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A theory of distances in software engineering

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ABSTRACT

Context: Coordinating a software project across distances is challenging. Even without geographical and time zone distances, other distances within a project can cause communication gaps. For example, organisational and cognitive distances between product owners and development-near roles such as developers and testers can lead to differences in understanding and interpretation of the business requirements. Applying good software development practices, known to enhance alignment and coordination within development projects, can alleviate these challenges.
Objective: The aim of our research is to identify and describe underlying factors which can explain why certain practices support aligning and coordinating software development projects.
Method: We have inductively generated a theory analysing empirical data consisting of 15 interviews from 5 different companies. The systematic and iterative analysis was based on an initial hypothesis that distances affect development, and on results from previous research.
Results: We present a theory of distances that explains how practices improve the communication within a project by impacting distances between people, activities and artefacts. We also present a theoretical model of how specific alignment practices affect different types of distances.
Conclusions: The results provide a basis for further research and can be used by software organisations to improve on software practice.

1. Introduction

Coordination and communication within software development [7] is affected by distances [4]. The effects of geographical, socio-cultural and temporal distances are fairly well known and researched for globally distributed software development (GSD) [1,35]. However, the role of distances within co-located development projects and teams has not been explored to the same degree even though there are indications that other types of distances, e.g. organisational, cognitive and psychological distances also affect how requirements are negotiated, communicated and coordinated [84]. The flow of information within an organisation can be improved by mapping and optimising communication paths [51,75]. However, how the communication along these paths is affected by distances is yet to be explored and understood in more depth.

In this paper we theorise on the concept of distance and ground the constructed theory of distances to our own observations on the alignment of requirements engineering and testing. Testing activities ensure that the released software matches the requirements and the customer expectations. However, this requires alignment of the RE and the testing activities in which human-to-human communication and coordination play a vital role [7,8,43]. In a previous study, we identified a number of practices for coordinating and aligning the Requirements Engineering and Testing (RET) activities within a development project [8]. Several of the identified alignment practices involve the human and organisational side of software engineering, which suggests that software development can be improved by increasing the interaction between testers and requirements engineers. Examples include communication practices with customers, cross-role and cross-functional meetings in requirements elicitation and reviews, communication of changes, as well as, a proposed job rotation practice to improve human-to-human communication. This work gave rise to the idea that distances may be an underlying factor causing challenges in aligning and coordinating software engineering activities. This led us to define the research question of this paper, namely *How are RET alignment practices related to distances?* This question is answered herein by a theory that states that alignment practices affect distances between people, between activities, and between artefacts by shortening them.

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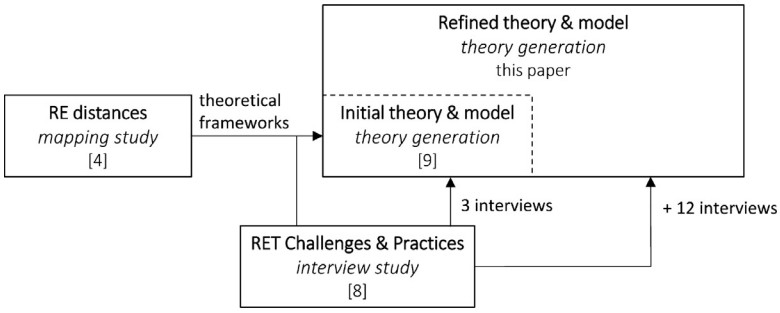

Fig. 1. This paper in relationship to our previous work.

The presented Theory of Distances and its context-specific instance in RET alignment, the Gap Model, were inducted through an iterative analysis of interview data from five case companies. While the Theory of Distances explains how practices in general affect distances, the more specific Gap Model provides grounding for the theory and describes in more detail how practices affect various types of distances and can be used to mitigate communication gaps caused by long distances. For the sake of simplicity, we present first the general Theory of Distances and then the detailed and context-specific instance of it in RET alignment, i.e. the Gap Model. An iterative research process has been applied and the initial version of the theory resulting from the previous iterations, based on three interviews from one company, was presented in [9]. For this paper, an additional full iteration of the research process has been performed and fifteen interviews from 5 companies have been analysed and the theory has been further refined, see Fig. 1. The generation, description and validation of the theory was inspired by guidelines for constant comparison by Seaman [71] and theory generation by Sjøberg et al. [73].

The theory is based on empirical findings of how RE distances, e.g. geographical, organisational and cognitive, are affected by RET alignment practices. The results can be used by practitioners in pinpointing potential causes of communication issues, in identifying particularly troublesome distances and alignment practices for addressing these, and for developing measures that can monitor distances (some initial work on this is provided in [6]). The theory also provides a basis for further research in software development practices, methods and techniques, especially related to project coordination and process improvement.

The research underpinning the presented theory is described in Section 2, while the case companies are presented in Section 3. Section 4 outlines the research method used to generate our theory. The Theory of Distances is presented in Section 5, while the Gap Model is described in Section 6. We evaluate our theory in Section 7, and then summarise this paper and outline future work in Section 8.

2. Background and underpinning research

The work presented in this paper is based on our previous work into two areas of research, namely alignment of requirements engineering (RE) and testing, and the role of distances in software development. The Theory of Distances has been built on the findings from our systematic mapping study of distances in software development [4] and on the interview study on challenges and practices of RET (Requirements Engineering and Testing) alignment, see Fig. 1.

2.1. RET alignment

Aligning, coordinating and avoiding gaps between RE and testing is a challenge within software development projects that we previously investigated in a large interview study at six development companies [8]. The results include a framework consisting of 10 main challenges and 10 categories of practices (in total 27 practices were identified in the study[1]). The challenges cover a wide range of topics including organisation, process, people, tools, requirement changes, traceability and measurements [8,69]. Similarly, the RET practices also cover a wide range of areas. The main categories of practices are the intersecting areas, i.e. RE and testing, including validation and verification, as well as, change management, tracing, tracing practices, tools, metrics, and other practices. The initial RET study also provided a mapping between challenges and practices, i.e. the challenges found to be addressed by each practice.

In this study, further analysis of the empirical data from the RET study has been performed and the set of previously identified RET alignment practices has been extended. Furthermore, the RET practices have been further categorised and abstracted according to how they affect distances between people and between artefacts resulting in the abstracted practices presented in the Gap Model, see Section 6.2.

The main techniques applied in industry to address the challenges of RET alignment are traceability and model-based approaches, for which there is also a substantial amount of research. An alternative, complementary and less researched approach is taken by introducing practices that increase and improve the communication, e.g. by involving testers early in the project and in requirement reviews [78]. Similarly, Marczak and Damian [51] found that in requirements-driven collaboration there is often close communication between requirements and testing roles; key roles which when absent cause disruptions within the development team.

2.1.1. Traceability

Traceability has been researched since the beginning of software engineering in the 1960s [64]. However, despite its (acknowledged) importance in high quality development [79,61] the implementation of this practice remains elusive and challenging [26,79,39,62]. Traceability between requirements and other development artefacts can increase the product quality [79,61] by supporting impact analysis [26,79,61,21,78,44], lowering of testing and maintenance cost [79,44], and increasing test coverage [79,78]. However, challenges with traceability have also been reported, e.g. by Cleland-Huang et al. [19]. These challenges include artefact volatility, informal processes, lack of clear

[1] In subsequent analyses, additional RET practices were identified, see Fig. 2.