Architecture decisions

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Abstract

The perspective of looking at software architecture as the result of a set of architecture decisions has gained acceptance among researchers today. Nevertheless, although notable progress has been made in defining which content architecture decisions should entail, there is currently no commonly accepted approach to architecture decision modeling. Existing approaches do not satisfy all stakeholder concerns in decision description; they do not optimally support the architecting process, and they do not integrate well with the rest of the architecture documentation, which is usually arranged in multiple architectural views. The goal of this dissertation is to address the aforementioned problems by means of a new decision modeling approach. Apart from integrating into viewpoint-based architecture documentation, the modeling approach should support architects during the process of decision-making and during architecture evaluation.

In order to support the decision-making process, we first need to understand how decisions are made in practice, and which deficiencies exist in the reasoning process. To contribute to this understanding, this dissertation reports on two surveys. The first survey explores the decision-making process of final-year software engineering students. The results of the survey are compared to the architecture literature, in order to identify shortcomings in the reasoning process that should be supported by means of systematic decision documentation. The second survey was conducted to explore the optimal decision-making process of professional architects, from which we distilled a set of reasoning best-practices.

After gaining a good understanding of the decision-making process in practice, we started investigating how decision modeling can be improved. We first thought about a method to capture decisions and the rationale behind them, that does not require much effort by the architect during the design process. Many software systems are designed using patterns, which provide rich information about the applied solution and the rationale behind the solution in the form of a problem description and the forces that influence the selection of a solution. If an applied pattern can be identified in an architectural design, then a great part of the rationale that went into the decision can be deduced from the pattern description. This dissertation describes a controlled experiment with practitioners from industry and academia, which was conducted to find out if a focus on software patterns during architecture decision recovery leads to higher quality and quantity of the recovered decisions, compared to recovery that is not focused on identifying patterns. The experiment delivers statistically-significant evidence that a focus on patterns increases the quality of recovered decisions, while no conclusive

evidence concerning the quantity of recovered decisions was found.

Pattern-based decision recovery can help to recover and describe architecture decisions effectively, but it does not satisfy many other stakeholder concerns in architecture decision description. To address these concerns, and to integrate decision modeling with other viewpoint-based architecture descriptions, we developed a description framework for architecture decisions, which follows the conventions of ISO/IEC/IEEE 42010, the international standard for (software) system's architecture description. The framework consists of five interrelated viewpoints, each of which being dedicated to satisfying different stakeholder concerns in architecture decisions. The viewpoints of the framework can be used individually, or in combination, to describe the architecture decisions made in a software project. The framework's compliance with ISO/IEC/IEEE 42010 allows to combine it with other viewpoint based architecture descriptions. The framework was validated in two empirical studies, which provide evidence for the suitability of decision viewpoints to satisfy typical stakeholder concerns in architecture decision description.

In addition to being used for documenting architecture decisions, this dissertation explores the potential of decision viewpoints for supporting designers in making rational decisions. Therefore, a comparative multiple-case study was conducted with four groups of senior software engineering students. The results show that student groups, who create views according to the architecture decision framework, explore and evaluate candidate architectural solutions more systematically than student groups who do not use the decision framework.

The potential of decision viewpoints for supporting rational decisions lead to the assumption that recovering decision views after-the-fact supports evaluating how well decisions address the relevant decision forces. As a consequence, we developed an architecture evaluation method, which uses architecture decisions as primary evaluation targets. The method, called *Decision Centric Architecture Review* (DCAR), uncovers and evaluates the rationale behind the most important architecture decisions made in a software project, considering all relevant forces that must be addressed by the decisions. It uses viewpoints from the decision framework to support the evaluation process. Multiple executions of the method in companies from the distributed machine-control system domain have shown the applicability of DCAR in large industrial projects.