Information and Software Technology xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Information and Software Technology

journal homepage: www.elsevier.com/locate/infsof

Group decision-making in software architecture: A study on industrial practices

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ARTICLE INFO

Keywords:
Group decision making
Software architecture
Architectural design decisions

ABSTRACT

Context: A Software Architecture results from a comprehensive process in which several stakeholders deliberate upon the key requirements, issues, solutions and make architectural design decisions. Literature shows that most architectural decisions, in practice, are made in groups. Still, there is a limited understanding of industrial group decision-making practices in software architecture and the challenges that software architecture groups face.
Objective: Our study, by drawing inspiration from group decision-making theories and models, aims at understanding (i) Existing decision-making practices in software architecture groups (ii) the comparison between practice and theory, (iii) the challenges that the groups face, and (iv) the satisfaction of group members with various aspects of Group Decision Making.
Method: The study has been conducted through a questionnaire-based survey. 35 practitioners participated in this survey and the responses were analyzed qualitative and quantitatively.
Results: The analysis of individual responses reveal that software architecture groups (composed, on average, of 3–5 co-located or dispersed members) adopt a discussion based approach while evaluating alternatives, thereby lacking a structured way of decision-making. In these groups, despite the involvement of group members in the discussions, the final decision is made by an individual of authority. Not only is structured decision-making less common, the usage of dedicated software tools for decision-making too is rare. These groups face challenges that are indicative of Groupthink and Group Polarization. Group members feel that quantity of alternatives generated during discussions and tool availability are below satisfactory and they have low satisfaction with the tool support available.
Conclusion: This study has helped us develop an understanding of software architecture groups, their decision-making practices and challenges faced together with the satisfaction of group members. What the industry needs is integration of group decision-making principles into software architecture decision-making and design of decision-making tools that assist the architecture groups.

1. Introduction

"Architecting = Decision Making" was the title used by Hans Van Vliet for his keynote speech at ECSA 2014, the 8th European Conference on Software Architecture. It summarizes a trend initiated in 2005, emphasizing that a software architecture (SA) consists of both Architectural Design Decisions that lead to a chosen solution and a blueprint of the solution [1].

Designing a good architecture involves making the right architecture design decisions (ADDs). Therefore, design decisions can be looked at as first class entities [2]. Substantial amount of research has been carried out, in the last decade, to document and record ADDs in the form of Architectural Knowledge and the design of tools and methods to support the decision-making process [3]. While most of these tools and methods put an individual at the center of the design decision process, the industrial studies on ADDs show that decisions are taken by groups of stakeholders [4]. With several stakeholders interacting with each other to make key ADDs, it may be useful to view SA decision-making as a Group Decision Making (GDM) process. Therefore, *"Architecting = Group Decision Making"* is the way we would like to rephrase and expand Hans Van Vliet's statement. The "group" dimension adds another layer of complexity and opportunities to the current decision-making processes and methods.

Existing SA decision making tools and methods provide very little support for the GDM processes followed in organizations while architecting software [4–6]. The vast amount of knowledge and insights

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https://doi.org/10.1016/j.infsof.2018.04.009
Received 15 August 2016; Received in revised form 27 April 2018; Accepted 28 April 2018

Table 1
Main findings.

RQ	Key Finding	Description
RQ1	Existing GDM Practice	Real world SA groups adopt a purely discussion based approach to decision-making with minimal inclination to structured approaches. There are two types of decision-making styles that are observed in SA groups: i) Democratic style where discussions happen in a group while the final decision is made by person of authority, or b) Laissez-faire styles where group has full control over the process and decisions. Autocratic decision-making style has not been mentioned by any respondent.
RQ2	Alignment with GDM literature	GDM literature reveals that structured decision-making methods and heterogeneity of composition lead to better outcomes. Our study shows a preference for unstructured decision-making methods and homogeneity among SA groups.
RQ3	Challenges Faced	The existing GDM practices among SA groups cause a lot of challenges like lack of diversity in perspective, not exploring the full range of risks of a specific decision, accepting low risk solutions etc. Some of these challenges indicate the presence of *Groupthink* and *Polarization*.
RQ4	Satisfaction of SA group members	Group members feel that quantity of alternatives generated during discussions is below satisfactory and they have low satisfaction with the tool support available for making group decisions.

available in GDM literature is yet to be harnessed by the SA community.

In this paper we present a study of industrial practices of GDM in SA. The research questions that guide our study are: RQ1: What are the existing Group Decision Making practices in real world SA groups? RQ2: Are the group decision-making techniques currently being practiced in line with techniques in GDM literature? RQ3. What are the challenges that SA groups face while making architecture-related group decisions? RQ4: How satisfied are SA group members with various aspects of GDM?

Guided by the research questions, a questionnaire was designed consisting of 49 questions and circulated online. Question wise analysis of the survey responses was done using quantitative and qualitative methods and the analysis yielded answers to the research questions.

1.1. Main findings

Our main findings are highlighted in Table 1.

1.2. Paper outline

Our paper is organized as follows. Section 2 presents a thorough background on GDM literature, as well as information on Architectural Design Decisions. Section 3 presents detailed information on the methodology used for collecting, organizing and analyzing our survey data. The systematic analysis of data and a summary of results is presented in Section 4. A discussion of our findings is presented in Section 5. Threats to validity are discussed in Section 5.2. Related work are presented in Section 6. We conclude and lay the foundation for our future work in Section 7.

2. Background and motivation

This section introduces background information on group decision-making (Section 2.1), as well as state-of-the art information on architecture design decision (Section 2.2).

2.1. Group decision making

Group decision-making is a research area that aims to understand and develop methods to enhance the collective decision process. This area, combined with research on negotiation, has a vast and growing literature associated with diverse areas of Economics, Engineering, Psychology and Neuroscience [7].

While studying GDM, researchers have focused on different aspects of the groups including *group characteristics* like size, composition and cohesion [8–12], the *stages in the formation of groups* [13], *information exchange* within the group [14–16], GDM *methods* [17] and *issues* faced like Groupthink, Groupshift (risky-shift) and Polarization [18–22].

Early works on GDM focus on understanding *how and under what circumstances* were groups better than individuals. Laughlin et al. have proved, through their experiments, that groups definitely outperform individuals on complex tasks and the ideal group size for an efficient performance is between 3 to 5 members [23]. Group performance is impacted by the *cohesiveness* of members. Festinger defines cohesiveness as *the resultant forces which are acting on the members to stay in a group* [24]. Cohesiveness is developed when members have worked with each other on a specific task for an extended period of time and the members have resolved issues that arises in new groups [25].

The outcome of the GDM process and the quality of outcome is significantly impacted by the *amount of information that is shared* amongst the group members [26]. A “good” GDM process should ensure that more “unshared” information (i.e., information that is known only to a few members in the group) is brought to light through a process of discussion and deliberation [14].

There are several studies on the *GDM methods* and their applications in various fields. Peniwati in [17] has used an evaluation framework with 16 criteria to evaluate the various GDM methods in literature. When it comes to GDM processes, Aldag and Fuller [27] describe a Generic Group Problem Solving Model (GGPS) that summarizes different aspects of GDM including: *decision characteristics, group structure,* and *decision-making context* that impact the overall *emergent group characteristics*. Insights derived from the GGPS model and evaluation framework of Peniwati [17] has guided the design of our questionnaire.

2.2. Architectural Design Decisions

Architectural Design Decisions (or simply, ADDs) are recognized to be important building blocks in the design of a software architecture. ADDs involve choosing the right architectural entities that satisfy the stakeholder concerns as well as the quality criteria set for the system.

These decisions form a vital part of architectural knowledge and hence recording and maintaining them is of utmost importance [28]. Practically, it may be difficult to change the architectural decisions since they are closely intertwined with other decisions, and any change impacts the architecture, design and the code of the system. Due to this complex interconnections, a bad decision-making process may result in the choosing of worst alternatives thereby impacting the final outcomes [29]. Hence a lot of care is taken to make (quasi-)optimal decisions that are valid for a long period of time. The ADD techniques as surveyed by Falessi et al. [29], and the tools currently available for ADD are focused on capturing and storing architectural knowledge. These tools help architects to record the requirements, decision alternatives, solutions, rationale, constraints and criteria. SA decision-making methods like ArchDesigner [30], ATAM [31], and CBAM [32] not only facilitate recording of decisions but also assist architects in making decisions. To some extent, they also support GDM by allowing multiple stakeholders to express their preferences and make optimal choices through trade-offs or pair-wise comparison. Attribute-Driven Design is an approach to designing software based on quality attribute requirements. The method requires architects to work in teams [33]. To a certain extent, AD_{kwik} proposed in [34] supports collaboration by allowing multiple stakeholders to create and share architectural