

Inter-team coordination in large-scale agile development: A test of organizational discontinuity theory

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ABSTRACT

We draw on Organizational Discontinuity Theory (ODT) to identify factors that increase communication and coordination problems between teams working on large software development projects. ODT posits that faced with a disruption in the expected flow of communication, called a *discontinuity*, individuals must make sense of the disruption to address the problem. They may be motivated to pay more attention to the situation and consider alternative actions to deal with the discontinuity, leading to the emergence of *continuities*, which are new behaviors, group practices and expectations. Continuities reduce or eliminate the attention and effort required to understand and manage the situation associated with problematic discontinuities. We propose a mixed-method study based on this model to examine the effects of discontinuities and the development of continuities on inter-team coordination in large-scale agile software development.

CCS Concepts

- Software and its engineering → Agile software development
- Software and its engineering → Programming teams

Keywords

Organizational discontinuity theory; inter-team coordination

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1. INTRODUCTION

In this paper, we propose a study of factors affecting inter-team coordination problems in large-scale agile software development. Agile software development emphasizes close interaction among developers in a small team, making team members responsible for deciding what the team should do and how to do it. While small highly interactive teams can be well coordinated internally, a major problem in large-scale development using agile methods is ensuring coordination among teams [1].

Few studies have provided theoretically-based managerial advice for coordination of agile development [2], even though the use of agile methods in large-scale development projects brings additional multi-layered interdependencies and resulting challenges. Better understanding of inter-team coordination is important as organizations increasingly set up multi-team projects to develop complex large scale projects, including automobiles [3], construction [4] and transdisciplinary science projects [5].

Existing practice-oriented frameworks (i.e. SAFe, LeSS, and DaD) for scaling agile development method offer limited, and often contradicting, solutions for the issues experienced in large-scale agile development projects. While they recognize the prevalence of coordination and communication issues, the solutions offered usually are limited to restructuring the scrum methodology and combining it with traditional software development methodologies in order to resolve those issues [see 6]. While these frameworks offer potential benefits, they mandate major methodological changes that might hinder the advantages of agile development methodologies.

There are also more radical approaches that suggest restructuring the organization and breaking it down into smaller units instead of scaling the agile methodology. This second set of practice-oriented solutions might not mandate major changes to the agile development methodology but may have less practicality. These frameworks and solutions limit organizations to local resources and have very limited applicability to international organizations accessing competitive capabilities in different international locations.

To address the problem of inter-team coordination in agile development, we develop a theoretical perspective to identify factors leading to inter-team coordination problems and describe a proposed study of this theory.

2. THEORY DEVELOPMENT

[7] performed a field study of 17 large systems development projects (some successful and some not) to identify problems affecting software productivity and quality. The three problems they considered most salient, in terms of additional effort or mistakes attributable to them were, “the thin spread of application knowledge,” “fluctuating and conflicting requirements,” and “communication and coordination breakdowns.” They concluded that large projects have extensive communication and coordination needs which are not mitigated by documentation. They also found that breakdowns were likely to occur at organizational boundaries, but that coordination across these boundaries was often extremely important to the success of the project. These findings motivate our examination of the relation of boundaries to communications and coordination problems.

Communications and coordination problems arise because large systems require knowledge from more domains [8] and involve many more requirements than can be managed by a single team. Even though designers attempt to decompose systems into pieces that are not tightly coupled, it is difficult to create pieces small enough for a small team to work on and with only limited interactions with the rest of the system. Coordination problems are further driven by a set of root causes, including task volatility (e.g., new requirements, requirement reprioritizations, ex-post requests); technological disruption (e.g., technological novelty or turbulence); and team instability (e.g., changing product owners, new or leaving team members, cross-functional teams, addition of another sub-team) [9]. As well, since team communication is important to address these problems, these problems will be further exacerbated by problems in inter-team communication [10].

Agile software development teams in large-scale projects present a particularly complex coordination environment. Many firms have adopted agile methods to add flexibility and responsiveness to the increasing unpredictability of the software development process [2]. Agile methods emphasize iterative and incremental development processes, team level decision-making, and informal communication and coordination practices [11]. To employ these methods for large-scale development, complex features of large projects are broken down into smaller and better-defined tasks that can be assigned to multiple teams [12]. However this strategy introduces significant communication and coordination challenges at the inter-team level due to the emergence of complex and unforeseen interdependencies between modules that often have domino effects [12].

There are a number of root causes that can create problems in coordinating at the inter-team level [9]. For example, one team may be dependent on a component to be developed by another team, but that component may be developed in a way that is problematic for the first team, or indeed, may not be developed at all if it is not prioritized by the second team. This issue might be more anticipated when the teams are organized around components (as “component teams”). A solution for this problem is removing interdependencies by forming teams around customer value (“feature teams”), with each team having all the required skill-set for end-to-end feature development and deployment [1]. For example, one proposed solution is to eliminate the need for inter-team coordination by creating multi-disciplinary teams that

“can deliver business value without coordinating with any other team” [13]. However, as the scale of the project grows forming such teams is increasingly difficult, again raising the need for inter-team coordination. Coordination problems can be exacerbated if the teams are geographically distributed, reducing opportunities for informal adjustment or increasing communications problems [14].

To summarize, this work suggests a number of problems (i.e., root causes) that can lead to coordination problems and that these problems are exacerbated by communications problems.

2.1 Organizational Discontinuity Theory

To identify how boundaries affect communication and coordination problems, we draw on organizational discontinuity theory (ODT). ODT provides a perspective for analyzing the problems encountered by members of teams who must span various boundaries in the course of getting their work done: boundaries of place (e.g. company locations), organization, discipline (e.g., development, user interface or testing), language, national culture and so on [15]. Boundaries are important because they distinguish one domain or situation from another, ordering and simplifying the environment [16-18]. For example, knowing that someone is from the same institution as oneself may make it easier to know how to contact and work with him or her.

Boundaries are also points where differences between team members become salient and potentially problematic. Prior research has found that working across geographic boundaries may increase conflict [19] and miscommunication [20]. The problems faced when working across boundaries are not due simply to the demarcations separating the different subgroups but rather to the differences in actions, attitudes, and expectations [21-23]. For example, individuals from different disciplines may use different terminology, consider different kinds of data more important, or deem different kinds of analyses more valid.

Nevertheless, boundaries are not uniformly or even necessarily problematic. For instance, time zone differences may initially lead to problems scheduling meetings between far-flung group members. However, over time the group members can develop practices that help to manage differences (e.g., specifying the time and time zone for each member when scheduling meetings). In many cases, members of teams dispersed across boundaries, including those involved with problems requiring innovative solutions, are able to adapt their processes over time to span these differences [24-26].

ODT argues that a boundary becomes problematic when an individual perceives a change in information and communication flows that requires conscious effort and attention to handle [15]. This disruption is defined as a discontinuity. We note that working across a boundary need not necessarily lead to a discontinuity. Similar to dormant faultlines, or demographic differences among group members that have the potential to create conflict but are not always activated [27], boundaries may exist but may not lead to discontinuities between group members. Thus, if flows of communication and action are as expected or require minimal attention and effort to manage, then the situation is perceived as normal, i.e., a discontinuity is not present [15]. Faced with a discontinuity, that is, with a disruption in the expected flow of communication, individuals must make sense of the disruption and address the problem. This extra effort may prompt them to vary their actions to reduce discomfort surrounding the situation [24]. They may be motivated to pay more attention to the situation and consider alternative actions to

deal with the discontinuity, leading to the emergence of new behaviors and expectations. Thus, a corollary to discontinuities is the emergence of continuities (that is, developed group practices) that reduce or eliminate the attention and effort required to understand and manage the situation associated with problematic boundaries (i.e., discontinuities) [15, 28].

Examples of continuities include changed formal communication processes between members of the team (e.g., meetings, use of knowledge repository), changed informal communication processes between members of the teams (e.g., “water cooler” chats between individuals, or instant messages between members to ask a quick question or get an update), changed task responsibilities, or new rules, norms or routines.

Continuities can be created through deliberate management or group member intervention or emerge as members work through problems arising from the presence of discontinuities. For example, [28] found that some pre-existing boundaries provided means for continuity to emerge, such as members with previous marketing experience banding together to form an *ad hoc* team to address new issues that required marketing expertise. However, a change in behavior only leads to a continuity when it is repeated over time, typically because it resolves problems triggered by perceptions of the discontinuity. The repetition of actions leads to expected patterns of behavior and a new normal in work practices is created [29].

To summarize, ODT suggests that boundaries between and within teams can lead to communications problems (i.e., discontinuities) but these discontinuities can be mitigated by developed practices for communication (i.e., continuities).

2.2 Research Model

Combining the two strands of theory development above that identified the importance of relationships among boundaries, discontinuities, continuities, communication and coordination problem, we propose the research model shown in Figure 1. The figure shows that boundaries are expected to create inter-team communication problems (that is, discontinuities).

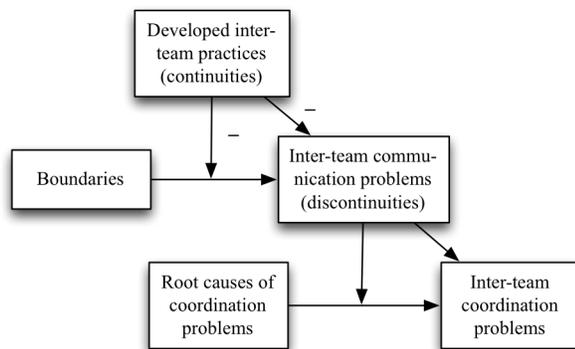


Figure 1. Research Model.

For example, team level boundaries may (appropriately) limit people’s motivation to interact with inter-team colleagues but at the same time result in limited opportunities to exchange knowledge and different understanding of technical interdependencies between teams [30]. These inter-team communication problems in turn exacerbate inter-team coordination problems driven by a set of root causes [31]. Continuing our example, disagreements between the two teams on the correct technical approach to use can lead to difficulty in integrating the resulting modules [30]. However, we expect that

the discontinuities can be reduced by the development of inter-team practices, that is, continuities, such as sufficiently frequent informal and direct inter-team communication [10]. We also hypothesize direct impacts of continuities to reduce discontinuities and of discontinuities to increase inter-team coordination problems.

2.3 Research Questions

In this study, we will address two broad research questions and sub-questions, to understand factors leading to inter-team coordination problems in large-scale agile development:

1. What discontinuities do members of multi-team systems with distributed team members face? What are the consequences of these discontinuities for the team? For the team members?
2. What kinds of continuities do team members develop that are helpful in addressing these discontinuities? What factors influence the development of these continuities?

3. PROPOSED RESEARCH METHODS

The goal of our study is to determine what kinds of discontinuities arise depending on the pattern of boundaries, what kinds of continuities are developed, how those inter-team processes reduce discontinuities, and how those inter-team communication problems affect inter-team coordination problems.

3.1 Study Design

We plan a cross-sectional study to test the relationships shown in Figure 1. The unit of analysis for this study is the dyad: the extent to which there are boundaries between one team and another teams with which it works, the level of inter-team communication problems (e.g., discontinuities) between members of the dyad, the level of development of team practices to address discontinuities (e.g., continuities), root causes of coordination problems applicable in that setting and inter-team coordination problems experienced. Data for these constructs will be collected from a team’s Scrum master, product owner and individual team members who will be asked to report on their perception of the situation of their team and its relation to another team. If the respondents are on multiple teams, they will be asked to report on the one that they worked on most in the most recent time period. Boundaries and problems will be assessed between the team and the one other team with which it interacted most in the most recent time period. Data analysis will test the relations among the perceived level of boundaries, discontinuities and coordination problems.

3.2 Data Collection

Our primary data collection methods will be an on-line survey supported by initial supplemental interviews. Data collection will be conducted in two phases.

Phase 1 will be an exploratory phase to improving understanding of the particular work environment in order to fine tune questions on a survey. In this phase we plan to interview (via phone or Skype) approximately 6 people who can provide background information about the organization, projects, development methods, communications practices and general characteristics of teams. Interviews are expected to last about 60 minutes and will be conducted in English. An interview protocol has been developed based on the model in Figure 1. For example, boundaries will be assessed by asking how the teams are geographically distributed, perceived differences in work practices or demographic differences. Communications problems can be assessed by asking for satisfaction with communication

and then probing for specific problems, e.g., timeliness or completeness of communication.

An initial version of a survey instrument for the various measures has been developed based on the theoretical model in Figure 1. Based on the interviews, this survey will be adjusted (e.g., to use terminology appropriate for the site). We will ask two or three of the interview subjects to review the revised survey to ensure questions, terminology, and acronyms are clear and reflect common usage in the organization. Interviews will also be used to identify data available to characterize projects (e.g., from a project management system) such as project size, project duration or timeline, budget, project complexity, presence or absence of certain boundaries or location of distributed team members.

Phase 2 will be the primary data collection phase. We want to survey members of agile teams for a total of 80 to 150 project team member participants in multiple teams and projects. To achieve the required sample size will require cooperation from the organization to encourage team members to complete the survey as well as distribution of the survey to a large group of developers.

Finally, surveys will provide an option for respondents to self identify if they are willing to participate in follow up interviews. Such interviews will be used to further explore any unexpected or unclear findings.

Before beginning any data collection, the project will undergo Institutional Review Board (IRB) examination to ensure data are collected and managed in a way that safeguards the privacy of respondents. A pseudonym will be used to mask the identity of the participating organization and its employees in all conference presentations and journal publications.

4. EXPECTED CONTRIBUTIONS

Though the study will be limited by its focus on one (or a few) organizations, we expect our results to provide mechanisms for helping to resolve some of the issues of scaling agile development without reducing the potential benefits of the agile methodology. Using our results, teams will be able to identify relevant boundaries and develop norms and practices to prevent them from disrupting their work, without necessitating changes to the core of the agile methodology. In addition, our research will provide advice to managers of distributed software development teams to improve the overall success of these teams and facilitate their growth into more diverse environments.

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