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Empirical evaluation of a process to increase consensus in group architectural decision making

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ABSTRACT

Context: Many software architectural decisions are group decisions rather than decisions made by individuals. Consensus in a group of decision makers increases the acceptance of a decision among decision makers and their confidence in that decision. Furthermore, going through the process of reaching consensus means that decision makers understand better the decision (including the decision topic, decision options, rationales, and potential outcomes). Little guidance exists on how to increase consensus in group architectural decision making.
Objective: We evaluate how a newly proposed process (named GADGET) helps architects increase consensus when making group architectural decisions. Specifically, we investigate how well GADGET increases consensus in group architectural decision making, by understanding its practical applicability, and by comparing GADGET against group architectural decision making without using any prescribed approach.
Method: We conducted two empirical studies. First, we conducted an exploratory case study to understand the practical applicability of GADGET in industry. We investigated whether there is a need to increase consensus, the effort and benefits of GADGET, and potential improvements for GADGET. Second, we conducted an experiment with 113 students from three universities to compare GADGET against group architectural decision making without using any prescribed approach.
Results: GADGET helps decision makers increase their consensus, captures knowledge on architectural decisions, clarifies the different points of view of different decision makers on the decision, and increases the focus of the group discussions about a decision. From the experiment, we obtained causal evidence that GADGET increases consensus better than group architectural decision making without using any prescribed approach.
Conclusions: There is a need to increase consensus in group architectural decisions. GADGET helps inexperienced architects increase consensus in group architectural decision making, and provides additional benefits, such as capturing rationale of decisions. Future work is needed to understand and improve other aspects of group architectural decision making.

1. Introduction

Designing the software architecture for a system involves making many architectural decisions [1]. Typical examples of architectural decisions are choosing development platforms (e.g. Java EE, .NET), database systems (e.g. Oracle, MongoDB), frameworks (e.g. object-relational mapping frameworks), or architectural patterns. Architectural decisions involve trade-offs (e.g. one decision may increase usability, but reduce security), are hard to make due to necessary trade-offs, and expensive to change (e.g. changing from the Java EE to the .NET platform) [2].

1.1. Problem description

In practice, most software architecture decisions are made in groups (and involve different stakeholders), rather than by individual architects [3,4]. Unfortunately, little is known about group architectural decisions, and how to improve group architectural

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decision making. In a recent mapping study on architectural decisions [5], we found that not much research exists on group architectural decisions. Group architectural decision making entails substantial challenges, such as communication among decision makers and the need to reach a certain degree of consensus between decision makers and other stakeholders [6].

Increasing consensus among decision makers is a critical factor of group decision making. On the one hand, low consensus in early architectural decisions may lead to misunderstandings within the group of decision makers [6]. Such misunderstandings may cause problems. For example if a stakeholder feels that her point of view about a decision was not taken seriously, that stakeholder might not accept the final software system. On the other hand, benefits of consensus include higher acceptance and better understanding of the architectural decision by all involved stakeholders. Furthermore, consensus increases confidence in the correctness of the architectural decision [6]. Therefore, consensus needs to be addressed explicitly as part of group architectural decision making. However, as mentioned before, no approach from software architecture literature targets explicitly the increase of consensus in group architectural decision making.

Regarding the scope of this paper, we focus on *consensus* (i.e. ‘we have some general agreement and we understand each other’s perspectives’) instead of *unanimity* (i.e. ‘all of us have the same perspectives’). Furthermore, in our work, *consensus* has two main components: *general agreement* and *mutual understanding* among stakeholders involved in making a decision [7]. Therefore, in this paper, we focus on how to increase *general agreement* and *mutual understanding* among inexperienced architects.

1.2. Contributions

In this paper, we propose and evaluate GADGET (*Group Architectural Decisions with repertory Grid Technique*), which is a group decision making process for helping architectural decision makers (e.g. architects and other stakeholders who have a decision-making role) increase consensus about their decisions. GADGET aims at helping groups that are recently formed and which do not have common procedures and processes in place, and therefore may benefit from a standardized way of interaction. The process offers guidance for increasing consensus incrementally, making explicit the knowledge of the decision makers, and helping them structure their group interactions.

This paper contributes with the GADGET process and empirical evidence of how GADGET increases consensus in group architectural decision making. The validation has two parts:

- a case study with seven students and 13 practitioners
- an experiment with 113 students to answer research questions that emerged from the case study

1.3. Paper structure

Fig. 1 shows an overview of the research presented in this paper. Phase 1 consists of previous work that motivated the research in this paper. While investigating how architectural decisions are made in practice [3], we found out that most architectural decisions are group decisions, similar to [4]. Furthermore, one of the outcomes of a systematic mapping study on architectural decisions literature was that there is little research on group architectural decisions [5]. These outcomes motivated us to propose an approach to improve consensus in group architectural decisions in phase 2. The resulting approach (GADGET) is presented in Section 2. In phase 3, we conduct a case study to collect initial evidence on the practical applicability of GADGET. As reported in Section 3, case study results also suggested that no systematic approach is used in practice for reaching consensus (we term any ad-hoc approach used as ADHOC). In phase 4, we conduct an experiment to compare GADGET vs. ADHOC, and obtain causal evidence on how GADGET increases consensus compared to ADHOC (see Section 4). Furthermore, we discuss validity threats of the case study and the experiment in Section 5, and related work in Section 6. Finally, Section 7 presents conclusions and future work.

2. The GADGET process

To describe the GADGET process, we present its roots (Section 2.1) and concrete steps (Section 2.2).

2.1. GADGET roots

GADGET extends our previous work on making and capturing architectural decisions with the **Repertory Grid technique** [8–10], with the idea of group evaluations and feedback from the **Delphi technique** [11].

The **Repertory Grid technique** [12] is a structured technique for knowledge acquisition [13]. In our previous work, we adapted the Repertory Grid technique for architectural knowledge acquisition [8–10], and presented evidence about advantages and disadvantages of using the Repertory Grid technique for making and capturing architectural decisions. For example, the Repertory Grid technique provides systematic architectural decision making support, concise documentation, and reduces architectural knowledge vaporization. The Repertory Grid technique adapted for architectural knowledge acquisition consists of the following steps:

1. Indicate a decision topic.
2. Indicate decision alternatives.
3. Get concerns that characterize decision alternatives (e.g. through repeated comparisons among alternatives); the output of Steps 2 and 3 is a matrix (or grid) with concerns as rows and alternatives as columns.
4. Prioritize concerns (e.g. using the *hundred-dollar approach*: assign a priority to each concern from 0 to 100, so that the sum of priorities is 100 [8]).
5. Rate alternatives against each concern using a one-to-five Likert scale, which fills the matrix of alternatives and concerns with ratings.
6. Analyze the matrix of alternatives, concerns, and ratings to indicate the most preferable alternative (for detailed examples, see [8–10,12]).

The **Delphi technique** is a ‘*method for structuring a group communication process so that the process is effective in allowing a group of individuals, as a whole, to deal with a complex problem*’ [11]. In Delphi, participants answer questions on a complex problem in several iterations, receive a summary of answers from all other participants, and are given the opportunity to revise their answers for the next iteration. After several iterations, the answers converge and determine the solution to the complex problem.

In addition to Delphi, we also considered other techniques to be included in GADGET, namely *brainstorming* [14] and *nominal group* [15]. However, we preferred Delphi for the following reasons. *Brainstorming* is strong at generating new, creative ideas, while performing evaluations. Since our goal was to increase consensus, these characteristics were not high priority for GADGET. The *nominal group* technique has similar steps as Delphi, but the evaluation step is anonymous. We preferred that GADGET has an open evaluation step, so that participants can communicate and understand faster each other’s perspective

2.2. GADGET steps

Fig. 2 shows the five steps of GADGET. The input of GADGET is an architectural decision topic (e.g. choice of database, architectural