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Response to 'Comments on: A cohesion measure for object-oriented classes'

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SUMMARY

Indicating that CBMC does not satisfy the monotonic property in terms of the number of interactions, Xu and Zhou proposed an augmented definition of CBMC by adopting cut set instead of glue methods. The augmented CBMC clearly satisfies the monotonic property. However, CBMC is designed to overcome the problem with respect to the number of interactions and, therefore, focuses on the interaction pattern, especially, member connectivity. Consequently, it does not make sense to mention the monotonic property of CBMC with respect to interaction number. Moreover, the notion of glue methods allows several interpretations on the design quality of a class. However, that meaningful interpretation is not possible for the augmented definition due to the removal of the notion of glue methods. Copyright © 2001 John Wiley & Sons, Ltd.

KEY WORDS: class; object-orientation; cohesion; interaction numbers; interaction patterns

1. INTRODUCTION TO THE RESPONSE

Xu and Zhou discuss the measuring result of CBMC that is inconsistent with intuition in the following two aspects:

(1) a class with complex interactions might have the same measuring value of cohesion as a class as simple interactions; and
(2) a class with complex interactions might have a lower measuring value of cohesion than a class with simple interactions.

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Xu and Zhou found that the class decomposition approach based on glue methods led to such problems and resolved the problem by adopting cut-set instead of glue methods. That is, they defined the connectivity factor in terms of cut set and constructed a structure tree by removing cut-set instead of glue methods.

The augmented definition of CBMC based on cut-set instead of glue methods obviously resolves such a monotonic property-related problem; that is, the augmented definition meets the monotonic property. However, we respond to Xu and Zhou's augmentation in two respects; response to the criticism of the monotonic property of CBMC and the implication and the role of glue methods in CBMC.

2. ON THE CRITICISM OF THE MONOTONIC PROPERTY OF CBMC

Xu and Zhou's comment is basically concerned with cohesion criteria; that is, what contributes to increasing the cohesiveness of a class? The following sentence from the comment gives us a hint about the viewpoint of Xu and Zhou on cohesion criteria:

> 'Apparently, the more complex the interactions among the members of a class are, the more cohesive the class is'.

According to this, and the above two problem statements, complex interaction appears to mean a lot of reference relations between methods and instance variables in a class. The above two critical statements on CBMC can be rephrased as 'the greater the number of interactions a class has, the more cohesive it is. And, CBMC does not conform to this principle'. In other words, they criticized the monotonic property from the viewpoint of instance-variable usage criteria [2].

However, we have an opposite opinion to instance-variable cohesion criteria. In the preceding paper [1], we described such cohesion criteria as leading to some cohesion measurement problems, and proposed a CBMC that focused on interaction pattern instead of the number of interactions; that is, we maintained that the degree of member connectivity by glue methods rather than the number of interactions among class members is the major factor in the discrimination of cohesiveness.

Consider classes A and B in Figure 1(a) and (b), where both of them have the same number of methods and instance variables. Class A should be more cohesive than class B from the viewpoint of the instance variable usage criteria since class A has a larger number of edges than class B. However, from the viewpoint of the relatedness among class members, class A consists of two collections with little relationship, and the members of class B have relatively more relations among them. Thus, it should be claimed that class B is more cohesive than class A.

It was one of the motivations of CBMC to overcome such problems resulting from the instance-variable usage criteria. Therefore, it does not make sense to assess CBMC from the viewpoint of the number of interactions since CBMC was designed to focus on the interaction pattern rather than the number of interactions.

The adoption of member connectivity as a new cohesion criterion is concerned with the original measurement goal of cohesion in CBMC. The existing cohesion measures were primarily proposed to evaluate the relatedness among class members and to indicate indirectly some quality attributes such as maintainability, reliability, error-proneness, etc. However, CBMC was proposed to directly indicate the quality of a class, specifically the well-designedness of a class. That is, CBMC can indicate whether

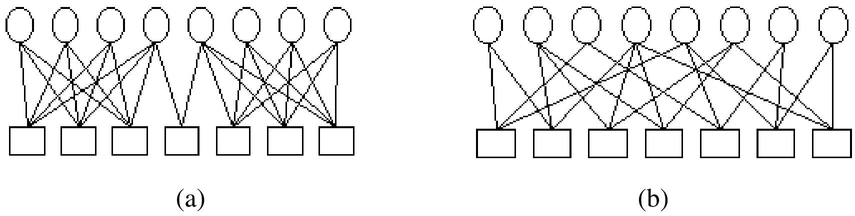

Figure 1. (a) Class A, (b) Class B.

a class is well designed such that the class captures the attributes and operations of some objects; a class with low CBMC may have some design deficiency and for such a poorly-designed class we should take some appropriate actions such as restructuring or redesign. In order to achieve such a measurement goal, CBMC introduces several concepts such as the special methods, the glue methods, the connectivity factors, the structure factors and strategies towards the inherited members and non-public methods.

We believe that a well-designed class is one with a strong connectivity among its members rather than with a many-interaction number, and CBMC was designed to reflect such a notion of well-designedness. In the preceding paper [1], we described a case study on a well-known C++ library where the design deficiencies for low CBMC classes were analyzed.

3. THE IMPLICATION OF GLUE METHODS

Xu and Zhou mentioned that the concept of the glue methods provided the fundamental reason for the violation of the monotonic property. That is, since all the connected edges of a glue method are removed, it is impossible to reflect the monotonic property in terms of interaction numbers. The authors proposed an augmented version of CBMC based on cut set instead of glue methods; the augmented version will satisfy the monotonic property in terms of interaction pattern.

However, the glue methods were proposed to allow various meaningful interpretations about the well-designedness of a class. In contrast, a similar interpretation cannot be applied to the augmented version where cut-set instead of the glue methods is adopted.

First, for a highly cohesive class, the glue methods can be interpreted to represent the essential behavior of the objects captured by the class. In other words, the glue methods, the minimum set of methods without which the relations among class members are disconnected, have a higher probability of capturing the corresponding object behaviors than the non-glue methods. In contrast, for class of weak cohesion (especially, in the case of low connectivity factor and high structure factor), glue methods can be interpreted as being poorly designed methods; that is, class members with little relationship are accidentally merged by the glue methods. Class A in Figure 1(a) may be such an example. It is impossible to derive such a quality indication of the well-designedness of methods from the augmented definition of CBMC adopting cut-set instead of the glue methods.

Second, there may be no meaningful interpretation of the recursive application of cohesion concept to the sub reference graph in the augmented CBMC. In the original definition of CBMC, the sub referenced graph obtained by removing the glue methods and their edges can be considered to be another reference graph that may represent some subset of the original class members. Therefore, we recursively apply CBMC to the sub reference graphs. In addition, the notion of structure factor was proposed to express that a class with a sub reference graph of stronger cohesion value would be more cohesive. However, the sub reference graph in the structure tree defined by the authors is only a graph-theoretically defined subset of an original reference graph, and cannot be considered a component which may represent some subset of the original class members. Therefore, since the sub reference graph in the augmented version does not follow the underlying idea that a sub reference graph can be another reference graph that may represent some subset of the original class members, there is little justification for the recursive application of cohesion value to the sub reference graph.

Finally, as described in our original paper, CBMC can be used to indicate the design quality of a class as well as the overall cohesiveness of the class. In addition, we proposed some restructuring or redesigning approach to improve the quality of a poorly-designed class. For instance, a class with a low connectivity factor and a high structure factor can be restructured into a more cohesive one by creating a new class for each sub reference graph and having as instance variable the instance of the newly-created class instead of the sub reference graph. We think that such a guideline about quality evaluation and restructuring approach cannot be applied to the augmented CBMC.

In summary, Xu and Zhou proposed the theoretically sound augmentation of CBMC by adopting cut-set instead of the glue methods. However, in the augmented CBMC, it is not possible to give several meaningful interpretations in the original CBMC because those meaningful interpretations have their base on the notion of the glue methods that were dismissed in the augmented CBMC.

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