A Quantitative Approach to Selecting Architectural Tactics Using Tactic Knowledge Base

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1 Introduction

Software architecture is mainly used to fulfill non-functional requirements(NFRs) regarding performance, availability and security at the earlier phase of software development[2]. Software architecture is used not only for shaping the structure of software, but also for organizing development teams, predicting development cost and planning integration of components so that it is crucial for a successful project. However, selection of architectural solutions has been mostly carried out in an ad-hock manner due to the abstract and informal nature of solutions. This leaves solution selection largely depending on the knowledge and experience of software architects on architectural solutions[4].

There has been some work to facilitate decision of architectural solutions(e.g., see [3, 4]). There are two research streams. One is the process based approach that suggests several activities and artifacts for deciding better architectural solutions. However, it is hardly used without skilled architects due to the lack of suggestion of concrete solutions. Others propose a quantitative approach to measure cost of each architectural solution by using the AHP[6]. Those have a shortcoming that software architects should estimate the cost only with their experience without considering in-depth complexity of each solution.

To address the above issues, we propose a quantitative approach to choosing architectural solutions based on the architectural tactic knowledge base, which is our previous work[5]. An architectural tactic as the one of the architectural solutions is an architectural design building block pertaining to a software quality[2]. The tactic knowledge base is a tactic knowledge repository composing of structural and behavioral models of architectural tactics, and their relationships expressed in feature model. In the paper, a cost of each architectural tactic is predicted by using the use case point method, and importance-level of each NFR is estimated in the AHP. Based on these, the architectural tactics with the minimal cost and high NFR satisfaction are selected by the proposed equations. At last, validation of the selected tactics are carried out in sensitivity analysis[7] to increase confidence for the selection.

2 A Quantitative Approach To Selecting Tactics

In our previous approach, we analyzed structure and behaviors of over twenty tactics for availability, performance and security quality attributes and specified their collaborative relationships in architectural tactic feature model[5]. Tactic knowledge base is consisted of the semantic of each tactic and relationships among them. The approach for selecting tactics is based on the knowledge base and it comprises three steps as shown in Fig. 1. It starts with tactic knowledge base and estimates a cost of each tactic using the use case point method[1]. The second step computes selection factors of candidate tactics for each NFR by predicting the minimized cost and maximized NFR satisfaction. Finally, the third step validates the selection factors with sensitivity analysis in order to increase confidence of selections.
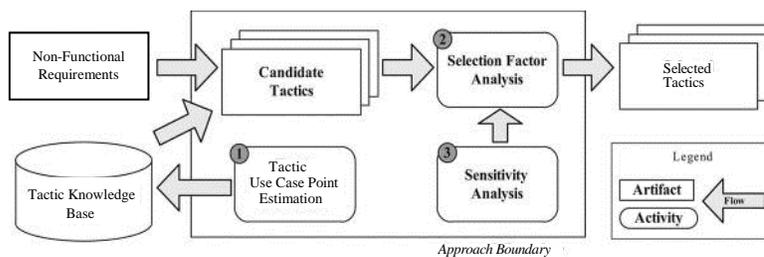

Fig. 1: An Overview for Selecting Tactics

Step 1. Tactic Cost Estimation

A *tactic cost* is a cost to realize an architectural tactic. We adopt use case point method to estimate the tactic cost, which has been used in conjunction with use case driven software development methods. To compute use case point, use case diagram, implementation technology and project environment should be considered. Although the tactic knowledge base does not have use case diagram including UML meta-level class and sequence diagram, it contains more concrete analysis model. Thus, we can extract information of use case diagram from the analysis model (e.g., the number of transactions between actors and a system). As the second step, a technical complexity factor(TCF) is computed to take technical characteristics of each tactic into account. We assigned scaled values into 13 technical aspect based on characteristics of tactics [2]. In addition, the use case point method proposes Environmental Factor(EF) to consider the project specific environments(e.g., application experience, stable requirements, etc.). However, we do not handle project specific states in the paper. Nonetheless, this factor may be tailored for the sake of accuracy.

Step 2. Computing Selection Factors

This step includes three sub-steps. It starts with choosing candidate architectural tactics for the given NFRs by consulting the architectural tactic feature model. Then, architects predict the architectural tactic contribution factors(ATCFs) for each candidate tactic

through the AHP. ATCF results from architect's quantitative estimation by pair-wise comparison between candidate tactics. Finally, the selection factors(SFs) of *ith* tactic are computed as below, where *n* is the number of candidates tactics for the *ith NFR* and TUCP is tactic use case point of each tactic. The equation implies that the tactic with the minimum cost and high contribution to the NFR has a high selection factor.

$$SFi = ATCFix \left(1 - \frac{TUCPi}{E^3_{3\_}{}^{n_i}TUCPi}\right)$$

Step 3. Sensitivity Analysis

The weakness of the previous step is a subjective measure of ATCF with AHP, which has potential to have wide variants. In order to mitigate the weakness and increase confidence of the measure, we applied the sensitivity analysis[7] into estimating ATCF. Sensitivity analysis computes the minimal value that guarantees the selection with the following equation.

$$Sens\,ATc\,F(T_k) \quad \frac{MAX(SFT,..SFT,_{\_l},\ SFT_{k+},..SFT,,)}{1 - TUC\,PT_k\,I\,E^{3\,=}_{3\,7}TUC\,P_3}$$

3 Conclusion

In this paper, we have presented an approach for selecting architectural tactics. This approach enables quantitative selection among architectural tactics from the tactic knowledge base in association with tactic cost and NFR satisfaction. Tactic cost estimation provides a mechanism to consider multiple aspects for tactic realization. The equations for deciding appropriate tactics and sensitivity analysis facilitate to formalize tactic selection and increase confidence for the selected tactics. Please note that all architectural solutions are not covered by the tactic knowledge base due to the evolution of the solution space. However the tactics specified in the tactic knowledge base can be automatically instantiated by using our previous work and tool support [5].

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