maintainability issues associated with just about aspect oriented software and the impact of the potential outcome of a metrics based maintainability model provide to the paradigm aspect oriented software development.

II.LITERATURE REVIEW

The exploration on the aspect oriented fuzzy maintainability prototype model initiated with the identification of aspect-oriented maintenance metrics and scrutiny of an assortment of works carried out in predicting, assessing or estimating the maintainability features of aspect oriented systems.

Singh et al [4] recommends a prediction model of maintenance for aspect oriented systems, which draw on fuzzy approach. Based on aspect oriented maintenance suit of metrics a framework for prediction of maintenance effort was proposed and the framework was corroborated using fuzzy system. The work was short of a benchmark that instituted the approach as a better one. The research by Momeni and Zahedian [5] engaged an Adaptive Neuro Fuzzy Inference System (ANFIS) to evaluate the maintainability of Aspect Oriented Systems. Even though the study showed ANFIS as a better choice for evaluating

maintainability, it did not engage a whole suit of metrics which make the model unaccountable for assessing maintainability for real time systems. Sant'Anna et al [6] suggest an evaluation framework for maintainability. The framework used whole suit of metrics and was validated against two real-time systems. Even though the study advocates design properties of software like Separation of Concern (SoC), Coupling and Cohesion can assess software quality, it was incomplete in providing ideal values for the metrics suite. A correlation analysis executed by Kumar et al [7] showed that Weighted Operations in a Module (WOM) is insignificant in predicting maintainability. The study used changeability which is the count of modules affected by modification as the surrogate measure for maintainability. In the study [8] Burrows et al observe that coupling metrics can be effectively used as an indicator to fault proneness. They also theoretically and empirically validated two coupling metrics for fault proneness of aspect oriented systems. Zhao [9] proposed that coupling metrics is strongly correlated with maintainability of aspect oriented systems. A correlation analysis was carried of by Eaddy [10]. The analysis tried to find that consequence crosscutting concern has on the quality non-defective. The study concluded on the note that more empirical studies are required to draw conclusion about the effect of concerns on the qualityof the software.

III. PROBLEM DEFINITION

The rationale of a metrics based maintainability model for aspect oriented system is to diagnose the elements of the software that contribute to high maintenance efforts for the product. Even though manystudies confirm that aspect oriented paradigm is better to object oriented paradigm in terms of the maintainability of the software, studies that propose a comprehensive metrics suite that assess and identify the components that affect the maintainability of aspect oriented software is considerably less.The aspect oriented maintenance metrics, is identified using an empirical study where the participants are from email newsgroup interested in aspect oriented paradigm. The identified metrics is mapped to internal attributes and internal attributes mapped to factors of maintainability using multi-criteria decision approach namely Analytic Hierarchy Processing [11]. Based on the factors of maintainability, a fuzzy XNOR [12] model for assessing the maintainability of aspect oriented software is developed. The work proposes a framework for aspect oriented software maintainability and validated using FuzzyInference System (FIS).

IV. THE RESEARCH DESIGN PROCESS

4.1 THE METHODOLOGY

The research process for the work is an assortment of statistical, data mining and soft computingtechniques. The work proceeds through three main modules. The first module uses statistical technique to identify the metrics capable of assessing maintainability. The second module employ data mining approach called Analytic Hierarchy Processing to find the eigen vector that decide the factors of maintainability for the model. The third and the final module apply fuzzy approach for validating the model to find the maintenance index for the developed fuzzy prototype model. The overall depiction of the

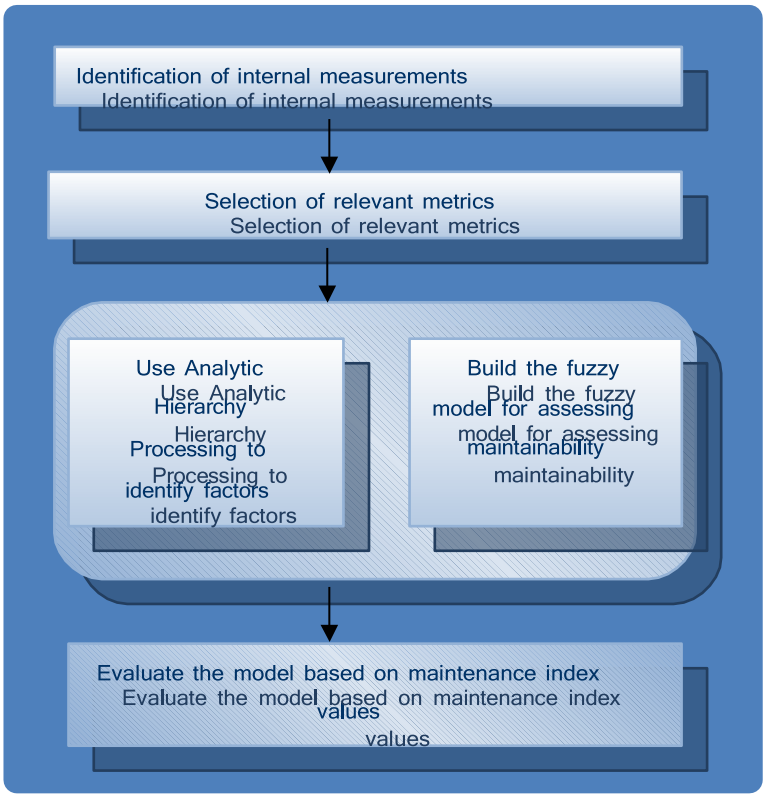

Figure 1. The framework for aspect oriented maintainability model system is sketched in Figure 1.

4.1.1 Identification and Selection of Metrics

The metrics that were identified for the purpose include Weighted Operations in a Module(WOM), Lines of Class Code(LOCC), Lack of Cohesion in Operation(LCOO), Crosscutting Degree of Aspect(CDA),Response For a Module(RFM), Coupling Between Modules(CBM), Coupling on Advice Execution(CAE) and Coupling in Intercepted Modules(CIM). Statistical technique is applied to select the metrics that are considered to be relevant to the maintenance of aspect oriented system mail newsgroup interested in aspect based technology. The metrics identified to be significant to the maintenance of the software are WOM, LOCC, CDA, LCOO and CAE**.**

4.1.2 Use of Analytic Hierarchy Processing to choose internal attribute and factors of maintainability

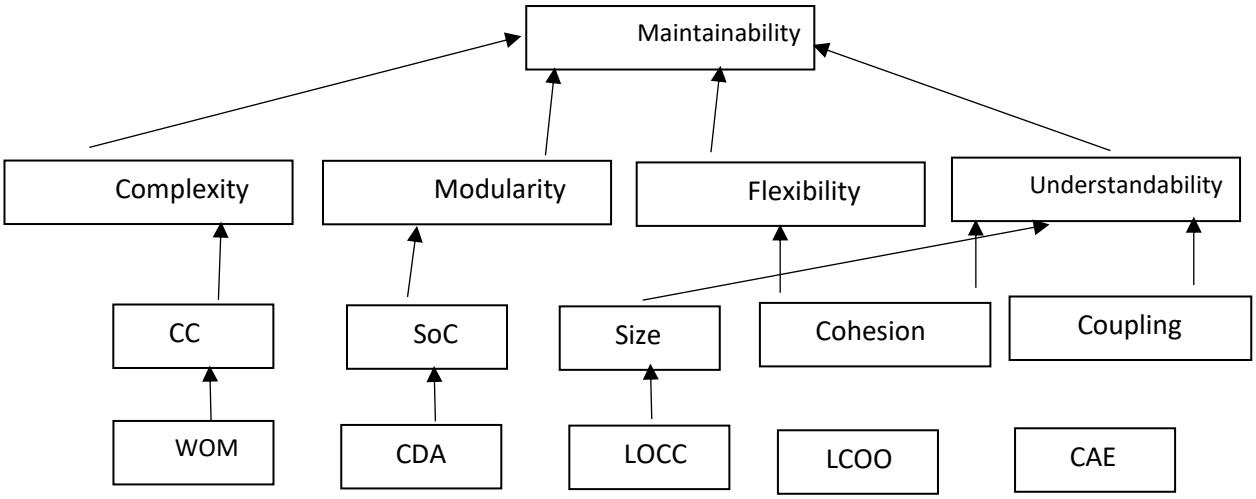

Figure 2: Analytic Hierarchy Processing

Once the metrics are identified, the data mining technique called analytic hierarchy processing is used to decide the internal attribute influenced by the metrics. After the internal attributes are identified, the factors of maintainability are also calculated using the same approach. Analytic Hierarchy Processing [11] is a multi criteria decision making approach widely used in all major domains like business decision making, industrial applications, medicine et al. The utilization of AHP validates the appropriateness of internal attributes and factors of maintainability for building the maintainability model of the aspect oriented systems. Figure 2 shows the relation between metrics, internal attributes and factors of maintainability after AHP is applied.

4.1.3 A Fuzzy Inference System (FIS) for the assessment of maintainability

Based on the factors of maintainability identified using analytic hierarchy processing in the previous stagea fuzzy based prototype model is designed to assess the maintainability of aspect oriented systems. The system flow design for the fuzzy model is depicted in Figure 3. The output of the system is the maintenance index, based upon which the quality factor, maintainability of the software is assessed.

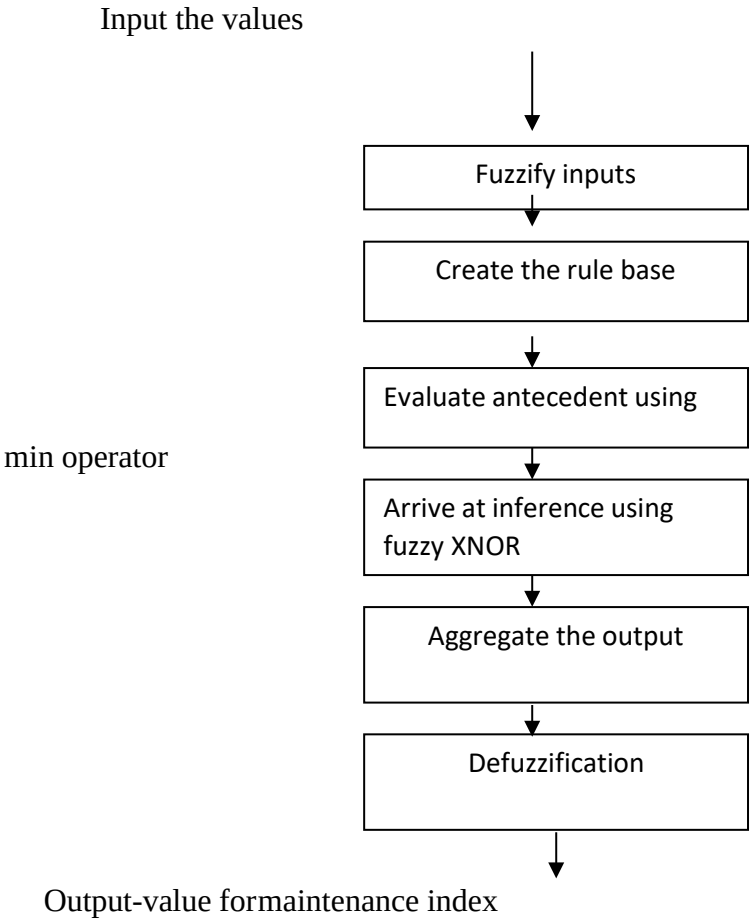

Figure 3: Flow design of the fuzzy system of maintainability

4.2 Experimental Procedure

The maintainability model for aspect oriented system is validated using fuzzy logic toolbox of MatLab.The four factors of maintainability viz: Complexity, Modularity, Flexibility and Understandability takes three values for membership functions. These membership functions with their ranges are low (0 0.185 0.37), medium (0.31 0.495 0.68) and high (0.63 0.815 1). The output of the system is maintenance index for aspect oriented software, which is categorized as high, medium and low.

The rule base is filled with potential combination of rules. The 'fuzzy AND' operator estimate the antecedent part of the rules. The customized operator 'fuzzy XNOR' is engaged for the implication operation from antecedent to consequent. 'Fuzzy OR' is the aggregation operator.

V. RESULTS AND DISCUSSION

The work resulted in a fuzzy prototype model for assessing the maintainability features of aspect oriented systems. The model is appraised for the performance based on the values of maintenance index.

Table 1 shows the output value obtained for the fuzzy maintainability model for aspect oriented system (FAEMM). Table 2 explains the output values for fuzzy AND model for maintainability. The comparison chart for the model with fuzzy AND is depicted in Figure 4(With different set of inputs on X-axis and corresponding output value on Y-axis).

Input MF value for				Input Name	Output value for maintenance
Understandability	Flexibility	Modularity	Complexity		
0.826	0.826	0.846	0.208	ip1	0.219
0.503	0.503	0.503	0.254	ip2	0.589
0.128	0.386	0.159	0.853	ip3	0.731

Table 1: Input-Output values for fuzzy XNOR-OR combination

Input MF value for				Input Name	Output value for maintenance
Understandability	Flexibility	Modularity	Complexity		
0.811	0.869	0.886	0.069	ip1	0.285
0.451	0.251	0.825	0.355	ip2	0.491
0.253	0.323	0.253	0.901	ip3	0.721

Table 2: Input-Output values for fuzzy AND-OR combination

The output value obtained for the combination of inputs when employing fuzzy prod as the operator is depicted in Table 3. The comparison of these with the model is represented by Figure 5(With different set of inputs on X-axis and corresponding output value on Y-axis).

Input MF value for				Input Name	Output value for maintenance
Understandability	Flexibility	Modularity	Complexity		
0.88	0.79	0.881	0.5	ip1	0.311
0.488	0.505	0.223	0.289	ip2	0.597
0.462	0.315	0.341	0.38	Ip3	0.811

Table 3: Input-Output values for fuzzy AND-OR combination

For the evaluation of the result, the output value obtained for the three approaches is taken and representedin Table 4. As per the benchmarking, the one that produces the least maintenance index is capable of producing highly maintainable software. The graphical representation for the benchmarking of the modelis depicted in figure 6.

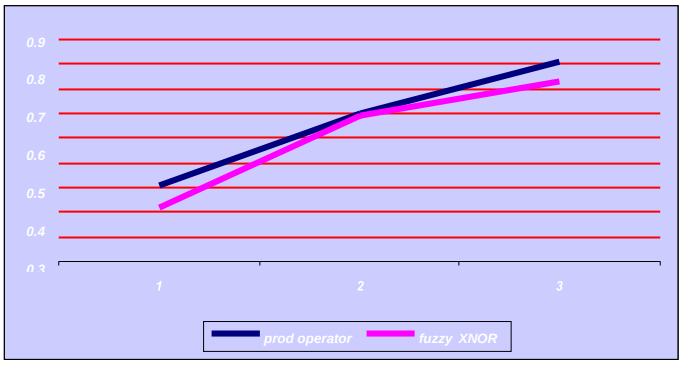

Figure 4:Comparative chart of the model against fuzzy AND

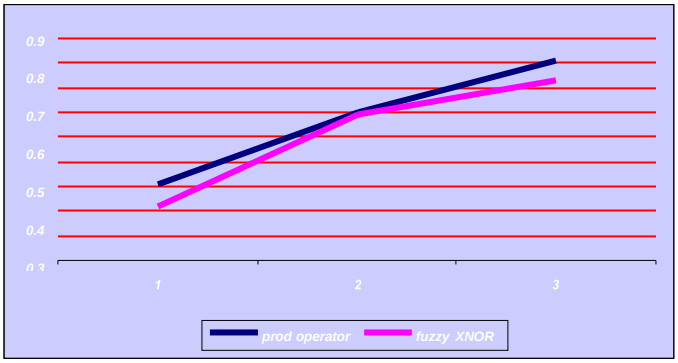

Figure 5: Comparative chart of the model against prod operator

T-norm operator	MI Value
FAEMM	0.219
Fuzzy AND	0.285
Prod	0.311

Table 4: Output value for various t-norm operators

The throughput of the prototype model (FAEMM) is calculated based on the obtained value ofmaintenance index with ideal value. The throughput is calculated based on the formulae, Throughput= $(MI_{obt} / MI_{ideal})*100$

The throughput obtained for the model and the other models are given in Table 5. Figure 7 represents thegraphical representation of the comparison of throughput of the prototype model with other models (Various models on X-axis and throughput value on Y-axis)

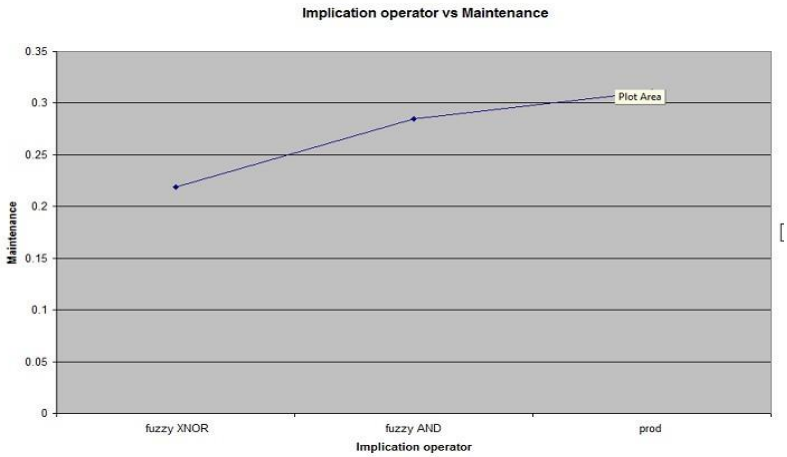

Figure 6: Comparison of output value against t-norm operators

T-norm operator	Throughput (%)
FAEMM	92
Fuzzy AND	62
Prod operator	63

Table 5. Throughput Comparison for the prototype model with other models

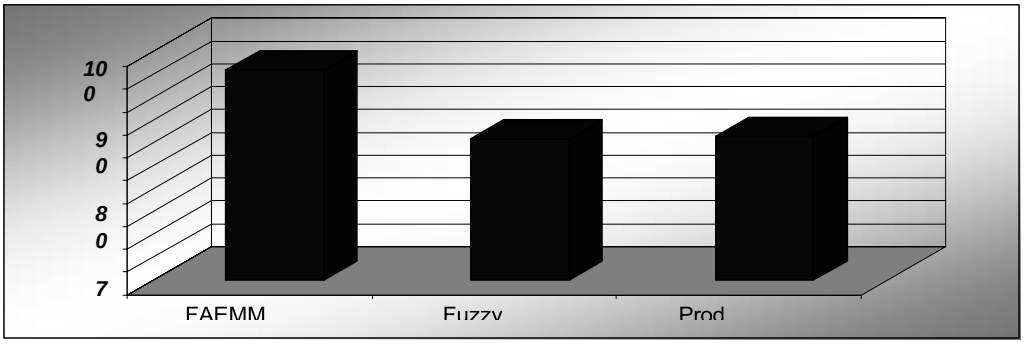

Figure 7: Throughput comparison of the model with other models

VI. CONCLUSION AND FUTURE SCOPE OF THE WORK

The conclusion that can be drawn from the work is that the maintainability model is better in terms of estimated maintenance index. The system level predictions made by the model enhances the ability of the model being used by quality managers for determining the design and coding criteria to be adopted while developing aspect-oriented systems.

In the software development phase, maintenance is the most cost consuming one. So developing maintainable software is of much relevance to the software industry. So this work

proposes a prototype system that can be used by the software industry to assess the maintainability of the aspect oriented systems.

The work sketches a prototype system. This prototype system can be enhanced to complete the automated testing features of aspect-oriented systems. Additionally, the value of the metrics could be collected from a real time system and the model could be validated.

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