

Rethinking Coordination in Large-Scale Software Development

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ABSTRACT

Coordination was early identified as a key challenge in software development, and in particular in large development projects. With the arrival of agile methods and their increasing use also in large-scale projects, this calls for rethinking how the software engineering community addresses coordination. We argue for increasing the focus on coordination in software engineering and describe four directions for research. Focus on these areas can supplement advice given in current development methods with relevant research-based advice.

CCS CONCEPTS

• **Software and its engineering** → **Software creation and management**; *Software development process management*;

KEYWORDS

Coordination, large-scale agile development

1 INTRODUCTION

Large software projects were early identified as a challenge in software engineering, where Curtis et al. [1], found that "*the thin spread of application domain knowledge, fluctuating and conflicting requirements, and communication bottlenecks and breakdowns—affected software productivity and quality*".

A more recent study of large-scale projects and coordination breakdowns state that "*the success of software development projects depends on carefully coordinating the effort of many individuals across the multiple stages of the development process*" [2]. A survey on coordination in large-scale software teams found respondents to hope for more effective and efficient communication and an emphasis on the importance of good personal relationships [3].

Coordination is important in software development, and in large-scale projects this is even more important as the number of developers and other stakeholders increase, and as the size of the technical system increases.

Coordination is often defined as "*management of interdependencies between activities*" [4] and coordination mechanisms as "*the organizational arrangements that allow individuals to realize a collective performance*" [5]. Mechanisms for coordination include direct supervision, mutual adjustment, and standardization of work, outputs, skills, and norms [6]. Some of these have been studied in *computer-supported cooperative work*.

Software development today is primarily conducted using agile methods [7]. These methods "*de-emphasize traditional coordination mechanisms such as forward planning, extensive documentation, specific coordination roles, contracts, and strict adherence to a pre-defined specified process*" [8]. When agile methods are applied to large-scale projects, new coordination challenges arise. In a study challenging underlying assumptions in large-scale agile development, Rolland et al. [9] found that current studies of agile methods share several assumptions that are challenged when a development project is conducted by a large number of teams. In this setting, work across teams becomes at least as important as work within teams.

New challenges are exemplified in a study of a coordination breakdown in a large-scale agile project, reported by Paasivaara and Lassenius [10]. They found that teams who followed the agile practice of coordinating through Scrum of Scrums were not able

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to coordinate effectively. Bick et al. [11] identified a lack of dependency awareness across teams as a primary cause of ineffective coordination. This lack of awareness stemmed from misaligned planning activities. An exploratory study of a large-scale agile development programme identified several more coordination arenas than prescribed in agile methods, and also found that these arenas change over time [12].

2 APPROACHES TO COORDINATION

Four approaches to coordination are used in studies [8, 13-15] which address challenges with large-scale agile development:

In *Software Engineering*, Strode et al [8] have suggested a coordination model based on a study of co-located agile development teams. A coordination strategy consisting of three components: *Synchronization* such as a daily meeting where all team members meet at the same time and place. *Structure*, which includes physical closeness, team member availability and that team members can substitute others, and finally: *Boundary spanning*, which includes activities, artefacts and roles to coordinate with other people or units beyond the project. Developed from studies of agile teams, this model puts particular emphasis on coordination with a team, and coordination using oral communication and physical artefacts.

In *Sociology*, van de Ven et al. [16] discussed three main determinants for how organizations coordinate. Coordination is seen as either done through persons ("personal") or through artefacts ("impersonal"). If coordination is done through persons, it could be done individually or in groups. Impersonal coordination is "programmed" or "codified" for example through plans or written coding standards. The study shows that when task uncertainty, task interdependence and size of work unit change, the coordination mechanism also changes. This emphasis on uncertainty, dependencies and size is relevant for large-scale development projects where dependencies have been identified as a main challenge, task uncertainty has long been recognized as a challenge in software development, and a large-scale development project per definition will involve a high number of people.

Organizational Psychology has recently studied multiple teams that work to achieve a common goal, *multiteam systems* [14]. Mechanisms for coordination on team level are seen as relevant for inter-team coordination. The big five model [17] describe three coordination mechanisms: *Shared mental models*, a common understanding of tasks, work process and knowledge of others. *Closed-loop communication*, that senders of messages ensures that the message is correctly received. *Mutual trust*, a shared belief that team members will perform roles and protect interests of teammates. These mechanisms put emphasis on the importance of relations between individuals for coordination.

Moreover, in *Management Science* researchers refer to the process of *Coordinating* to underscore the dynamic and emergent characteristics of coordination mechanisms. Jarzabkowski et al. [18] argue that coordinating mechanisms are subject for change, are established, fall apart, and are transformed over time. This lens on coordinating mechanisms can be helpful for understanding how mechanisms need to change over time in large projects.

3 CONCLUSIONS

Software engineering can draw on number of relevant studies and theories in order to provide research-based advice on coordination. The complexity of large-scale agile development calls for rethinking coordination, emphasizing characteristics such as: oral communication, work in teams, a high level of interdependencies, uncertainty in tasks, many people involved, relations between individuals and that coordination needs change over time. We hope this research note will inspire others to focus future studies on managing challenges with coordination.

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