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An expert survey on kinds, influence factors and documentation of design decisions in practice

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HIGHLIGHTS

- We present results of a qualitative expert survey on design decisions in practice.
- We examine design decision classification, documentation, and influence factors.
- We collect architects' experiences in decision making and documentation.
- We provide recommendations for potential improvements and research directions based on the results of our study.
- Results are compared to literature and similar studies.

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ABSTRACT

Support for capturing architectural knowledge has been identified as an important research challenge. As the basis for an approach to recovering design decisions and capturing their rationale, we performed an expert survey in practice to gain insights into the different kinds, influence factors, and sources for design decisions and also into how they are currently captured in practice. The survey was conducted with 25 software architects, software team leads, and senior developers from 22 different companies in 10 different countries with more than 13 years of experience in software development on average. The survey confirms earlier work by other authors on design decision classification and influence factors, and also identifies additional kinds of decisions and influence factors not mentioned in previous work. In addition, we gained insight into the practice of capturing, the relative importance of different decisions and influence factors, and into potential sources for recovering decisions.

1. Introduction

Documenting the rationale of architectural choices is at the heart of software architecture knowledge management (SAKM) [1]. In the past few years several approaches to capturing design decisions and documenting their rationale have been proposed and successfully applied in practice [1]. When architectural knowledge is captured adequately, it serves as a means of preserving otherwise tacit knowledge. However, capturing and maintaining design decisions and their rationale raise the same issues as creating and maintaining other kinds of documentation, such as the high amount of effort involved in documentation [2,3], the lack of immediate benefits [4], the lack of time and budget [5] and the general difficulty of documenting design decisions during product development [4,6].

Different approaches have been developed specifically to address the problem of efficiently and systematically capturing design decisions. For example, ADDRA [7] is an approach that aims to recover architectural design decisions by comparing architectural views from different releases of a software system. The result is an architectural delta, which provides clues to an architect for recovering decisions. Another example is presented by Eloranta and Koskimies [8], which aims at systematically recovering and documenting architectural design decisions during architecture reviews. They specifically use the DCAR [9] review method, which is a decision-oriented review method, though in principle, any other architecture review method could be used. For example, identifying design decisions and rationale as part of *architectural evaluation approaches* is also an important aspect of ATAM (see [10, p. 48]).

We are currently working on an approach that combines several strategies for facilitating the capture of design decisions on both the technical and process levels. On the process level, we intend

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to support the capture and maintenance architectural decisions during architectural reviews through context information [11] and through providing a conceptual framework for capturing specific types of architectural decisions and influence factors for such decisions. On a technical level, we intend to (automatically) detect design decisions in code and other artifacts and to support the (manual) recapturing of the rationale for the detected decisions. We intend to base this research on existing work on the extraction of architectural structures from already implemented software systems [12].

To support these planned (and partly ongoing) research activities, we conducted an expert survey in practice to identify the potential kinds of architectural decisions, their drivers, and the sources of their documentation as used in practice. The presented study is an extension of a (more limited) study that has been performed with software architects from Austria [13] (see Section 6.7 for a discussion of the differences with this previous study). The survey presented here has been performed with 25 software architects, software team leads, and senior developers from 22 different companies in 10 different countries with, on average, more than 13 years of experience in software development. It confirms earlier work by other authors on design decision classification and influence factors and also identifies additional kinds of decisions and influence factors not mentioned in this previous work. In addition, we gained insight into the practice of capturing, the relative importance of different kinds of decisions and influence factors, and into potential sources for recovering decisions.

The remaining part of this paper is structured as follows. In Section 2, we discuss some previous and related work on design decision classification and on potential influence factors for these decisions. In Section 3, we present the research objectives and research questions. In Section 4, we describe the research approach and the study design. In Section 5, we present the results of the survey. The findings are discussed in more detail in Section 6. This section also contains a set of recommendations we derived from the findings and a discussion of the differences with the previous (more limited) study mentioned above. Validation and limitations are discussed in Section 7. The paper concludes with a summary of the main findings in Section 8.

2. Previous and related work

A taxonomy of design decisions is presented by Kruchten [14,15] and Kruchten et al. [16]. In this taxonomy, architectural design decisions are classified into existence decisions, nonexistence decisions (bans), property decisions, and executive decisions. An existence decision states that some element/artifact will exist in the systems design or implementation [17]. Existence decisions can affect either the structure or the behavior of systems. Structural decisions lead to the creation of subsystems, layers, and components, while behavioral decisions are more related to how elements interact to address some functional or nonfunctional requirement. Kruchten argues that existence decisions are the least important to capture since they are the most visible element in the systems design or implementation. Still, they should be captured in order to relate them to other decisions (e.g., to alternatives). We should add that Kruchten implies that the rationale for a decision is documented as part of the design or implementation artifact. The second kind of decision is nonexistence decisions, or bans. Such decisions state that some element will not appear in the design or implementation. It is very important to document such decisions and their rationale because they are not visible from the resulting architecture design or implementation [17]. The third kind of decision is property decisions. Property decisions state the central qualities of a system and include design rules and guidelines, as well as constraints on a system (in the sense of a property the system will not exhibit). Finally, executive decisions do not relate to the design or the system qualities and are driven by the business environment. They constrain the other kinds of decisions and affect the development process, people, organization, and the choices of technologies and tools.

van der Ven and Bosch [18] distinguish between high-level decisions, medium-level decisions, and realization-level decisions. High-level architecture decisions affect the whole product. Examples include deciding on a particular programming language, COTS components, or architectural styles. Medium-level decisions affect the selection of components or frameworks and the realization of architectural patterns. Realization-level decisions affect the structure of the code, the realization of design patterns, or API usage. Based on industrial experiences, van der Ven and Bosch argue that medium-level decisions are the hardest to make because they have a high impact on functional and non-functional system properties; they change constantly and are costly to change; it is hard to know all relevant alternatives; and they have unpredictable results until implemented in the system.

Zimmermann et al. [19] assign SOA-specific decisions to seven decision types on four refinement levels. Executive decisions and requirements analysis decisions reside on the executive level, as defined in the taxonomy by Kruchten et al. [16]. Pattern selection decisions and pattern adoption decisions reside on the conceptual level and are concerned with choosing architectural patterns from the literature and selecting pattern variants. Technology selection decisions and technology profiling decisions reside on the technology level and select certain technologies to implement the selected and adopted patterns and to specify implementation details such as technology standards. Vendor asset selection decisions and vendor asset configuration decisions reside on the vendor asset level and select commercial or open source assets and cover their installation and customization details.

Bass et al. [20, p. 293] categorize design decisions that architects have to make, including requirements that might affect the different decisions. The different categories mentioned are allocation of responsibilities, coordination model, data model, management of resources, mapping among architectural elements, binding time decisions, and choice of technology.

Influence factors are very important for characterizing a design decision and for providing the rationale for a design decision. Therefore, many authors have explored ways to capture influence factors [5], also called forces [16,9] and drivers [7,19]. In a survey on architectural design rationale, Tang et al. [5] identified several factors that influence decision making using a quantitative survey on design rational with 81 practitioners with more than 3 years of experience each. The participants were asked about factors that influence their design choices. Tang et al. proposed a number of generic factors identified in the literature, including design constraints, design assumptions, design weaknesses, costs and benefits of a design, design complexity, certainty of design, certainty of implementation, and tradeoffs between alternative designs. They then collected the relative importance of these factors according to the participants of the study, the frequency of use, and the frequency of documentation. For most of the presented generic factors, they observed that usage frequency is less than perceived importance, and documentation frequency is again less than usage frequency. In terms of usage frequency, constraints on the design, design benefits, and certainty of design were rated highest. In addition to these generic factors, the participants revealed a number of additional influence factors (without commenting on their importance, their frequency of use, and their frequency of documentation). Tang et al. classified these additional influence factors into three broad categories: business-goals-oriented, requirements-oriented, and constraints and concerns.