

An Optimal Trade-off Solution of the Software Architecture Choice Problem

Kharchenko A¹, Bodnarchuk I^{2*}, Galay I.¹, Yatsyshyn V²

¹ National Aviation University, Kosmonavta Komarova ave. 1, Kyiv, 03058, Ukraine

² Ternopil Ivan Pul'uj National Technical University, Ruska str, 56, Ternopil, 46000, Ukraine, Tel.: +38-050-437 7606. E-mail: bodnarchuk_io@gmail.com

(Received May 12, 2016, accepted September 20, 2016)

Abstract. The problems of a multi-criteria decision making model of software system architecture dealing with definition of criterion function and formalization of the trade-off estimation procedure are discussed. Taking into account the domain requirements and criteria values limitations, the universal scalar convolution is proposed where the weights of the quality criterion depends on its proximity to the limitation. An optimization model of "replacement-compensation" was used for solution of reengineering problems and directed selecting of software architecture.

Keywords: software system architecture, software architecture quality, quality characteristics, trade-off, decision making.

1. Introduction

The component technology based on the usage of components taken from earlier executed projects (reused components) is widely applied for software systems (SWS) design [1]. The design of such an architecture technology starts with the frame selection based on the SWS requirements and filling it with necessary components taken from the repository or Internet. The frame is a high-level abstraction of the SWS design and it combines the set of interacting objects into some integrated environment [2]. The pattern is an expansion of the component concept. It is also an abstraction that contains description of interactive objects in generalized cooperative action where roles of participants and their responsibilities are defined. The great amount of components is developed. They are classified according to the types and kinds of applications, and also the technologies of their usage for SWS architecture design. Since the repository of patterns usually contains several components that produce the same functionality, the set of alternative SWS could be obtained in the component technology design. Selection of the most acceptable architecture option with the respect to the set of quality criteria requires either arrangement of alternatives according to the quality criteria values or use of some integral index with own value for each alternative.

Only few SWS architecture evaluation methods are used in practice. The most popular methods are based on the development and testing scenarios for certain architecture to satisfy the quality criterion. ATAM and SAAM are the most known methods of this type [3], [4]. The most common disadvantage of these two methods is generation and analysis of rather large quantity of development scenarios upon implementation which makes them laborious, expansive and complicated for formalization. Emergence of Analytical Hierarchic Process (AHP), that was proposed to overcome ATAM and SAAM drawbacks, led to considerable improvement of the architecture selection procedure and its further formalization for automation of decision making processes [5], [6].

In turn, the essential disadvantage of AHP is the limited quantity of alternatives for evaluation ($n \leq 7 \pm 2$) that caused by the inconsistency of elements in the matrices of pairwise comparisons. Inconsistency also increases as quantity of alternatives grows [7]. To solve this problem, Pavlov offered the modification of AHP where weight multipliers alternatives are obtained from the condition to minimize misalignment matrix of paired comparisons [8]. Such a modification would simplify the initial problem to the problem of mathematical programming. The problems of modified AHP (MAHP) application in terms of the task of evaluating alternatives architecture of software systems with a large number of alternatives are described elsewhere [9, 10].

Final selection of architecture option is often performed via replacement of multi-criteria optimization with single criterion usually expressed as additive convolution of partial quality criteria. The weights of partial criteria are determined herewith by expert method of subjective nature that is badly formalized and

could be a source of additional errors. The trade-offs made between criteria are also remain hidden when scalar convolution is used. The acceptable structure of scalar convolution should be first selected. In order to reduce the subjective influence on the weights of quality criteria selection and to take into the account requirements of subject area, formalized methods of partial criteria weighting should be applied. By using universal scalar convolution [11] in this report, the objective function that depends on the measure of situation tension and determined by proximity of criteria values to their limits is optimized. The iterative procedure of simplex planning is used for formalization of criteria weighting process. The other important problem is mathematical formalization of SWS reengineering processes for optimal utilization of required resources. To address this issue, we used "replacement-compensation" procedure and optimization model of software architecture (SWA) alternatives' quality criteria changes definition in this report. These changes can reflect changes of requirements to the architecture.

2. Problems of software architecture multi-criteria selection

The scheme of the evaluation problem and multi-criteria SWS architecture selection from the set of alternatives is shown on the Fig. 1.

The following denotations are used: $K_j^1, j = \overline{1, p}$ are quality criteria of SWS itself, defined according to the ISO/IEC 25010 requirements in terms of standard; $K_i^2, i = \overline{1, n}$ are architecture quality criteria defined from the set of $K_j^1, j = \overline{1, m}$ using SQFD (Software Quality Function Deployment) method or pairwise comparisons method [7]. K^0 is integral quality criterion of SWS; $R_i, i = \overline{1, n}$ are given limits of architecture quality criteria; $A_i, i = \overline{1, m}$ are alternative architectures. Since the set of criteria $\{K_i^2\}$ is obtained from the set $\{K_j^1\}$ then the level of quality criteria of SWS can be excluded from the discussion.

The comparative assessments of alternatives $\{A_i\}$ for each criterion $K_i^2, i = \overline{1, n}$ can be obtained from the AHP or Modified AHP (MAHP).

Their applications are described in details elsewhere [5], [10]. The difference between MAHP and AHP is that first method determines the alternatives assessments by quality criteria solution from the condition of a minimum degree of consistency of the matrix of pairwise comparison. This approach allows expanding the limits of AHP application for greater quantity of alternatives (criteria) ($n \leq 30$) [10]. The weights of criteria are determined with expert method by calculating the integral criterion of alternatives' quality with applying of scalar convolution.

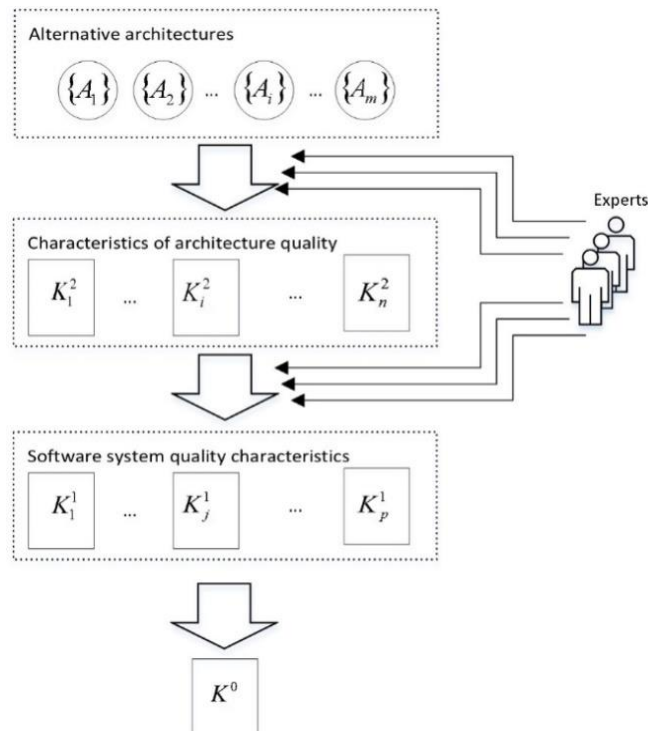


Fig.1. General description of the problem of multi-criteria software architecture evaluation.