Organizational Debt in Large-Scale Hybrid Agile Software Development: A Case Study on Coordination Mechanisms

Zixuan Liu[1], Viktoria Stray[1,2(✉)], and Tor Sporsem[2]

[1] University of Oslo, 0373 Oslo, Norway
stray@ifi.uio.no
[2] SINTEF, Trondheim, Norway

Abstract. Software development is a complex human-centered activity, increasingly complicated by agile organizations scaling and adopting hybrid work. While technical debt has been extensively studied, other forms of debt-organizational, process, cultural, and social-have received less attention. We conducted a case study using ten semi-structured interviews, observations, and document analysis to identify coordination mechanisms used in large-scale hybrid agile. We identified organizational debt challenges such as a lack of shared mental models, team coordination, team cohesion, and team learning. Also, the hybrid working arrangement was found to create tension between increased individual autonomy and team objectives, as well as between team autonomy and inter-team coordination. We found 23 coordination mechanisms that the teams used to address challenges in their organization. We propose that implementing many of these mechanisms may help manage organizational debt.

Keywords: Agile transformation · Collaboration · Teamwork Coordination strategies · Knowledge sharing · Scalability challenges

1 Introduction

As companies adjust to the post-pandemic work-life, managers have been grappling with whether and how to bring employees back to the office, and many companies offer a hybrid work solution. Many employees see work location flexibility as a bonus on par with increased salary [3]. However, many experience difficulties related to communication, collaboration, and cooperation with other team members [2,10,16] when some or all are working from home.

Managers risk creating organizational debt, such as process debt [15] and social debt [23], when making new policies for hybrid work. New policies influence what new norms are created among workers. If managers permit poor norms to take root, they may find themselves having to "pay off" this organizational debt in the future, making it crucial to implement effective policies

P. Kruchten and P. Gregory (Eds.): XP 2022/2023 Workshops, LNBIP 489, pp. 75–84, 2024.
https://doi.org/10.1007/978-3-031-48550-3_8

from the outset. Is hybrid work truly the "best of both worlds", or is it rather the worst of both worlds? What will developers choose to do when given the freedom to choose between working from home and at the office? Several studies in software engineering have called for further research in the benefits, challenges and coordination strategies of distributed or hybrid software development teams [9,16,18,19].

Technical Debt has been rigorously investigated [14], and the metaphor is now used to describe also other types of organizational debt. For example, the debt metaphor has also been used in requirements engineering [11]. Ahmad and Gustavsson [1] recently conducted a systematic mapping review on nontechnical debt in software engineering and found 17 studies that investigate social, process, and people debts. They reported that both [8,17] found lack of communication, collaboration and coordination to be the cause of social debt. Lack of coordination is a common organizational challenge and has been found to be a cause of process debt [15].

Agile development at scale introduces new challenges. For example, there are more uncertainty, complexity, and dependencies between projects and teams, and thus coordination especially becomes a challenge [6]. Furthermore, the high degree of complexity and dependencies across teams threatens team autonomy [12]. A recent longitudinal study exploring coordination mechanisms in large-scale agile revealed that these mechanisms evolve in response to external and internal change events and that implementing the appropriate coordination mechanisms can significantly enhance the organization's resilience [4]. We hereafter use the umbrella term *organizational debt* to include both social and process debt. We aimed to understand how challenges with coordination, that cause both process and social debt, can be managed by the use of coordination mechanisms. We explored the following research question:

RQ1: *"What coordination mechanisms are used to manage organizational debt challenges in large-scale agile?"*

2 Methodology

The research was carried out in the case organisation *"PubTrans"*, which is an organisation responsible for the software development project of a platform for public transportation in Norway. The project has existed since 2016, and the first author was hired as an IT consultant in the project from the end of 2019.

The company could be defined as *large-scale*, as it has seventeen development teams ranging between five and eighteen team members, each with their own responsibility area, and together working toward developing the same products. The teams are able to choose their own tools, technology, agile methods and processes, and could thus be considered autonomous. As the pandemic restrictions were lifted in the middle of 2021, the company decided to experiment with a *hybrid working arrangement*, as many of its employees enjoyed the flexibility of being able to work remotely. Teams at PubTrans were allowed to design their

own approach to the hybrid working arrangement, due to a high degree of autonomy. As a result, the teams continuously experimented with new coordination strategies throughout the pandemic and post-pandemic period.

We carried out and transcribed 10 semi-structured interviews with developers and designers, spanning 7 different development teams at PubTrans. Also, we collected artefacts which were relevant to the hybrid working arrangement, such as Slack logs and documentation from Jira, Confluence, Miro and Microsoft Teams. This was done in order to enable better data triangulation, and to improve the validity and reliability of the case study. The research started in January 2022, and an overview of the research timeline is illustrated in Fig. 1.

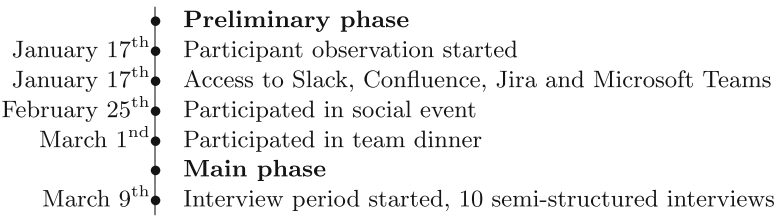

Fig. 1. Timeline of research

When chosing informants, we minimized sampling bias through *diversity* and *variation* as selection criteria. We initially compiled a list of all potential informants within PubTrans, encompassing about 100 individuals engaged in software development. Given diverse experiences across roles - developers, designers, team leads, and managers - a comprehensive exploration of all roles was impractical for this study's scope. Consequently, we focused on developers and designers at PubTrans, offering a diverse skillset within the informant group while maintaining manageable interview scope. In the preliminary research phase, it became evident that autonomous teams exhibited varying approaches to the hybrid work arrangement. To capture a spectrum of perspectives, we opted to select one or two representatives from several teams, facilitating the gathering of diverse narratives. Additionally, we deliberately chose informants with varying experience levels, personalities, life situations, and work settings (home or office).

A *thematic coding analysis* approach was taken when analyzing the data. We first created root nodes on NVIVO following the theoretical framework, and deductively generated the initial codes. However, we also inductively generated codes in order to stay close to the data. This resulted in a list of benefits and challenges caused by the hybrid working arrangement, and a list of coordination mechanisms identified based on the model by [22].

From January 2022 to March 2022, the first author assumed the role of a participant observer within the PubTrans organization. The participation included attending planned and impromptu meetings, formal discussions, informal interactions, and team collaborative efforts. Additionally, engagement extended to

social gatherings like Friday gatherings and seminars. These activities provided a comprehensive understanding of the intricacies inherent to the PubTrans company. This understanding was particularly profound during the period of hybrid work arrangements. Importantly, this active involvement facilitated the establishment of rapport with key individuals before the subsequent interview phase.

3 Results

3.1 Shared Mental Models

We found one major challenge to be maintaining a *shared mental model* of the location and availability of other team members within the team. First, many informants were unsure about how many of their coworkers will be at the office on any given workday. Most did not see a reason to travel to the PubTrans office when their collaborators were working remotely, and only wished to co-locate if enough team members were at the office. Some felt lonely when staying at the office without other team members, as they did not know many other employees. Many wished to adjust their co-location plans according to the other team members, but this was difficult as most team members did not document their co-location plans. The majority decided their work location right before the work day started. *"Yesterday I went to work, and there was no one there, and that wasn't so fun. I could've just as well stayed at home"* (Interview C2). Likewise, it was even more difficult for the employees to find the co-location plans of other teams. Most employees informed about their co-location plans in private team Slack channels, which were hidden from those outside the team.

Secondly, the informants experienced difficulties *accommodating the other work mode* when working from separate locations, due to a lack of shared awareness. This created challenges related to *inclusivity*. For example, those who were co-located at the office could often forget to accommodate to those working remotely, and those alone at the office could experience difficulties trying to participate in all the digital activities in an open office landscape. As a result, information shared between the co-located team members may not reach those working remotely. Similar challenges were also reported from *hybrid meetings*. Those who were co-located sometimes had informal conversations which excluded the digital participants. These conversations could be disruptive to the remote participants, and the remote participants also missed out on important information and decisions.

3.2 Team Coordination

We identified *team coordination* as a major organizational debt challenge at PubTrans, with hybrid work increasing meeting complexity and communication barriers. The interviewees reported fewer ad-hoc meetings in hybrid teams due to reduced co-location time. Initiating video calls without prior planning on Slack was uncommon, unlike in-person interactions at the office. Ad-hoc meetings

mostly occurred when teams were co-located. *"It's a bit more painful when you're at home. You always have to call. It's such a big step [...] it feels like you're interrupting others way more. Like, 'oh my god, now there's another message or a direct phone call from him'. It feels so dramatic"* (Interview B1).

Secondly, the frequency of communication *between* teams was significantly reduced. Prior to the pandemic, teams working on similar domains at PubTrans were placed in the vicinity of each other, thus promoting the collaboration between these two teams. Similarly, task forces (i.e. a temporary team consisting of members from different teams working on the same feature) were built prior and during the pandemic as an inter-team coordination mechanism. This had however disappeared as a result of the hybrid work arrangement, as the teams no longer came to the office on the same days.

The employees also experienced *longer feedback loops* when collaborating on the same task, compared to before the pandemic. This was due to the increased barriers to initiating ad-hoc communication. In hybrid teams, conversations had to be more explicitly planned and executed using communication tools such as Slack and Microsoft Teams. Setting up the tools and waiting for asynchronous answers resulted in longer waiting time, and longer feedback loops during the collaboration sessions. This increased the threshold for asking questions, and decreased the coordination efficiency between team members.

3.3 Team Cohesion

Team cohesion was also identified as a major challenge caused by hybrid work. The team members reported to have decreased levels of attachment to the team, due to a lack of face-to-face social activities and informal conversations. It was more difficult to carry out informal conversations with the entire team in hybrid teams, as a result of the reduced and mismatched co-location time. Communication via tools such as Slack often felt impersonal, as they lacked additional dimensions such as body language. Furthermore, prior to the pandemic, the employees often gathered for dinners and other social activities after work. The frequency of social activities had drastically decreased after the pandemic.

Finally, despite encouragements to co-locate on particular days, some team members preferred to *never* come to the office. In comparison to individuals who frequently worked from the office, informants said it was harder to get to know the remote team members. Due to significant obstacles to initiating conversations when working remotely, the hybrid teams spent more time on casual interactions when co-located than before the pandemic. Those who preferred to not co-locate were thus excluded from these interactions.

3.4 Team Learning

At PubTrans, *team learning* was the fourth major challenge in hybrid teams. Due to the limited and mismatched co-location time, many people had difficulty asking questions and transferring knowledge. Particularly, the sharing of *domain*

knowledge and *tacit knowledge* was cited by almost every informant as a significant challenge. The project's large scope necessitated the integration of a vast number of teams, subsystems, stakeholders, and technology. Understanding the PubTrans domain therefore required an understanding of the organisation as a whole, and this knowledge was frequently tacit and undocumented. Almost all of the informants said that obtaining domain knowledge was more challenging than learning specific technologies and programming languages. While there were many internet resources for specific programming languages, finding answers to inquiries about the PubTrans domain was impossible.

Table 1. Coordination mechanisms managing organizational debt

		Shared mental models	Team coordination	Team cohesion	Team learning
Co-location structure mechanism	Co-location with team				
	Co-location across teams				
	Co-location rules				
	Incentives for co-location				
Slack synchronization & boundary- spanning tool	Slack as main coordination tool				
	"Good morning" message on Slack				
	Slack icons				
	Inter-team Slack channels				
Meetings synchronization & boundary- spanning activity	Daily standup				
	Retrospective meeting				
	One-on-one meeting				
	Informal conversations during meeting				
Tools for hybrid meetings Synchronization & boundary- spanning tool	Video conferencing software				
	Digital calendars				
	Integrated meeting rooms				
Documentation Synchronization & boundary - spanning tool	Documentation				
	Documentation tools (Jira, Confluence)				
	Visual collaboration tools (Miro)				
Gaming Synchronization & boundary- spanning activity	Multiplayer games				
	Quizzes				
Pair-programming Synchronization activity	Pair-programming				
Physical social events Synchronization & boundary- spanning activity	Social events with team, e.g. team dinner				
	Physical seminars				

4 Discussion

We will now discuss our research question: "What coordination mechanisms are used to manage organizational debt challenges in large-scale agile?" In large-scale

agile environments, agile practices are often used together with other organizational practices [5]. This was reflected in our findings, as the coordination mechanisms identified included both agile coordination practices, such as stand-up meetings, retrospective meetings and task boards, as well as non-agile practices like social events and gaming.

In total, we found 23 coordination mechanisms used to manage organizational debt challenges. We have categorized them into eight general coordination mechanisms and if they were affecting the aspects: Shared mental models, team coordination, team cohesion and team learning, see Table 1. Some coordination mechanisms are closely interrelated - for instance, creating shared mental models also improves the team cohesion, which in turn encourages team learning.

Shared mental models represent knowledge held in common by members that lets them understand tasks and relationship among tasks, and coordinate their actions and interactions [7]. Our findings suggested that hybrid teams should *explicitly discuss their hybrid work processes*, in order to create a shared mental model amongst its members. This is in line with other research [18,21].

The coordination mechanisms *co-location rules* and *Slack norms and etiquette*, helped by explicitly discussing and describing the hybrid collaboration pattern within the teams. Discussing common *co-location rules* created a shared understanding of the team's *work location* on a given work day. The team members could thus anticipate one another's needs, and adjust their co-location plans accordingly. Our work builds on the findings that Slack is an essential tool for coordination in distributed teams [20]. Further, in our teams, the shared *Slack etiquette* created a common understanding of the *availability* of team members, by for example agreeing on traditions such as sending "good morning" messages when ready for work, and changing Slack icons when unavailable.

We found a set of coordination mechanisms that teams might utilize to increase *team cohesion*, which could improve the overall team performance [7]. These mechanisms included *social activities with a common purpose*, such as multiplayer games, daily quizzes, physical social events with the team and the company, and informal conversations during meetings. We found coordination mechanisms employed to encourage *team learning*. These mechanisms generally focused on *lowering barriers to asking questions* within and across teams. Frequent communication within teams are shown to improve psychological safety, which in turn lowers the barriers to asking questions and encourages knowledge sharing [4,13].

In our study, teams worked in a hybrid setting. Unlike co-located large-scale agile, hybrid organizations must align co-location rules across teams to establish a shared mental model organization-wide. To ease tension between team autonomy and inter-team alignment, creating incentives for co-location can be beneficial. Enforcing company-wide rules, such as co-location on a set day, may threaten team autonomy in a large-scale agile organization [12]. Instead, *incentives* could be used to encourage co-location. For instance, PubTrans introduced the "baked goods trolley" on Thursdays, strengthening the employees' willingness for co-location.

5 Conclusion

In conclusion, our research highlights the importance of addressing not only technical debt but also other types of organizational debt, such as process and social debt, in software development organizations, especially in the context of large-scale hybrid settings. We identified 23 coordination mechanisms that were used to manage organizational debt. By raising awareness of these non-technical forms of debt and the coordination mechanisms to address them, we aim to provide practitioners with insights to improve their software development processes and enhance overall organizational performance. Further research is encouraged to uncover additional strategies that could be beneficial in managing the complexities of large-scale, hybrid agile organizations.

Acknowledgements. Thanks to the company for their research engagement. This work was supported in part by the Research Council of Norway (Project Transformit, grant 321477).

References

1. Ahmad, M.O., Gustavsson, T.: The pandora's box of social, process, and people debts in software engineering. J. Softw. Evol. Process (2022)
2. Bao, L., Li, T., Xia, X., Zhu, K., Li, H., Yang, X.: How does working from home affect developer productivity?-a case study of baidu during the covid-19 pandemic. Sci. China Inf. Sci. **65**(4), 142102 (2022)
3. Barrero, J.M., Bloom, N., Davis, S.J.: Let me work from home, or i will find another job. University of Chicago, Becker Friedman Institute for Economics Working Paper (2021–87) (2021)
4. Berntzen, M., Stray, V., Moe, N.B., Hoda, R.: Responding to change over time: A longitudinal case study on changes in coordination mechanisms in large-scale agile. Empirical Softw. Eng. **28**(114) (2023)
5. Berntzen, M., Stray, V., Moe, N.B.: Coordination strategies: managing inter-team coordination challenges in large-scale agile. In: Gregory, P., Lassenius, C., Wang, X., Kruchten, P. (eds.) XP 2021. LNBIP, vol. 419, pp. 140–156. Springer, Cham (2021). https://doi.org/10.1007/978-3-030-78098-2_9
6. Dingsøyr, T., Bjørnson, F.O., Schrof, J., Sporsem, T.: A longitudinal explanatory case study of coordination in a very large development programme: the impact of transitioning from a first-to a second-generation large-scale agile development method. Empir. Softw. Eng. **28**(1), 1 (2023)
7. Dingsøyr, T., Fægri, T.E., Dybå, T., Haugset, B., Lindsjørn, Y.: Team performance in software development: research results versus agile principles. IEEE Softw. **33**(4), 106–110 (2016)
8. Dreesen, T., Hennel, P., Rosenkranz, C., Kude, T.: "The second vice is lying, the first is running into debt." antecedents and mitigating practices of social debt: An exploratory study in distributed software development teams (2021)
9. Florea, R., Stray, V.: A global view on the hard skills and testing tools in software testing. In: 2019 ACM/IEEE 14th International Conference on Global Software Engineering (ICGSE), pp. 143–151. IEEE (2019)

10. Ford, D., et al.: A tale of two cities: software developers working from home during the covid-19 pandemic. ACM Trans. Softw. Eng. Methodol. (TOSEM) **31**(2), 1–37 (2021)
11. Frattini, J., et al.: An initial theory to understand and manage requirements engineering debt in practice. Information and Software Technology (2023)
12. Gustavsson, T., Berntzen, M., Stray, V.: Changes to team autonomy in large-scale software development: a multiple case study of scaled agile framework (safe) implementations. Int. J. Inf. Syst. Proj. Manag. **10**(1), 29–46 (2022)
13. Hennel, P., Rosenkranz, C.: Investigating the "socio" in socio-technical development: the case for psychological safety in agile information systems development. Project Manage. J. **52**(1), 11–30 (2021)
14. Lenarduzzi, V., Besker, T., Taibi, D., Martini, A., Fontana, F.A.: A systematic literature review on technical debt prioritization: strategies, processes, factors, and tools. J. Syst. Softw. **171**, 110827 (2021)
15. Martini, A., Stray, V., Moe, N.B.: Technical-, social- and process debt in large-scale agile: an exploratory case-study. In: Hoda, R. (ed.) XP 2019. LNBIP, vol. 364, pp. 112–119. Springer, Cham (2019). https://doi.org/10.1007/978-3-030-30126-2_14
16. Nolan, A., White, R., Soomro, M., Dopamu, B.C., Yilmaz, M., Solan, D., Clarke, P.: To Work from Home (WFH) or not to work from home? lessons learned by software engineers during the COVID-19 pandemic. In: Yilmaz, M., Clarke, P., Messnarz, R., Reiner, M. (eds.) EuroSPI 2021. CCIS, vol. 1442, pp. 14–33. Springer, Cham (2021). https://doi.org/10.1007/978-3-030-85521-5_2
17. Ramač, R., et al.: Prevalence, common causes and effects of technical debt: results from a family of surveys with the it industry. J. Syst. Softw. **184**, 111114 (2022)
18. Smite, D., Moe, N.B., Hildrum, J., Gonzalez-Huerta, J., Mendez, D.: Work-from-home is here to stay: call for flexibility in post-pandemic work policies. J. Syst. Softw. **195**, 111552 (2023)
19. Sporsem, T., Moe, N.B.: Coordination strategies when working from anywhere: a case study of two agile teams. In: Proceedings of the 23rd International Conference on Agile Software Development, XP 2022, 2022, pp. 52–61. Springer (2022)
20. Stray, V., Moe, N.B., Vedal, H., Berntzen, M.: Using Objectives and Key Results (OKRs) and Slack: a case study of coordination in large-scale distributed agile. In: Proceedings of the 55th Hawaii International Conference on System Sciences, p. 10 pages. HICSS (2021). http://hdl.handle.net/10125/80225
21. Strode, D., Dingsøyr, T., Lindsjorn, Y.: A teamwork effectiveness model for agile software development. Empir. Softw. Eng. **27**(2), 1–50 (2022)
22. Strode, D., Huff, S.L., Hope, B., Link, S.: Coordination in co-located agile software development projects. J. Syst. Softw. **85**(6), 1222–1238 (2012)
23. Tamburri, D.A., Kruchten, P., Lago, P., van Vliet, H.: What is social debt in software engineering? In: 2013 6th International Workshop on Cooperative and Human Aspects of Software Engineering (CHASE), pp. 93–96. IEEE (2013)