Systems of Systems Perspective in IT Project Quality Management

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Abstract

The quality management of projects, in general, and IT projects, in particular, have been a topic of research for several decades. However, quality management is usually considered as a subset of project management per se, which includes such aspects as project initiation, team formation, responsibilities allocation and others. In this position paper we abstract from abovementioned aspects and focus on only one perspective in project management, which to the best of our knowledge has not been intensively studied. We propose to focus on the perspective of Systems of Systems in project quality management paying more attention on the systems that are related to and inside a particular IT project. For this purpose, the questions for further research are defined regarding three aspects of IT project quality management: product, process, and inputs of an IT project.

Keywords

Complex Systems, SoS, Quality Management, IT Project, Enterprise Architecture, Requirements Engineering.

1. Introduction

Project quality management is part of project management in IT project development. Quality management as such has its application domain independent as well as specific features. For instance, Low and Ong [1] have amalgamated different generic issues of project quality management and developed a comprehensive systems of quality attributes for construction projects. In this paper, we focus on the quality management of IT projects that become more and more dependent on requirements for speed, flexibility, and user friendliness of the product in the era of digital transformation.

While project management (including IT projects) and quality management, as the disciplines, and their intersection "project quality management", are under the research for several decades [1], the quest for understanding the IT projects from the System of Systems perspective has attracted wider attention mainly from 2019 when ISO/IEC/IEEE 21839:2019 standard "Systems and software engineering – System of systems (SoS) considerations in life cycle stages of a system" was issued. Ncube and Lim [2] explain how the systems that form a SoS (constituent systems) can be related concerning ownership and operations and how the same constituent systems can belong to several systems. These issues are also relevant in IT project management. For instance, the service developed by company X belongs to the system of its offered services and will also belong to the information systems of user system Y.

The goal of this paper is to explore the scope of questions concerning the SoS perspective on IT project quality management. These questions might be helpful in defining the potential research tasks in developing methods and tools for supporting IT project quality with respect to this perspective.

The paper is structured as follows. In Section 2, we discuss current trends in IT project management and the quality challenges of IT projects. In section 3, we consider SoS aspects related to IT project

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management and propose research topics (questions) that can lead to IT project quality improvement. We conclude the paper in Section 4.

2. Current trends in IT project management regarding the quality

In the IT area, usually, the IT project quality management is considered as a subset of overall quality management and project management: "IT quality management" ⊇ "IT project management" ⊇ "IT project quality management" [3]. SoS's perspective on IT project quality management has not been, specifically, addressed. Nevertheless, IT project quality management has been viewed from the system perspective. For instance, Software Quality Journal has recently published an issue on information systems quality management [4], that considers a wide range of quality related issues such as temporality of technical debt, grouping of app reviews, test regression, secured bulk creation, migration to hybrid information systems, generating end-to-end test scripts, the use of sensors, and human factors in agile projects. The closest to the SoS perspective, in this issue, is the topic of controlling and evaluating the service and transaction dependability of complex IoT systems.

The systemic approach to IT project management is proposed in [5]. This paper discusses the need for joined effort from both project managers and the technical team in view of organizational level achievement in software quality assurance and provides a general overview of how software change control is carried out in the context of IT project management. Referring to their previous work, the authors of [5] show relationships between systems development and project life cycles. While, in most of cases, the software is regarded as a product of an IT project, this work considers IT product as both software and hardware; and distinguishes also between IT products and services. This helps to see the spectrum of issues to be considered regarding IT project quality management in a systemic way, but does not explicitly put these in the context of SoS.

IT project quality in the context of quality standards is discussed in [6]. Here, both the product quality model and the quality in use models are presented; and software internal and external quality and the quality in use are considered systematically in relation to requirements specification and evaluation. In this paper, the product is viewed on three layers: software, computer system, and system; and SoS issues are also, to some extent, considered in it. Nevertheless, the authors do not go beyond of the borders of software engineering in their research.

Indirectly, IT project quality management is discussed in recent works on problems regarding agile IT projects. The most comprehensive report on these problems and possible treatments is given in [7]. Analysis of these issues can lead to the conclusion that knowledge management has to be addressed with new tools and processes in IT projects [8]. Research on agile projects emphasizes the essential role of requirements in achieving high quality results in software systems development. Not surprisingly, the requirements engineering is an area comparatively intensively addressed from the SoS perspective [9]-[11]. However, the available research results rather concern suggestions for the research agenda than report on proposed and validated methods. In this paper, we will further discuss the areas where the research is needed to address the IT project quality management from the SoS perspective.

3. SoS related aspects of IT project quality management

When discussing the SoS related aspects of IT project quality management we will distinguish between three essential quality aspects: the quality of the *product*, the quality of the *process*, and the quality of the materials (*inputs* to the process) while leaving the quality of performers of the process out of the scope of the discussion. We assume here that any IT project takes place in an enterprise or in an enterprise ecosystem (or digital business ecosystem [12]). One of the well-founded ways of considering an enterprise as a system is using enterprise architectures [13]-[17]. Therefore, we will use ArchiMate [18] enterprise architecture representation language framework for illustrating the SoS related aspects of IT project quality management. Research on these aspects may lead to new solutions that may help to deal with such challenging aspects of SoSs as *independence*, *distribution*, *emergence*, and *evolution* [9] in the quality management of IT projects. We will use the full ArchiMate meta-model

with simplified relationships[2], extended with the physical layer, to illustrate the system aspects inside the enterprise (Fig.1). It must be respected that we shall not neglect that the SoS goes beyond of one enterprise and may concern similar enterprise architecture elements in other enterprises.

The enterprise architecture representation used further in this section reflects several constituent systems of the enterprise. The technology layer (C) illustrates computing infrastructure that includes hardware and operating systems; the application layer (B) illustrates software systems from the enterprise-user perspective; the business layer (A) stands for business execution system, the strategy view (E) and motivation view (D) stand for decision making system, physical layer (F) stands for physical environment system, while implementation view (G) stands for project management and execution system. IT project quality management aspects address the elements of these systems, and we can see that, in general, every element in one system is related to elements in other systems. Thus, it is essential to see when, how, and which relationships are to be considered when addressing, the product of an IT project, the process of the project, and inputs of the project.

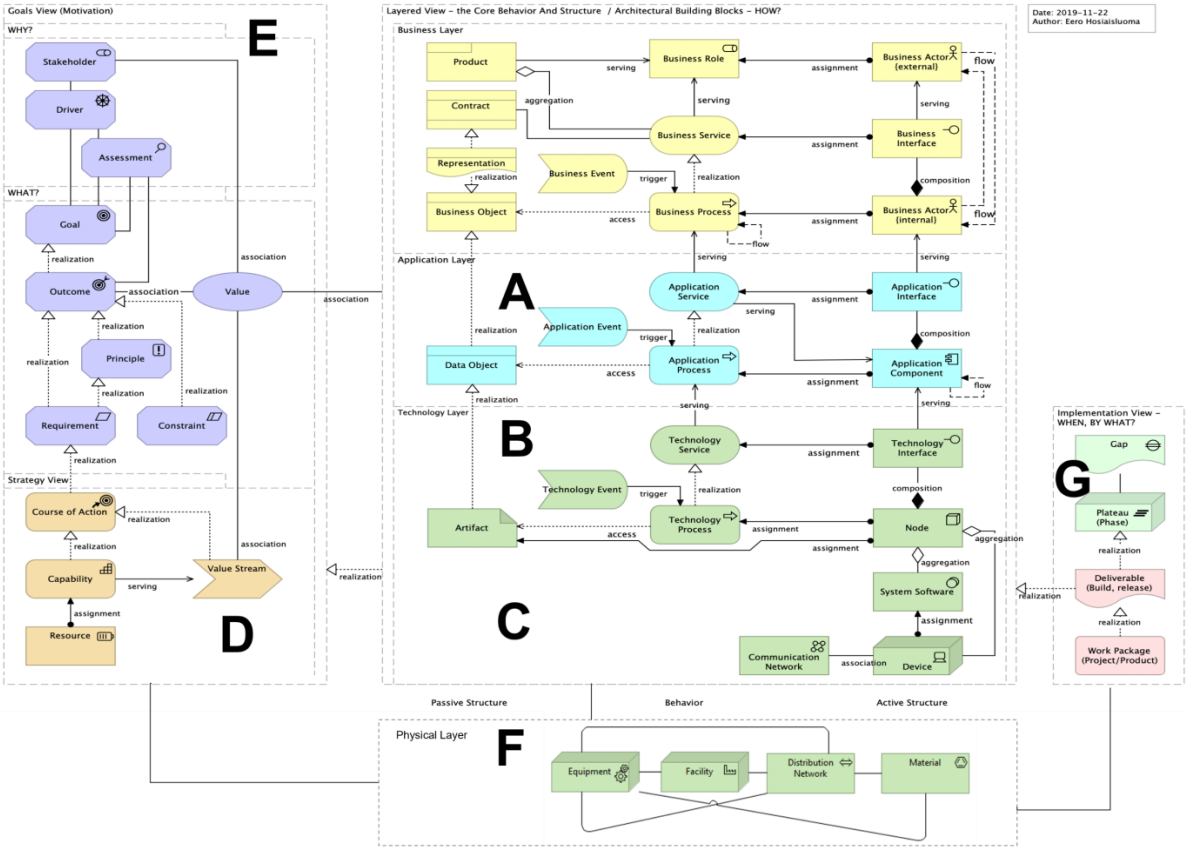

Figure 1: Constituent systems A-G of an enterprise (A,B,C,D,E, and G parts adopted from https://www.hosiaisluoma.fi/blog/archimate-metamodel/)

3.1. IT product from the SoS perspective

Depending on the project, an IT artifact can be regarded as just software or also as software and hardware [5]. Thus, in Fig. 1, the product can be represented with the System A, or with the System A&B. We can see that these systems themselves can be regarded as SoSs, as we can distinguish between data systems, service systems, package systems, etc. A and B are constituent systems of an enterprise as a system. Therefore, the IT project's product must also be viewed from at least business and decision-making perspectives. Consequently, for the product aspect of IT project quality management, we shall find the answers to the following questions:

[2] https://www.hosiaisluoma.fi/blog/archimate-metamodel/

- What tools and methods should be used to identify product scope and relationships in systems A or A&B?
- What tools and methods should be used to identify relationships between the constituents of the product and the rest of the systems (C-G) in enterprise architecture?
- How to ensure continuous estimation of an expected product quality respecting changes in the related elements in all related systems?
- Looking at the product as a SoS, how can its independence, distribution, emergence, and evolution be modeled and analyzed?
- Looking at the product as a constituent system, how does its independence, distribution, emergence, and evolution may impact other constituent systems and a parent SoS?

Concerning product quality per se, many methods are proposed for quality assurance and control, part of which are well automated [4]-[6]. These methods are beyond of the scope of this paper. Nevertheless, in further research, these methods can be analyzed from the SoS perspective and may add to answers to the questions stated above.

3.2. IT project process from the SoS perspective

IT project as a process can be situated in system G of Fig. 1. Knowledge-wise it is related with all other systems. In the case of in-house development, on the one hand, this process is a constituent system of processes of an enterprise which will use the product, but, on the other hand, it can also be a constituent system of processes of a developer enterprise. As a process, it might be a subject of the same quality characteristics as the enterprise business processes [19], including the quality of business process models [20]. Similar to the product aspect, the project process itself can be viewed as a SoS. Therefore, the following questions regarding it are relevant from the SoS perspective:

- What tools and methods should be used to identify the project process and dependencies among its constituents in System G?
- What tools and methods should be used to identify relationships between the constituents of the IT process and the rest of the systems (A-E and F, if applicable) in enterprise architecture?
- How to ensure continuous estimation of an expected process quality respecting changes in the related elements in all related systems?
- Looking at the process as a SoS, how can its independence, distribution, emergence, and evolution be modeled and analyzed?
- Looking at the process as a constituent system of other enterprise processes, how does its independence, distribution, emergence, and evolution may impact other constituent systems and a parent SoS?
- While process quality is a very well researched topic [19], the traditional methods do not directly address the above-stated questions. Therefore, additional research is needed to see how existing approaches could be used and/or extended to be applied in the SoS context.

3.3. IT project “Materials” (Inputs) from the SoS perspective

The main IT project “materials” or inputs are requirements. In Fig.1, requirements are situated in System E and are related to all other systems (A-D, F (if applicable), and G). Requirements can themselves form a SoS. Problems, challenges, and some of the possible solutions regarding requirements in SoS are discussed in [8]. Respecting the related work in [7] and [8], the following questions can be considered as relevant concerning requirements quality from the SoS perspective:

- What tools and methods should be used to identify and maintain the dependencies between the requirements so that they might be considered as a system?
- What tools and methods should be used to identify relationships between the requirements and the rest of the enterprise architecture elements?
- How to ensure continuous estimation of the expected requirements quality respecting changes in the related elements in all related systems?

- Looking at the requirements as the SoS, how can requirements independence, distribution, emergence, and evolution be modeled and analyzed?
- Looking at the requirements as a constituent system of other enterprise systems, how may requirement system's independence, distribution, emergence, and evolution impact other constituent systems and a parent SoS?

The related work [7], [8] shows that requirements quality may depend on project knowledge management quality. However, knowledge management in SoS is itself a scarcely researched topic.

4. Conclusion

This paper amalgamated open questions when considering IT project quality management from the SoS perspective. We looked at three main aspects of IT project quality management, namely, the quality of the product (software and/or hardware), the quality of the project process, and the quality of requirements (input of the process). Looking at the questions stated for each quality management aspect, we can see that the scope of questions is similar. For each aspect the methods and tools are needed which support considering the aspect as a SoS and discovering the relationship between this SoS and other SoSs, which might be at the same or at different levels of the systems' conceptual hierarchy. Additionally, for all aspects, the methods for identifying and handling of SoS related properties, such as independence, distribution, emergence, and evolution, are needed. It is also essential to be able to see the relationships between all identified SoS at the level of their constituents.

This work is limited only to the questions that arise when looking at IT project quality management from the perspective of SoS. Further research is needed to get satisfactory answers to these questions, which have become more and more important in different digital transformation projects in enterprises' digital ecosystems. The future research to model project management using the SoS approach will be directed towards the investigation of morphological and functional structures for SoSs with and without central management entity. The systems which compile SoS for several case studies will be identified, the corresponding structural models will be constructed, analyzed as well as decomposed, and the result of decomposition, namely, constituent elements will be described from the static and the dynamic point of view based on systems thinking considerations. The next step will be the cause-consequence analysis of relationships between components with purpose to understand the antecedents of project quality and the various criteria for its assessment. The overall research strategy will be focused mainly on collaborative and virtual SoSs where the use of multiagent systems paradigm seems to be perspective issue regarding the practical implementation of the proposed approach. At the same time the directed and the acknowledged SoSs also may be studied from the same perspective using the basic ideas of the hierarchical systems theory.

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