Exploring Coordination in Large-Scale Agile Software Development: A Multiteam Systems Perspective

Research-in-Progress

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Abstract

The widespread use of agile development methods entails a fundamental shift in how large-scale organizations try to cope with complexity and volatility issues of the environment. As many people need to be coordinated, this often results in a team of teams setup called multiteam system. The coordination of several teams in large-scale agile settings is of interest to this research. Based on extant literature, a framework is developed to guide this research project. It attempts to explain the events leading to changes in the coordination configuration and their influences on coordination effectiveness based on punctuated equilibrium theory. By investigating the time dependent interplay between coordination type, locus and direction and its key contingencies, underlying aspects necessary for inter-team coordination will be identified. Based on empirical observations, we show first insights and expect to provide explanations on why some multiteam systems seem to struggle with coordination effectiveness while others do not.

Keywords: Coordination, Case Study, IS Development, Large-Scale Agile

Introduction

Lean and agile development methods have become widespread in use and are the de facto standard in large parts of many software organizations of different sizes (VersionOne Inc 2012; West et al. 2010). The introduction of these approaches shows a fundamental shift in how organizations try to cope with complexity and volatility issues (Dybå and Dingsøyr 2008).

The introduction of agile development and lean principles over the last decade (Beck 2001; Poppendieck and Poppendieck 2003) have shifted coping strategies for complexity and volatility of the environment towards more collaborative and cooperative approaches with empirical process controls (Schwaber and Beedle 2001). Self-empowered teams are one of the main changes regarding this issue. Many of these approaches have been regarded in light of small companies, single team settings, or with student developer teams. However, these development methods have gained prominence in large-scale settings as well (e.g. Begel & Nagappan, 2007; Fry & Greene, 2007; Nerur, Mahapatra, & Mangalaraj, 2005). These contexts show particular challenges as large groups of people need to be coordinated, which usually results in a hierarchical team of teams setup (Larman and Vodde 2008) where several teams have to work closely together in order to release a single software product. This organizational setup has been defined as a multiteam system (MTS) by Mathieu et al. (2001) who assert that MTSs are “two or more teams that interface directly and interdependently in response to environmental contingencies toward the accomplishment of collective goals” (Mathieu et al. 2001).

Coordination literature has presented top-down planning and bottom-up adjustment as opposing and incompatible approaches. However, the predominantly knowledge intensive tasks in software development need to be coordinated across different organizational levels including bottom-up approaches for capturing specialized knowledge and top-down actions to ensure efficiency within the system. This evidently calls for an environment where both types of coordination are necessary. The cooperation of several teams within an MTS depicts these levels prominently and calls for a differentiated view as teams cannot be depicted as abstracted individuals but must allow for certain new types of coordination behavior, e.g. boundary spanning activities by specific individuals.

Previous studies revealed that the theoretical understanding in the field of agile development is lacking and have called for more studies on the underlying fundamental concepts of agile software development (Abrahamsson et al. 2009; Ågerfalk et al. 2009; Dybå and Dingsøyr 2008). This research project intends to advance the understanding of coordination in multiteam agile software development systems and tries to answer the central research question:

How do different coordination configurations influence coordination effectiveness in large-scale agile software development systems?

Existing Literature and Foundations

Agile Software Development

In 2001, several prominent advocates of lightweight development methods gathered to create the Agile Manifesto (Fowler and Highsmith 2001). They proposed four values which constitute the essence of agile development methods: individuals and interactions, working software, customer collaboration and responding to change.

These values illustrate the considerable mind shift in agile software development. It emphasizes cross-functional teams with time boxed development phases and continuous management of requirements. Several empirical studies have evaluated the agile approach (Abrahamsson et al. 2002; Dybå and Dingsøyr 2008; Erickson et al. 2005) and have found significant benefits. However, since the origins of agile development lie in small team contexts, it has only recently and hesitantly been promoted and studied in large scale settings (Blau et al. 2011; Kettunen and Laanti 2008; Larman and Vodde 2008; Scheerer et al. 2013, 2014; Schmidt et al. 2012).

The main inter-team coordination mechanism in these types of development environments is, according to practitioner literature, the Scrum-of-Scrums approach (Larman and Vodde 2010; Schwaber 2004). Previous publications on this topic remain scarce, only seven papers could be identified by the author

(Bannerman et al. 2012; Lee 2008; Paasivaara and Lassenius 2011; Paasivaara et al. 2012; Smits and Pshigoda 2007; Sutherland et al. 2008, 2009) which come to the conclusion that coordination on an inter-team level remains extremely challenging (Paasivaara et al. 2012). Especially agile's desired organic structure, tacit knowledge management and informal communication seem difficult in large-scale settings. As little is known about the structure of large-scale agile development organizations, one needs to decide on a unit of analysis which depicts the organizational structure present in such systems. To benefit from extant knowledge in neighboring disciplines, we chose the multiteam systems unit rooted in organizational psychology, to conceptualize the team of teams setup.

Multiteam Systems Research

The type of large-scale development system examined is one in which several teams have to work together in order to complete a release of a software product. This type of organizational setup has been described within the organizational psychology domain as a multiteam system (MTS). The collective goal of this system can be broken down into a goal hierarchy and constitutes a key characteristic of any MTS. The goal hierarchy marks the boundary of a MTS in that all teams within the system share at least a distal goal while the individual teams pursue their more proximal goals. This structure of goals leads to teams displaying input, process and outcome interdependence with at least one other team (Mathieu et al. 2001).

While MTS have received increasing attention in organizational psychology over the last decade (e.g. Asencio et al., 2012; Davison et al., 2012; DeChurch & Marks, 2006; Lanaj et al., 2012), the aspect of coordination is underdeveloped. So far, especially the areas of compositional attributes and linkages have been explored. Marks et al. (2001) present a time based conceptual framework of team processes, including action and transition episodes. Action phases primarily include activities directly related to goal accomplishment and transition phases include evaluation or planning activities. Within MTSs, the management of these performance episodes is viewed as a central part of coordination (DeChurch and Marks 2006). Marks et al. (2005) found that cross-team processes had the most value in MTSs with a high interdependent goal hierarchy. Well-managed MTS transition processes influenced MTS performance positively, but did not support team-level action processes. Decentralized planning led to enhanced multiteam performance by fostering proactivity and higher aspiration levels. Nevertheless, strong negative effects were found in excessive risk seeking and coordination failures (Lanaj et al. 2012).

Asencio et al. (2012) propose multiteam charters as a means to develop efficient leadership structures and communication networks. Boundary spanners and communication norms across teams are mentioned as important considerations in MTS collaboration. These differentiated team roles are viewed by Davison et al. (2012) as a key factor in performance. Teams which included boundary spanning roles consistently outperformed teams which had not. The reasoning lies in the information processing complexity inherent in large organizations which lead to the need for formalized boundary spanning (Davison et al. 2012).

In their study of leadership in multiteam systems, DeChurch and Marks (2006) trained leader teams in two ways, either by facilitating strategy development or coordination. They found that strategy training was positively related to explicit coordination, with coordination training affecting implicit coordination stronger.

Beyond these first forays, little is known about coordination in MTSs. However, coordination as a specific topic has long been investigated in diverse research streams.

Coordination Research

Coordination is a multi-faceted research area which takes its inputs from a variety of fields including but not limited to Economics, Organization Theory and Computer Science. Previous theoretical work on coordination presents a framework for analysis of coordination in that it defines coordination as the management of dependencies. These dependencies are to be managed by coordination mechanisms (Malone and Crowston 1994). However, no predictive power arises from this work as no hypotheses or propositions are stated (Strode et al. 2012). Crowston et al. (2006) recognizes these limitations and calls for future research to develop testable hypotheses.

The study of coordination in organizational theory has identified several mechanisms to coordinate professionals (March and Simon 1958; Mintzberg 1980; Thompson 1967; Van De Ven et al. 1976). Thompson (1967) who cites March and Simon (1958) in his description of three key generic coordination approaches presents standardization or rules, plans and schedules, and mutual adjustment. Van De Ven et al. (1976) added a fourth dimension of team, which extends mutual adjustment by joint simultaneous interactions within a usually collocated team. Similarly, Mintzberg (1980) proposes mutual adjustment, direct supervision, and standardization (of work processes, work outputs, norms and worker skills) as basic mechanisms for coordination.

The mix of mechanisms according to situational context factors is of interest when regarding coordination strategies. Strode et al. (2012) present first insights into the combination of coordination mechanisms in small-scale agile development. They present a coordination strategy which includes synchronization, structure and boundary spanning as key elements which influence coordination effectiveness (Strode et al. 2012). Furthermore, intensified communication was observed as a facilitator of mutual trust and shared cognition by Li and Maedche (2012).

In an effort to classify coordination mechanisms, Espinosa et al. (2010) present three types of coordination: mechanistic, organic and cognitive coordination. While mechanistic coordination includes coordination by plan or rules with little communication, organic coordination refers to coordination by means of mutual adjustment or feedback via interaction. This communication can be formal and planned or informal and spontaneous. Cognitive coordination, on the other hand, is based on knowledge the actors have about each other and is achieved implicitly. Shared mental models (Cannon-Bowers et al. 1993) and transactive memory systems (Moreland et al. 1996) are two examples of this type of mechanism. Cognitive Coordination is viewed by Espinosa et al. as a key enhancer of mechanistic and organic coordination (Espinosa et al. 2010).

Coordination in Large-Scale Agile Software Development

Grounded in the previously discussed literature, the following describes the conceptual framework underlying this study. Originating from organization theory, the effectiveness of the coordination process (Pavlou and El Sawy 2006; Strode et al. 2011) is viewed as one of the factors of team effectiveness, in our case MTS effectiveness. Coordination effectiveness encompasses an implicit dimension, which focuses on knowledge of the process, goal and task and an explicit dimension, which is concerned with the typical values of right place, right functionality and right time. The multiteam system unit of analysis will be utilized in order to give structure to the multi-level data to be gathered, as the different event types (external/internal) are situated on the multiteam and organizational level, respectively. Internal events are closer to the direct goal of the MTS and originate from within the MTS boundaries, while external events stem from the larger organization surrounding the MTS and can include budget and other regulatory decisions which usually cannot be influenced by the MTS directly. The MTS Characteristics have been included, as the structure of the system under study can have an impact on the coordination configuration since changes in the compositional, linkage and developmental attributes strongly influence coordination (cf. Zaccaro 2012 p. 14).

The coordination configuration is based on the previously discussed literature with three core dimensions. The coordination type describes the type of coordination mechanisms in use and ranges from a pure mechanistic approach to a predominantly organic type. The coordination locus resembles what Mintzberg (1979) calls decentralization of decision making in that it signifies the location in the multiteam system where coordination activities take place. It ranges from a primarily centralized system, i.e. with decisions about coordination situated in a central coordination team, to a decentralized approach, e.g. where coordination is located among the team product owners. These product owners are either key stakeholders or representatives of the customer with a product vision of the software to be developed. Within the coordination direction dimension, the orientation of communication necessary for coordination is depicted. The obvious directions follow from the coordination locus; a more central approach will most likely necessitate more vertical coordination. However, we know from first interviews with members of one MTS, more central coordination does not imply less horizontal coordination.

The three dimensions can be arranged to form archetypes, of which two are outlined in Figure 1. Top-down planning represents a mechanistic, centralized approach with predominantly vertical coordination.

On the other hand, bottom-up adjustment is portrayed as a largely organic and decentralized strategy with horizontal coordination. As cognitive coordination is viewed as an enhancer of mechanistic and organic coordination (Espinosa et al. 2010) and its interaction effects have so far not been fully understood in this context, we have decided to omit it from the conceptual framework. However, we hope to be able to explain these effects in the final results of this study.

The episodic approach to team processes within a release cycle is our point of departure for pursuing a process theoretical approach (Mohr 1982). Between software releases however, deeper changes can occur which are then kept predominantly static within the MTS and the current release cycle. This indicates a change type based on punctuated equilibrium theory. Originating from evolutionary biology, it describes evolutionary change through two states (Eldredge and Gould 1972). The extended stable condition called stasis, where little net change happens, is disrupted by periods of rapid change. This is in contrast to the gradualistic view which posits a gradual change over time. Punctuated equilibrium in organizational literature (Romanelli and Tushman 1994; Tushman and Romanelli 1985) constitutes a composite or hybrid theory in the typology of organizational change and development theories (Poole et al. 2000). In the previously described alternating states, an evolutionary reproductive motor of change is operating at the population level in the period of stasis, while a teleological constructive motor causes rapid and infrequent change by top managers on the organizational level (Poole et al. 2000).

The different event types can lead to first- or second-order changes within the system (Lyytinen and Newman 2008). First-order changes are caused by events leading to incremental adaptation, while second-order changes lead to brief periods of upheaval, which change the systems deep structure. This deep structure refers to "the set of fundamental "choices" a system has made of (1) the basic parts into which its units will be organized and (2) the basic activity patterns that will maintain its existence" (Gersick 1991 p. 14).

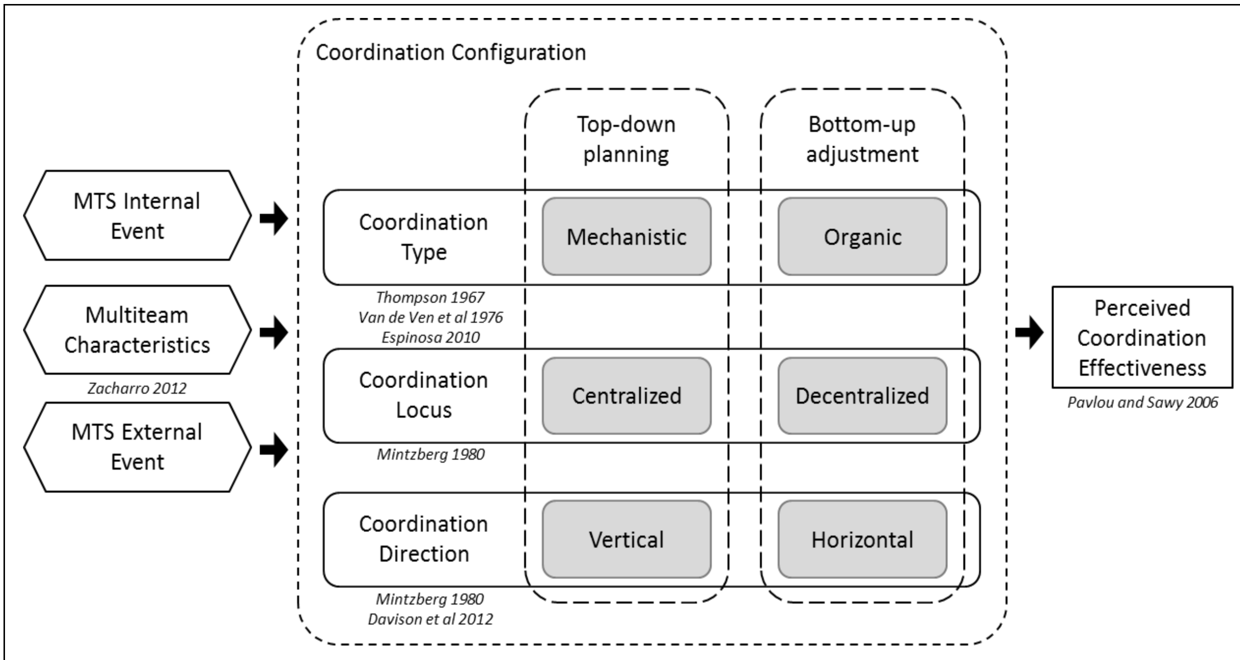

Figure 1. Conceptual Framework

Research Design

Research in the field of agile software development is considered to be at an intermediate state (Dybå and Dingsøyr 2008), with lean development being at an early or nascent stage according to Ebert, Abrahamsson, & Oza (2012). Based on this assessment, a qualitative case study approach (Yin 2009) seems particularly fitting as the research phenomenon is not supported by a strong theoretical base (Benbasat et al. 1987). Similarly, Edmondson and McManus (2007) suggest an exploratory qualitative approach for research areas in a nascent theoretical state. The tension between a top-down planning and agile's more bottom-up adjustment approach leads to the paradox that in large-scale settings one wants to combine approaches usually viewed as incompatible. Thus, the initial research question proposes an open-ended inquiry into the subject matter of coordination in multiteam systems.

The exploration of coordination configurations and their evolution over time will be conducted in a multinational software development organization specializing on enterprise software. This company has introduced lean principles and agile techniques starting in 2008 and has successively trained close to 12,000 developers worldwide in these practices. This research project has privileged access to aforementioned company as the author is partially embedded in this organization for a research project. The study will have the unique opportunity to gain deep insights into the issues in a real world professional software development setting.

In order to establish first insights into the problem space of inter-team work in large-scale agile development environments, an exploratory data analysis of one of the business units of aforementioned organization was undertaken. Hereby, the project management data of one full release cycle was scrutinized to visualize and understand bottlenecks in the software development process. Overall, data from a period of six months from more than 125 teams was examined.

Based on the understanding gathered from these insights and extant literature, a conceptual framework (Figure 1) has been developed as a point of departure for the next phase of this research endeavor. A process theoretical approach will be taken (Markus and Robey 1988; Mohr 1982) as this project intends to achieve more explanatory power through a time based view. In line with Lyytinen & Newman (2006, 2008), who propose interviews, observations and documentary analysis as principal data collection for process models, an exploratory multiple case study with 4-5 MTSs and approximately 40 interviewees will be pursued to shed light on coordination in large-scale software development. Furthermore, this research follows a two-stage iterative approach with exploratory phases intertwined with theory building phases, similar to what Edmondson and McManus (2007) describe as an alternating and iterative process between data collection and analysis and more continuous than the call of Eisenhardt (1989) for overlapping said phases.

In order to grasp the full spectrum of events that are likely to affect the coordination configuration development, a diverse sampling (Gerring 2007) approach will be taken. This matches the exploratory nature of this research as mainly the generation of event sequences are of interest and not hypothesis testing. Within the software development company under study, the cases will be selected based on varying the characteristics of the multiteam (Zaccaro et al. 2012) to generate a heterogeneous sample (Poole et al. 2000). The data will be gathered by retrospective semi-structured interviews with the chief product owners in charge of the multiteam systems and the individual team product owners. This data will be complemented by observations of the MTSs as well as project management data available in the IT systems used for coordinating work. All data will be entered in computer assisted qualitative data analysis software to help with the management and analysis of the empirical data collected.

Preliminary Results

In our first case, we interviewed the Product and chief product owners of a twelve team MTS which develops a logistics management solution. The product owners in this case were each responsible for one team, with the chief product owner being responsible for the entire MTS. Scrum was used as an agile project management framework. Through the analysis of the interview data, we have gained first insights. Figure 2 depicts the dependencies between individual teams of the MTS are depicted. The left side shows the reported dependencies based on our interview data, with red links depicting reciprocal dependencies and blue ones sequential. This shows a core team with strong reciprocal dependencies and linkages to other teams mainly being of a sequential type.

The right side depicts links between teams generated from project management data. The centrality of the product team on the right hand side can be explained by the project management setup. The central team creates Epics that are then assigned to an individual team. This lead team then is tasked with the implementation of this Epic and the coordination with other teams that need to work on this item as well.

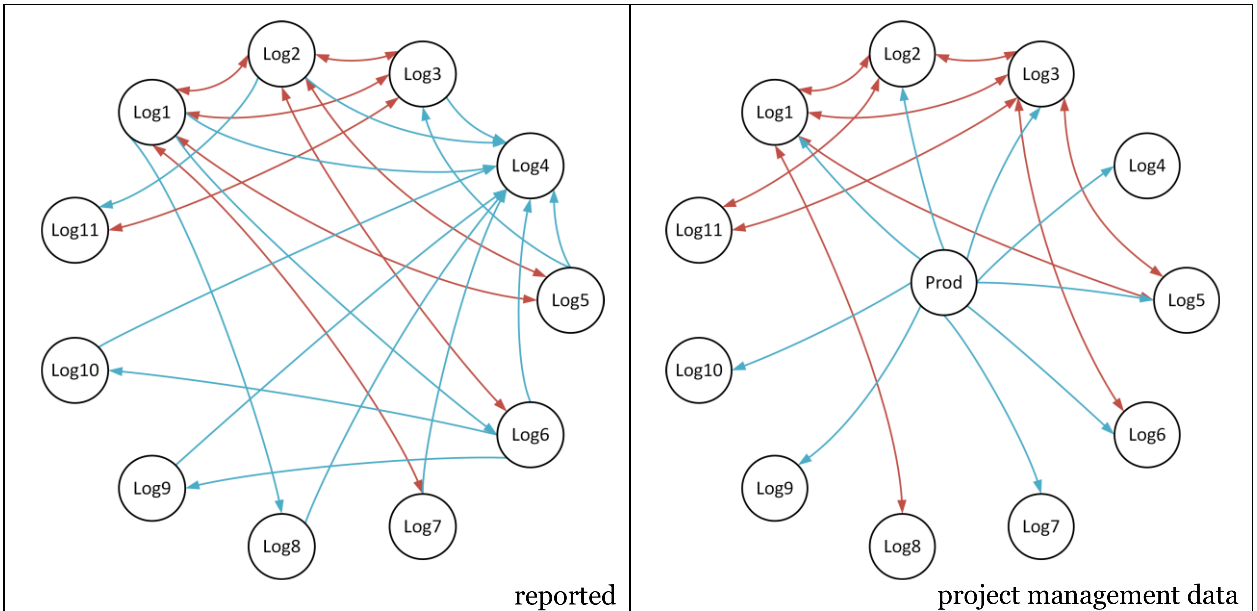

Figure 2. MTS Team Dependencies, reported vs. analyzed in project management data

An example of the previously mentioned first-order change is shown in Figure 3. In this context, a proximal goal ambiguity event triggers a change from a predominantly bottom-up adjustment configuration into a more centralized and vertical one. The product owners are not able to horizontally coordinate anymore and escalate the matter up to the central coordination team via organic mechanisms. This leads to a decrease in both implicit and explicit coordination effectiveness and to a plan-goal mismatch as previously defined work packages do not fit to the current situation. This redefinition or reprioritization is done by the central coordination team and then communicated to the individual teams via a new plan. To regain any kind of coordination effectiveness in this situation, a top-down planning configuration is enacted, which leads to an increase in only explicit coordination effectiveness.

This particular event shows that in case the initial bottom-up adjustment configuration is disrupted, a need for a central decision and top-down planning configuration emerges to realign the MTS. At this point it remains unclear if a bottom-up adjustment configuration approach, as suggested by the agile development paradigm, always needs to be supported by top-down planning efforts when facing disruptive events, or if an MTS is capable of learning and adapting its coordination mechanisms in the long-run.

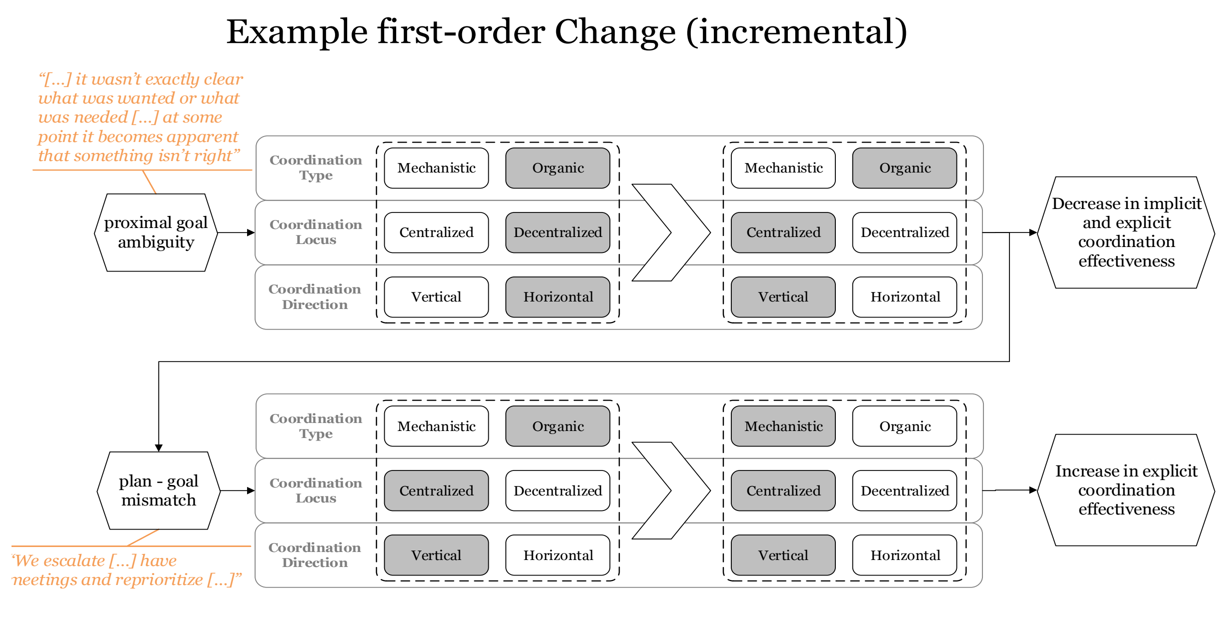

Figure 3. Example first-order Change

Expected Contributions

This study is expected to contribute to research on coordination and agile software development. Theoretical understanding in the area of large-scale agile development is still lacking. Previous studies in small and non-agile environments have strongly focused on the types of coordination mechanisms. This study attempts to fill this gap by drawing on existing coordination literature and the multiteam systems concept. By expanding the coordination strategy idea into the notion of a coordination configuration, a conceptual framework has been developed to guide this study. Furthermore, this research strives to gain deeper insights by investigating the time dependent interplay between coordination type, locus and direction and its key contingencies in a process theoretic approach. Current literature has so far not sufficiently considered large-scale agile software development settings. By identifying and explaining the underlying processes necessary for inter-team coordination, a deeper understanding of coordinated action between teams is sought. This research attempts to explain the events leading to changes in the coordination configuration and their influences on coordination effectiveness. This study draws on knowledge from other disciplines, such as organizational studies and organizational psychology and transfers it to information systems development. In this light, the presented research study is expected to contribute to the body of knowledge on large-scale agile software development and may also have an impact on the theoretical development within their original context.

Coordination in large-scale agile software development systems is a highly relevant topic for practitioners. As bigger and more complex software is being developed in an agile manner the need to understand inter-team coordination is essential. Based on empirical observations, this study will provide explanations why some multiteam systems seem to struggle with coordination effectiveness while others do not.

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