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Metrics based component systems assessment. A survey.

by
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Abstract. *The already research proposals about the component systems assessment are presented. An analysis of them considering various classification criteria are further presented. A discussion about future improvements follows, considering both advantages and drawbacks of the search approaches.*

Keywords: components, metrics, assessment

1. Introduction

Component-based development (CBD) advocates the acquisition, adaptation, and integration of reusable software components to rapidly develop and deploy complex software systems with minimum engineering effort and resource cost.

The problem of component selection was addressed in our previous research proposals [Ser07b, Ser08, Ser09, Ves09]. Informally, our problem is to select a subset of components satisfying the system requirements. The difficulty resides in the fact that each component had a related set of components that share similar functionalities and because of this, an algorithm for the decision process is needed. We have studied the problem in three different directions: Metrics-based selection, Fuzzy clustering-based selection, Evolutionary-based selection.

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Another concern about component-based development refers to the quality of the used components and of the obtained system. In the selection of the component that best fulfill the system requirements, among components with similar functional properties, the knowledge on quality attributes could often represent the most significant information. Thus, there is a need for an objective valuation methodology that may assist software developers to select appropriate components for projects. Regarding the overall quality of the system, we first must study the interaction among components in an assembly. When integrating components into a system assembly, it would be useful to predict how the quality attributes for the whole system will be. In order to predict and to asses quality attributes, the usage of software metrics is a necessity.

The above mentioned approaches were integrated into a Conceptual Framework for component systems assessment.

The aim of this paper is to analyze the proposed approaches for the Component Selection Problem and for the metrics assessment of a component-based system. The various research solutions for the problem are analyzed and compared considering various criteria. The advantages and the drawbacks are presented. Future improvements are addressed.

Remark. The resulted analysis of our previous work and the proposed improvements takes into consideration the related work concerning both the Component Selection Problem and the component based systems assessment. The related work for each proposal can be found in the published approach but due to space limitation we did not included here.

The paper is organized as follows: Section 2 presents the main contributions and various classifications of the proposed approaches considering various criteria. In the Section 3 some improvements are addressed and discussed. We conclude our paper in Section 4.

2. Classification results based on various criteria

This section presents our research results regarding the component systems assessment and classifies them based on various criteria.

Remark. The analyzed research papers are: EUROMICRO06, Studia06, ICAM06, KEPT07, ICAM08, HAIS09, UKSIM09, CIMSIM10, RoEduNet10. The information about the published research papers may be found at the reference section (the papers have doubled reference name).

2.1 Classification results based on the used algorithm to construct the final system.

Our research related to Component Selection Problem is based on some algorithms proposed by us. The classification of the proposed approaches based on the used algorithm is listed in Table 1.

A backtracking based method algorithm that obtains all the possible and correct system configurations was introduced in [EUROMICRO06]. Our research papers [ICAM06, KEPT07] used this algorithm, and the obtained system solutions are analyzed based on metrics values, metrics related to some quality attributes that are of interest for assembly evaluation.

Another proposed approach considered fuzzy clustering analysis to "evaluate" components. Referring to component selection problem, when a component is selected to be added to the system solution, different components may exist to satisfy the same needed requirement and our aim is to select the best available component. To help us in this decision, *fuzzy clustering analysis is used to partition the available set of components*, based on the values of metrics which quantify some considered quality attributes. In this respect, we have developed an algorithm [HAIS09] that partition the components at every step of selection. The advantages of this algorithm are: the search space dimension is drastically reduced, the obtained partition suggesting the component that should be selected at a given step; the execution time needed for selecting the best component is reduced due to the reduced search space; the selection criteria of the components are based on several characteristics of components (several metrics may be defined).

The third approach used principles of evolutionary computation and multiobjective optimization. The problem was formulated as multiobjective [UKSIM2009], considering different metrics values. We have performed two different experiments: first considering only two objectives and then

considering all objectives but with different population sizes and different number of generation.

Construction Algorithm Type	**All correct assemblies**	**Fuzzy clustering**	**Evolutionary algorithm**
Papers	ICAM06, KEPT07 (using Studia06, EUROMICRO06)	ICAM08, HAIS09	UKSIM09

Table 1. Approaches classification based on the used construction algorithm.

2.2 Classification based on the used metrics.

In our research regarding component assembly evaluation and component selection problem, we have used some relevant existing software metrics and we have proposed some new ones. Thus, in the article [ICAM06] an assembly of components is viewed as a graph and some metrics related with coupling and cohesion of the assembly were selected and proposed.

Regarding the component selection problem, some metrics were established to select a component between a set of possible candidates. In this respect, metrics as PSU, RSU, F, Cost [ICAM06, Hoe03] helped us in decision. The classification of the proposed approaches based on the used metrics is listed in Table 2.

Metrics	**CBC, DDT, BDT**	**PSU, RSU**	**F, Cost**	**F, Cost, PSU, RSU**
Papers	ICAM06	ICAM08, HAIS09, CIMSIM10, RoEduNet10	ICAM08, HAIS09, UKSIM09	HAIS09, UKSIM09

Table 2. Approaches classification based on used metrics

2.3 Classification based on the proposed research approach

Another classification of this current paper is based on research approaches. This classification is listed in Table 3.

When a system is built from a set of components, two issues are relevant for reaching a solution to better satisfy customers' needs:

- building a solution that meets the system requirements, the nearest possible to the best solution, by adopting heuristics methods [Hais09, Uksim09, Euromicro] – Component Selection Problem;
- assessing the assembly obtained during previous step, in order to compare among other alternative configurations [ICAM06] – Assembly evaluation.

The above two issues are integrated into a formal approach [CIMSIM10, RoEduNet10] concerning component based systems assessment. More precisely, we have defined a general, scalable and integrated framework for a quantitative evaluation regarding both individual components and the system obtained by connecting components. This framework has four layers of abstraction.

Research proposal	**Component assembly**	**Component selection**	**Metrics definitions and assessment**
Papers	ICAM06, KEPT07	ICAM08, HAIS09, UKSIM09	CIMSIM10, RoEduNet10

Table 3. Approaches classification based on research proposal

3. Improvements of proposed and current approaches

In this section the classification results based on various criteria from the previous section are analyzed and some advantages and drawbacks are discussed. Also, some improvements are proposed next.

An overlapping of the classification results based on various criteria is presented in Figure 1. From the left side figure we can conclude that the three criteria classification (Backtracking algorithm based, CBC, DDT, BDT metrics and the Component Assembly research type) have in common

two papers: ICAM06, KEPT07. In the right side figure the overlapping is much denser.

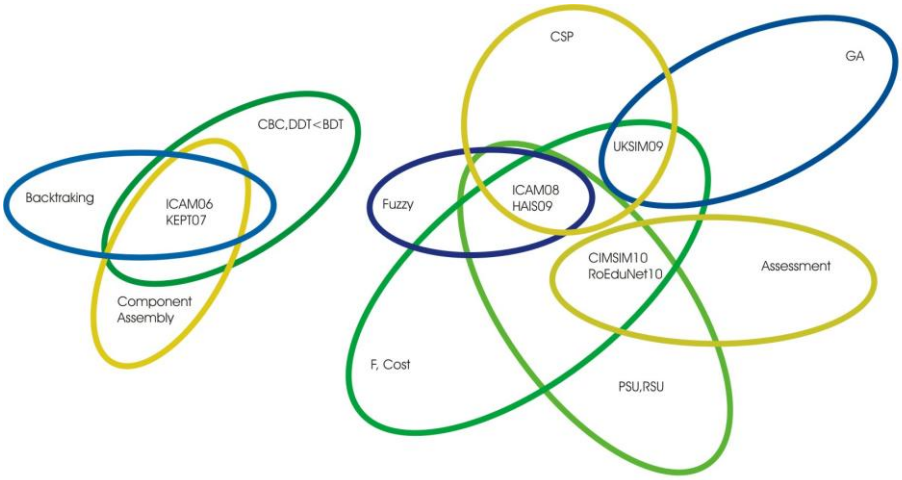

Figure 1. Overlapping classification results based on various criteria

The following **improvements** may be developed after analyzing the overlapping classification results:

- The Genetic Algorithm may be applied using PSU, RSU metrics. The previous algorithm used only individual evaluation of each component from the repository, so as improvement we would like to evaluate the (graduated) obtained solution.
- Using Fuzzy classification in the Genetic Algorithm "process". In this case two different possibilities may be applied:
    - using fuzzy classification on mutation: choose alternative component using the fuzzy classification;
    - using fuzzy classification in classifying the population (from one evolution to another, when choosing individuals from previous population).

Regarding future work as new research items the following may be considered:

- adding new metrics;
- using new algorithm for the Component Selection Problem;
- new problem formulation for the component-based systems:
    - update system (dynamic changing requirements);
    - multilevel system structure;
- new methods and techniques to provide a mechanism for interpreting measurement results and identifying those parts of the system that need improvements;
- using other fuzzy clustering algorithms in order to obtain the needed classification;
- extending the approaches by specifying and proving the compatibility between two connected components;
- we aim to extend the proposed CBS metamodel and to better emphasize its applicability through more case-studies;
- to extend the approach in order to define any metric found in literature for component-based systems;
- to define a library for component-based systems metrics definitions.

4. Conclusions

. A survey type article was intended by this paper. The previous developed research regarding the Component Selection Problem and component based systems assessment were analyzed and classified using various criteria. An overlapping classification helped us to determine improvements of our research and also future approaches were listed.

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