Towards an Architectural Perspective for Sustainability

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Abstract

The increasing importance of sustainability in organisations makes it necessary to integrate sustainability concerns into software-intensive systems at the earliest stages of development. However, there is a lack of guidance on how to target such concerns within software architecture. We want to fill this gap by proposing a specific type of architectural *perspective*—a sustainability perspective—tailored to guide software architects incorporating sustainability into their software architecture processes. Unlike architectural viewpoints, which are often too abstract or context-specific, perspectives are designed to be flexible across different architectural frameworks so that they can be used in various industry contexts. The goal of this extended abstract is twofold: (i) we motivate this research by discussing how a sustainability perspective can help architects addressing novel sustainability concerns; and (ii) we want to collect early feedback from the scientific community by outlining our planned research approach.

Keywords

Software Architecture, Architectural Perspective, Sustainability

1. Introduction

In this research, we aim to provide comprehensive guidelines for software architects in tackling sustainability at software design time. Sustainability has emerged as a key concern in contemporary software engineering, reflecting its growing significance in organizational strategy and practices [1]. However, achieving sustainability in software systems is not only the responsibility of isolated architectural components, but rather embraces the entire software design—the software architecture.

Despite business' increasing commitment to sustainability, integrating these new requirements into the software architecture process remains unclear [1]. Many architectural decisions are guided by experience and tacit knowledge [2, 3]. Despite sustainability gaining prominence only in recent years [4], this necessary experience is not yet fully established. Consequently, there is a need for structured guidelines to support architects effectively [5, 1]. Architectural perspectives [6], in short *perspectives*, could serve as these guidelines.

Perspectives are defined as *"a collection of architectural activities, tactics, and guidelines that are used to ensure that a system exhibits a particular set of related quality properties that require consideration across a number of the system's architectural views"* [2, p.47]. Addressing quality properties is the essence of the architecture process. We believe that perspectives could serve as a powerful tool to assist architects embedding sustainability into their designs—if they are developed based on the needs of industry.

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2. Motivation and Related Work

Viewpoints [7] guide the architect in illustrating and representing one or more quality concerns in form of views (i.e., diagrams or textual descriptions) by providing recurring patterns and conventions [7, 2]. For instance, the deployment viewpoint guides architects in creating views pertaining network and runtime concerns [2]. While this concept works on concerns that pertain a rather isolated context and only certain stakeholders, other quality concerns such as security are cross-cutting in nature and affect the whole architecture and various stakeholders simultaneously [2, 8]. Therefore, cross-cutting concerns must be addressed across multiple views, too. Research has shown that sustainability quality requirements can be considered as multi-dimensional [9] and thus cross-cutting. Architectural perspectives provide structured guidance for managing and addressing these cross-cutting concerns that affect multiple architectural views. This adaptability makes them particularly relevant to industry, where software systems must meet diverse and evolving requirements.

The work from Jagroep et al. [10] can be considered as the most related to ours. The authors propose an energy consumption perspective and validate it with a case study. The perspective is based on a new quality attribute 'sustainability' with its sub-characteristic 'resource consumption'. The authors provide a set of measures and metrics for the identified quality properties 'software utilisation', 'workload energy', and 'energy usage'. Even though such measures and metrics are indeed helpful for the further process of monitoring the software system and reflecting on taken decisions, the concept of measures and metrics are not per se part of an architectural perspective as these do not help in targeting certain concerns within architecture views. We would consider these rather as architecture assessment.

Compared to our vision of a sustainability perspective, we want to tackle the problem from an architecture knowledge angle rather than from a measurement angle. However, we want to build up on the results of Jagroep et al. and complement the existing gaps as outlined by their future work: (i) providing a comprehensive perspective including tactics, pitfalls, and the checklist; and (ii) putting the work into a fresh light by updating it with a recent view on the notion of sustainability in software engineering and software architecture.

In our research, we want to revisit the concept of perspectives by aligning them with industry needs. To the best of our knowledge, there is currently no empirical evidence on (i) whether and how perspectives are used in industry after their introduction 20 years ago, (ii) whether all elements of a perspective are equally useful, and (iii) whether 'energy consumption' is *the* quality concern that experts demand, as suggested by the existing perspective of Jagroep et al. [10]. Based on these new requirements, we define our intended research approach as outlined below.

3. The Envisioned Approach

To propose a sustainability perspective which is both grounded in theory and effective for its usage in industrial practice we plan to use Design Science Research (DSR) [11] to create iteratively our artifact. This paper represents our initial phase where we explore our research idea and motivate our vision. Figure 1 outlines our planned research approach and the different DSR phases, explained in the following.

Phase 1: ***Problem Definition.*** We adopt a **forward snowballing** approach to systematically scan the literature to identify studies that have proposed new perspectives. We want to understand how Rozanski & Woods' [2] perspective catalog has evolved over time. We base our forward snowballing on the two earliest works in which the notion of architectural perspectives was first proposed: (i) the research paper by Woods & Rozanski [6], and (ii) the book by Rozanski & Woods [2] that followed the paper a year later. Papers relating to perspectives should cite at least one of these works.

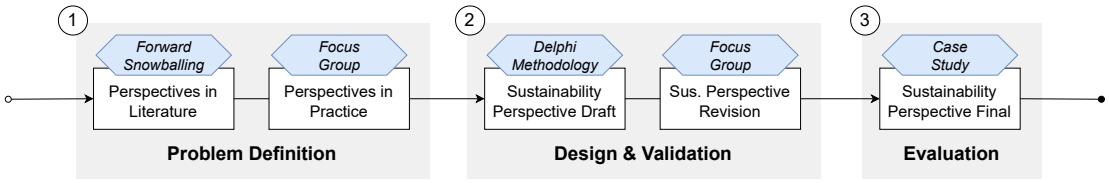

Figure 1: The planned research approach

Since the notion of perspectives was proposed already almost 20 years ago, we are curious about the industrial relevance of perspectives and whether the concept has evolved with industry needs. This understanding will allow us to elicit the requirements to deliver an artifact that is useful for professional practice. To this end, we plan to conduct a **focus group** among the authors of the concept of architectural perspectives and two more experts who have years of experience in industry and software architecture.

Phase 2: ***Artifact Design and Validation.*** Based on the elicited requirements, we conduct an iterative process to design our perspective. Instead of presenting a finished artifact grounded only in theory, we opt for an incremental design which is reviewed and improved by experts in the field. Given the results of Phase 1, we may adapt the perspective structure and its elements according to industry needs.

To select the perspective *qualities*, *concerns* and *viewpoints*, we plan to use the **Delphi method** [12]. To derive a clear picture about the current needs in industry, we use a Delphi as "group decision technique" [12] with multiple rounds until we reach consensus. We build consensus about what qualities and concerns our perspective should focus on, as well as which viewpoints it should target. For the other perspective elements (i.e., *activities*, *tactics*, *pitfalls*, and *checklist*), we will conduct further research, make use of existing knowledge in the literature, and facilitate our research experience in the field of software sustainability and sustainable architecture.

In the subsequent step we present the artifact to another group of experts in the form of another **focus group**. We expect a different set of experts compared to the Delphi to validate the perspective. We are interested in both the applicability in professional practice and further input about the sustainability angle of our perspective.

Phase 3: ***Evaluation.*** After we have constructed a first prototype of our artifact that is accepted by the focus group, we begin to implement and apply our perspective in a real case in the form of a traditional **case study**. We have access to various industry collaborators in different sectors.

We evaluate our perspective with the experts involved in the case study; if applicable, we refine it according to the feedback received.

4. Conclusion

In this work, we elaborate on the need for a novel architectural perspective on sustainability—with the ultimate goal of creating such a perspective in a systematic way. We present our research approach following the DSR phases. Our future work is to continue with research phase 1, i.e., exploring the literature through forward snowballing and reviewing the concept of perspectives within an expert focus group. In our vision, the impact of formulating a sound sustainability perspective would help software architects to create software-intensive systems that integrate sustainability by design and in the long term.

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