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Waste identification as the means for improving communication in globally distributed agile software development

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ABSTRACT

Agile approaches highly values communication between team members to improve software development processes, even though, communication in globally distributed agile teams can be difficult. Literature proposes solutions for mitigating the challenges encountered in these environments. These solutions range from general-level recommendations and practices to the use of communication tools. However, an approach covering the whole development process for identifying challenges, and improving communication in globally distributed agile development projects, is missing. In order to address this, we conducted a case study within a globally distributed agile software development project focused on using the concept of waste as a lens for identifying non-value producing communication elements. In order to achieve this, we constructed a waste identification approach through which we identified five communication wastes, and solutions to mitigate them. These wastes can help companies identify communication issues that are present in their development efforts, while the presented waste identification technique gives them a mechanism for waste identification and mitigation. This work contributes to the scientific community by increasing the knowledge about communication in globally distributed agile development efforts.

1. Introduction

Agile software development methods emerged during the late 1990s and early 2000s as a response to the industry's need for faster and more lightweight development approaches. One of the essential aspects of agile development methods is the emphasis on informal communication conducted preferably face-to-face (Beck, 2000). Informal communication has been defined by Kraut and Streeter (1995) as personal, peer-oriented and interactive. Further, Herbsleb and Grinter (1999) label informal communication as something that happens outside the official reporting structure of the project, and sometimes invoked without the knowledge of management. Informal communication enables correcting mistakes and filling in the required details fast (Herbsleb and Grinter, 1999). Physical proximity is essential for participants to engage in informal communication (Kraut and Streeter, 1995) and it is highly emphasized in agile literature. An agile development team should be located in a shared workspace and the customer (i.e. someone who will actively steer the project) should be on site to provide input and feedback (Beck, 2000). Close collaboration with the customers in agile software development has proven useful. For example, Ceschi et al. (2005) state that managing a customer relationship has proven easier in agile software development when comparing to traditional[2] approaches. 50% of the companies using traditional software development methods suffered from problems related to customer relationships. This is 40% higher than customer relationship issues encountered when using an agile development approach (Ceschi et al., 2005). Agile approaches are currently used in globally distributed environments that cross significant distances over time and space. This in turn makes physical, as well as temporal, proximity between the participants difficult to achieve and, hence, creates challenges for informal face-to-face communications (Nöteberg et al., 2003).

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[2] In this work, traditional development is synonymous with plan-driven development. Plan-driven software development is an engineering approach in which the software is developed following specific processes, commencing at the requirements gathering stage and ending with the final code (Boehm and Turner, 2003). Perhaps the most well known plan-driven method is the Waterfall method (Royce, 1970).

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Effective communication is essential in globally distributed software development regardless of the development approach (Herbsleb et al., 2001; Carmel and Agarwal, 2001; Mockus and Herbsleb, 2001). In contrast to agile methods, traditional approaches rely on formal communication which codifies process and product knowledge into extensive documentation (Nerur et al., 2005). Kraut and Streeter (1995) describe formal communication as communication through structured meetings, writing and other relatively impersonal and non-interactive channels. A globally distributed context creates its own challenges that affect communication between distributed partners (e.g. Noll et al., 2010). According to the study made by Komi-Sirviö and Tihinen (2005), 74% of the problems of distributed development were related to communication. They found that the lack of communication or poor quality of it was often the root cause behind other problems identified in the study (Komi-Sirviö and Tihinen, 2005).

In order to address the communication challenges, different solutions have emerged. These proposals focus on general-level recommendations to establish an environment that fosters meaningful communication (e.g. Layman et al., 2006; Korkala et al., 2010), and the use of individual communication tools (e.g. Kircher et al., 2001; Danait, 2005). These recommendations provide solutions to particular problems such as organizational challenges (Korkala et al., 2010) and means to maintain interactive communication. In summary, there are no concrete approaches covering the entire development process to help companies analyze and improve communication in their globally distributed agile development projects. In our study, we use the concept of waste to illustrate communication specific bottlenecks. Waste is defined as *any human activity consuming resources but not providing value* (Womack and Jones, 1996) and this concept has also been applied in the context of Lean software development (e.g. Poppendieck and Poppendieck, 2007; Mandić et al., 2010). While these wastes are not limited to any particular aspect of software development, our study aims to identify communication specific wastes. Hence, the motivation of this study was to create an approach that covers the entire agile development process to identify communication specific waste and to classify what those wastes are.

We conducted a single case study within a North American software intensive company that was implementing a product in a globally distributed fashion. In the study, we applied the constructed waste identification approach and analyzed the communication between the involved stakeholders using the key concepts of Media Synchronicity Theory (MST) (Dennis et al., 2008). The communication wastes were extracted from the data and we propose actions for mitigating the effects of the identified wastes.

The contribution of this paper is twofold. First, we propose a waste identification process through which the non-value producing communication elements can be identified. As a second contribution, we identified five types of waste related to communication; ***lack of involvement***, ***lack of shared understanding***, ***outdated information***, ***restricted access to information*** and finally ***scattered information***. This study concludes that the proposed waste identification process can point out non-value producing elements from communication, after which, measures to mitigate them can be identified.

The rest of the paper is organized as follows: Section 2 discusses background literature relevant to this study in order to provide the reader an understanding of communication in globally distributed environments. Section 2 also discusses the concept of waste in the context of software development and explains the communication theory through which communication was analyzed. Section 3 presents how the study was conducted and introduces the waste identification approach. Section 4 presents the findings of this study, and generalized descriptions of the wastes alongside proposals for mitigating them. Threats to validity are also discussed in this section. In Section 5 the findings are discussed along with future research opportunities. Finally, the conclusions are drawn with more detailed description of how to apply the presented waste identification approach.

2. Related literature

In this section, background literature relevant to the study is discussed. First, we discuss communication in the context of globally distributed software development from the perspectives of both traditional and agile software development, after which we introduce Media Synchronicity Theory. Finally, we address the concept of waste. These elements provide the theoretical framework for our study.

2.1. Communication in globally distributed development environments

Globally distributed software development (GSD) is a common approach in software engineering (Damian and Moitra, 2006) and several factors have contributed to the growth of this phenomenon. Some of the most commonly cited benefits include time-zone independent "follow the sun" development, access to well-educated labour, maturation of the technical infrastructure and reduced costs due to different salary structures based on geographical regions (Komi-Sirviö and Tihinen, 2005; Ebert and De Neve, 2001; Gorton and Motwani, 1996; Battin et al., 2001). In order to achieve these benefits, communication between the distributed parties must be effective. However, there are several challenges that hinder communication in distributed contexts.

Noll et al. (2010) have identified geographical, cultural and temporal distances as the key barriers for communication and collaboration in globally distributed environments. Holmström et al. (2006) state that it is the combination of these distances that makes globally distributed development complex. Table 1 presents challenges found in these categories both from the general GSD literature (not focusing on any particular development approach) and those found in agile GSD literature.

Several different approaches to address these challenges have been suggested. The reduced opportunities for synchronous and face-to-face communication from both geographical and temporal viewpoints can be mitigated by using interactive communication tools, such as videoconferencing (Kircher et al., 2001; Sureshchandra and Shrinivasavadhani, 2008), whiteboard software (Layman et al., 2006), web conferencing and Instant Messaging tools (Danait, 2005). Asynchronous tools can also be used. According to Damian and Zowghi (2003), email is the dominant asynchronous media due to its important role as a means of exchanging documents across temporal distances. The use of asynchronous media can, however, create challenges. Email messages can be forgotten or lost which leads to unresolved issues, and the time when a response to an email message will arrive is unsure (Damian and Zowghi, 2003). Carmel and Agarwal (2001) further state that asynchronous media often delays problem resolution and makes it more complicated. As an example, even simple issues can take days of email discussion before resolving (Carmel and Agarwal, 2001). In order to reduce communication overhead, strict communication policies are promoted if asynchronous communication tools are used, such as, emails need to be replied within 12 business hours as suggested in Vax and Michaud (2008).

Communication tools themselves can create challenges. Sound quality of teleconferencing tools may be poor. This can create misunderstanding and communication overhead can occur when messages need to be repeated several times (Williams and Stout, 2008). Additionally, significant amounts of time may be needed

Table 1
Challenges of GSD and agile GSD from the perspectives of temporal, geographical and cultural distances.

Challenge area	Findings
Temporal distance	**General GSD literature** Opportunities for synchronous communication are reduced (Ågerfalk and Fitzgerald, 2006). Communication needs to take place on unconventional times due to the lack of overlapping working hours and leads to overtime work. This is consuming and leads to communication overhead (Holmstrom et al., 2006; Conchúir et al., 2009; Sarker and Sahay, 2004). Possible unavailability of remote colleagues when help is needed can lead to delays. Asynchronous communication media used over temporal distance increases response times (Ågerfalk, 2004). **Agile GSD literature** Using interactive media for efficient communication can be very difficult due to temporal distance (Korkala et al., 2010).
Geographical distance	**General GSD literature** Face-to-face meetings are difficult to arrange and informal communication is lacking (Ågerfalk and Fitzgerald, 2006). This inhibits idea sharing (Conchúir et al., 2009). **Agile GSD literature** Explicit findings not found. However, the identified challenges can be seen valid in globally agile development as well.
Cultural distance	**General GSD literature** Misunderstandings in communication stemming from cultural differences (Holmstrom et al., 2006; Ågerfalk and Fitzgerald, 2006; Conchúir et al., 2009). **Agile GSD literature** Misunderstandings in communication stemming from cultural differences (Summers, 2008). Cultural differences may result into situations in which e.g. disagreements are not willingly expressed and negative issues are shared reluctantly (Lee and Yong, 2010; Drummond and Francis, 2008). Language barriers can significantly hinder communication (Layman et al., 2006; Uy and Ioannou, 2008; Kajko-Mattsson et al., 2010). Different work styles cause communication problems (Sutherland et al., 2007).

to resolve technical issues with videoconferencing (Williams and Stout, 2008). Poor technical communication infrastructure can create such challenges that meetings may even need to be rescheduled due to poor sound/video quality (Therrien, 2008). Other times, it is not even possible to use videoconferencing tools (Paasivaara et al., 2008; Herbsleb and Moitra, 2001). Considering the consuming nature of unconventional overlapping work hours that enable synchronous communication, it is recommended that work should be kept sustainable (Therrien, 2008).

In order to overcome cultural hurdles there are several recommendations available. For example, experienced domain experts should communicate with distributed teams daily. This should mitigate communication risks emerging from cultural differences by keeping the potential problems transparent (Summers, 2008). In addition, creation of specific roles has been proposed as an approach for mitigating communication issues stemming from cultural differences. Layman et al. (2006) proposed the creation of a role responsible for close collaboration between the developers and the management, in the event that they are separated. Korkala and Abrahamsson (2007) studied the propositions of Layman et al. (2006) and concluded that they are worthwhile to consider in distributed settings. Furthermore, they emphasize the importance of direct communication links between the participants. It should be noted however, that the distribution in the case project was not on a global scale (Korkala and Abrahamsson, 2007).

Bureaucratic organization can create barriers for communication in agile GSD projects. Bureaucratic organizations are characterized as hierarchical, procedural, regulated, established, structured, cautious and power-oriented (Wallach, 1983), and they have been identified as a difficult environment for agile development projects (Berger, 2007). Korkala et al. (2010) found supporting evidence for this claim in their study focusing on analysing communication in a globally distributed agile development project that had separate customer and vendor organizations involved. They found that bureaucratic organizational culture created significant challenges for communication. One of the challenges was deliberate information hiding, i.e. the customer organization did not grant the vendor access to important information such as their codebase. Further, the customer organization did not provide adequate information about the requirements for the vendor. The lack of domain knowledge at the vendor organization made their situation even more challenging. In order to respond to these findings, the study concludes with a set of guidelines aiming at creating an environment that supports meaningful communication (Korkala et al., 2010).

The literature study made for the purposes of this work shows that communication challenges of GSD are many, and exist regardless of the development approach. It also shows that the mechanisms for mitigating these challenges are merely general-level recommendations and encouragements for using individual communication tools. This finding, combined with the pivotal role of communication in agile development, further supports the purpose of this study to provide a concrete approach for companies to improve communication in their agile GSD projects.

2.2. Media Synchronicity Theory

Communication theory and the processes through which communication was analyzed during the study are presented in this section. An overview provides understanding of the main concepts that created the theoretical lenses of the study from the perspective of communication.

Media Synchronicity Theory (MST) is an extension of Media Richness Theory (MRT) (Daft and Lengel, 1986; Daft et al., 1987) and aims to predict the performance of communication and examine communication media capabilities in various contexts of use (Dennis et al., 2008). MST defines two separate communication processes, *conveyance* and *convergence*. In our study, we use these processes to categorize and analyze the use of different communication media in different phases of the case project.

Conveyance is related to transmission of new information that enables the receiver to create and revise a mental model of the information. In order to establish this understanding, as much relevant information as necessary is required. If information is insufficient (i.e. conveyance is defective), incorrect conclusions will be reached. ***Convergence*** process aims towards a shared

Table 2
The ability of different communication media to support synchronicity as defined in Dennis et al. (2008).

Communication medium	Ability to support synchronicity
Face-to-face	High
Video conference	High
Teleconference	Medium
Synchronous instant messaging	Medium
Email and asynchronous electronic communication	Low
Voice mail	Low
Fax	Low
Documents	Low

understanding on the meaning of information, and the participants need to mutually agree that the mutual understanding is achieved or that it cannot be achieved ("agree to disagree"). Convergence can require less information processing compared to conveyance if it focuses on a smaller set of information, for example a particular detail, than what was conveyed in the first place. However, if large differences in individual understandings exist convergence may require as much cognitive processing than conveyance. Defective convergence prevents individuals moving forward to other activities since they lack a shared understanding (Dennis et al., 2008).

Synchronicity is defined in MST as "*the ability to support individuals working together at the same time with a shared pattern of coordinated behaviour*". Further, media synchronicity is defined as "*the extent to which the capabilities of a communication medium enable individuals to achieve synchronicity*" (Dennis et al., 2008). Synchronicity is not always easy to achieve. Dennis et al. (2008) postulate that synchronous communication is necessary to synchronicity, but it is not necessarily sufficient considering participants can lack a shared focus during communication. The participants can for example, read their email during a meeting.

Using media with lower synchronicity should increase performance for conveyance processes (i.e. sharing new complex information), while convergence processes (agreeing on details, for example) benefit from using media with higher synchronicity (Dennis et al., 2008). In addition, a convergence process typically requires rapid transmission of small quantities of pre-processed information back and forth between the participants (Dennis et al., 2008). Communication media vary in their properties to support synchronicity. Table 2 is a summary from Dennis et al. (2008) depicting media abilities to support synchronicity.

According to Dennis et al. (2008), no single medium is inherently better than another and successful completion of tasks requires both conveyance and convergence processes. Therefore, it is proposed to use different media either simultaneously or in succession. Dennis et al. (2008) further suggest that the situation in which a medium is used affects its suitability for particular communication situations. The communication processes, the individuals engaged in communication and the social context in which the communication takes place all affect the medium's suitability for the given situation.

Dennis et al. (2008) also discuss *appropriation factors* that influence how people use different media. These factors further propose that when communicating participants' familiarity with each other increases, the need for media that supports high synchronicity is reduced (Dennis et al., 2008). Thus, the need to use different communication media is not constant, but evolves in time. In addition, media that fit the users' needs are more likely to be appropriated and used faithfully than those not meeting these needs (Dennis et al., 2008).

Considering the validity of MST, Niinimäki et al. (2010) studied twelve distributed projects and found evidence that MST can be used for selecting communication tools for projects operating in globally distributed settings. The study concludes that even though the tool use and decisions made on media choice were not always following suggestions of MST, the ideas presented in the theory are applicable and useful in globally distributed development projects. The results of a laboratory experiment on the theoretical underpinnings of MST are reported in Dennis et al. (1998). The study focused on the impacts of different media on effectiveness of both conveyance and convergence. The study provided preliminary support for MST. DeLuca and Valacich (2006) studied MST through seven hypotheses and found support for MST. Further, Dennis et al. (2008) provide a list of studies whose findings they explain via MST. Originally these studies applied MRT, whereas MST was able to answer to unexplained results of these works.

2.3. The concept of waste

The origins of waste can be traced back to the Japanese automobile industry of the 1950s and more specifically to Toyota Production System (TPS) (Ohno, 1988). The literature discusses two kinds of waste: *Type 1 waste* involves non-value adding activities that cannot be removed or mitigated from the current operating environment while *Type 2 waste* is a non-value adding activity that can be removed or mitigated (Womack and Jones, 1996). While the manufacturing industry has its own defined wastes, Poppendieck and Poppendieck (2007) have mapped these wastes to software development activities. These wastes, complemented with those identified by Mandić et al. (2010) and their descriptions, are discussed in Table 3.

A case study reported by Ikonen et al. (2010) revealed that the wastes presented in Poppendieck and Poppendieck (2003) are relevant to software engineering. It was concluded that software development projects can be successful even though waste exists and waste seems to be something that cannot be avoided in software development projects (Ikonen, 2010). There seems to be certain challenges in identifying waste in software development. Usually, in production and manufacturing the underlying nature of waste is visible and generally well understood (Hicks, 2007). In his work, Hicks (2007) argues that in the context of information management, the situation is the opposite. Ikonen et al. (2010) share a similar understanding around software development.

3. Research design

In this section, we describe how our study was conducted. The case study and its context are discussed along with the data collection and analysis techniques. In addition, we present the waste identification process.

Even though research in software engineering has a result-oriented, pragmatic view on research methodologies (Seaman, 2002), the philosophical perspective on this study can be seen as an *interpretative* case study. Orlikowski and Baroudi (1991) claim that an interpretive study attempts to understand a particular phenomenon (in this case, communication), through how the participants interpret their context. Hence these studies try to increase the understanding of this phenomenon and use this knowledge to inform other settings.

Case studies typically aim at answering "how" and "why" questions (Benbasat et al., 1987). In this study, we formulated three research questions. The main research question is:

- ***RQ:*** *How can waste identification improve communication in globally distributed agile software development?*

Table 3
The wastes of software development and their descriptions based on Poppendieck and Poppendieck (2007) and Mandić et al. (2010).

Waste	Description
Wastes and their descriptions identified by Poppendieck and Poppendieck (2007)	
Partially done work	Something that is not completed. E.g. untested code, undocumented or not maintained business decisions.
Extra features	Something that is not really needed.
Relearning	E.g. forgetting decisions, re-trying solutions already tried and the inability to utilize the knowledge of other people.
Handoffs	Passing work to someone else, getting work from someone else.
Task switching	How many other tasks the people need to do. Switching between tasks is distracting. For example, often switching between three or four smaller tasks requires more time to re-orientate to those tasks than to work on those. The time required to re-orientate to a task is waste.
Delays	Waiting for something.
Defects	Errors in program code.
Wastes and their descriptions identified by Mandić et al. (2010)	
Avoiding decision-making	This waste is about avoiding decision-making altogether and it should not be confused with "*Defer commitment*" practice of lean software development (Poppendieck and Poppendieck, 2007). The reasons behind this waste can vary from organizational issues, such as lack of empowerment, to individual characteristics.
Limited access to information	This waste is related to the existence of information; it might not exist. Limited access to relevant information may result in harmful decisions.
Noise or information distortion	Further divided to the dimensions of time and space. *Time related distortion* occurs when information is not recorded, not updated or is forgotten. *Space related distortion* occurs because actors are distributed across different levels or units of an organization and representing different contexts and sub-contexts. Space related information distortion is a phenomenon described by Melnik and Maurer in (2004).
Uncertainty	A variable or choice can have multiple values or options. These increased values or options increase the level of uncertainty.

This main research question is further elaborated by the following sub-questions:

- ***SQ1:*** *How can communication waste be identified in globally distributed agile software development?*
- ***SQ2:*** *What wastes can be found in communication in globally distributed agile software development?*

In this study, we identify waste that is specific to communication in globally distributed agile software development. We do not classify previously identified waste as communication specific in spite that they can be linked to communication in agile GSD. Similarly, we exclude well-known issues in GSD from being classified as communication waste.

The unit of analysis in this study was a single globally distributed agile software development project within a medium-sized North American software intensive company that implements interactive products for education and business. This site was selected based on the following criteria:

1. The case organization had operated using agile approaches for a period of nearly three years at the time of the study and had extensive experience working in a globally distributed context.
2. The case organization provided extensive access to individuals at multiple levels within the organization. These individuals were able to describe the situation from different viewpoints.

The project to we studied was suggested by the case company's management since it was working clearly in a globally distributed fashion with different tasks allocated to various sites across continents. In addition, management and the project personnel provided the authors extensive access to relevant data that was gathered using several different data collection techniques. The discussions with management and the project manager prior to the study revealed that they were, in general, satisfied with the project's progress. However, they identified the increased demands for communication with the offshore development organization as a challenge.

The project developed an improved version of an existing product that had been implemented by the case organization over the last 10 years. The software was divided into high-level units of functionality labelled as themes by the case organization. These themes contained different sets of functions that the product was supposed to provide. The themes were allocated to three different sites, remaining as independent as possible from the themes that were allocated to other locations, with the idea to minimize dependencies. Two of the sites were located in North America and were part of the case company. One site was located in India. This site was an independent contractor organization. Fig. 1 depicts the project organization along with temporal distances between the sites.

Initial Product Backlog was created before the actual programming work began. This process is described later in the paper. The programming work was not initiated at the same time in all sites. NorthAmerica 2 began development in September 2010. The programming work began at NorthAmerica 1 in June 2011 and in May 2011 at India. The reason why NorthAmerica 2 started earlier than the others was that the largest themes from the Product Backlog were assigned to them while the rest of the personnel allocated to the project at other sites were fully committed to other efforts. India had been collaborating with the parent organization for the last two years. NorthAmerica 1 was leading the development and contained the personnel responsible for steering the development along with the Product Owner. Before the implementation began at NorthAmerica 1, their leading role focused on steering the development at other sites.

3.1. Data collection

The application of several data collection methods such as archives, observations, interviews and questionnaires is often used in case studies in order to increase their validity (Eisenhardt, 1989; Yin, 1994; Stake, 1995). In our study, the data was collected using observations, informal discussions, documents provided by the case organization, and semi-structured interviews with open-ended questions. This data was collected at different phases of the project. The timeline of the study is presented in Fig. 2. The study had two main phases. The first phase focused on obtaining a solid overview of the case project while the latter phase focused on acquiring detailed information from the participants in the form of interviews. The actions described in Fig. 2 in some instances overlapped despite being presented in a linear fashion for the sake of clarity. Data collection and analysis were conducted throughout the project. The one-month gap between the phases is due to a vacation. The timeline presents the research activities after site and case project selection.

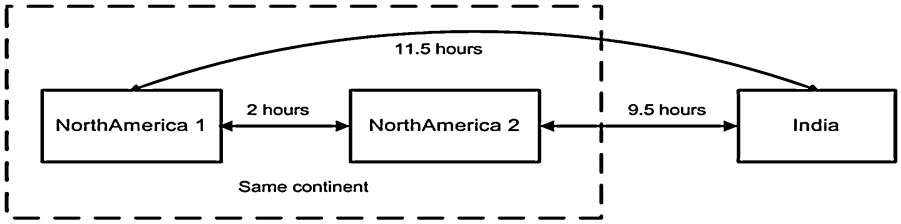

Fig. 1. The project organization along with temporal distances between the sites.

When the study was initiated all sites were involved in the project. NorthAmerica 1 and India were in the process of clarifying their individual requirements at the point when the study began. NorthAmerica 2 was implementing the product requirements assigned to them.

In order to ensure that the research data would be obtained from all necessary viewpoints, the key stakeholders of the project were identified together with the project manager, and the case company management. Table 4 presents the interviewed project stakeholders. In order to unambiguously identify stakeholders, their corresponding codes are preceded by the site name when there is a possibility of ambiguity in stakeholder location.

The study participants at NorthAmerica 1, excluding the developers, were team members who in addition to their work responsibilities worked as *Product Owner intermediates* for the teams relaying information from the Product Owner to the teams and vice versa. In addition, these senior members supported the Product Owner in decision-making on features to be implemented and provided direct feedback to the other sites.

The initial understanding of the project and the product was obtained during a total of 11 observation sessions taking place either onsite at NorthAmerica 1 or via telephone and screen sharing software. Field notes were taken during these sessions and a research diary was constantly updated during the study. In addition to observations, documentation about the requirements gathering and analysis process, as well as informal discussions and emails served as the means of providing information. If information was ambiguous, clarifying questions were asked until mutual understanding was achieved. In these observations, communication between NorthAmerica 1 and NorthAmerica 2 and between NorthAmerica 1 and India was studied.

During the first stage of data collection, one 70-minute interview focusing on the use of documentation and tools for sharing and storing it was conducted face-to-face at NorthAmerica 1. This interview involved all NorthAmerica 1 participants excluding the developers.

Data collection in research phase 2 was conducted via interviews. A total of 12 semi-structured interviews with open-ended questions and probes were conducted. Each interview lasted from 60 to 90 minutes and all participants were interviewed once. The interviews at NorthAmerica 1 were conducted face-to-face, while Skype was used in interviews involving NorthAmerica 2 and India. Due to company policies at India and to help with language related issues India.ProjectManager participated in all the interviews conducted with India. All the interviews were recorded and transcribed verbatim. In addition, field notes were taken and the research diary was updated.

3.2. Waste identification process

The project's development process contained two main phases labelled *pre-development* and *development*. As the names suggest, the pre-development phase included work conducted before the implementation begun. In this phase we focused on communication during the definition of the initial requirements and the initial Product Backlog. The development phase followed a Scrum approach (Schwaber and Beedle, 2002; Schwaber, 2004) with fixed-length three week synchronized Sprints (i.e. all sites began and ended at the same time). In this phase, we focused on analysing communication during identified development steps. The analysis of documentation as a communication tool during the project was included in the waste identification process. Fig. 3 describes the waste identification process applied in this study.

The use of different communication channels used by key stakeholders during different process steps is analyzed and related communication wastes are extracted in this process. The improvement actions responding to these challenges are determined and applied in the development process.

In our study, the **input** for each analysis step was a set of questions used to obtain a holistic view of communication within each phase. The questions focused on the steps belonging to Pre-Development and Development phases were based on the following main topics: *(1) who was involved in communication during the step*, *(2) what media were used during the step*, *(3) what kind of information was discussed during the step*, *(4) what were the benefits*

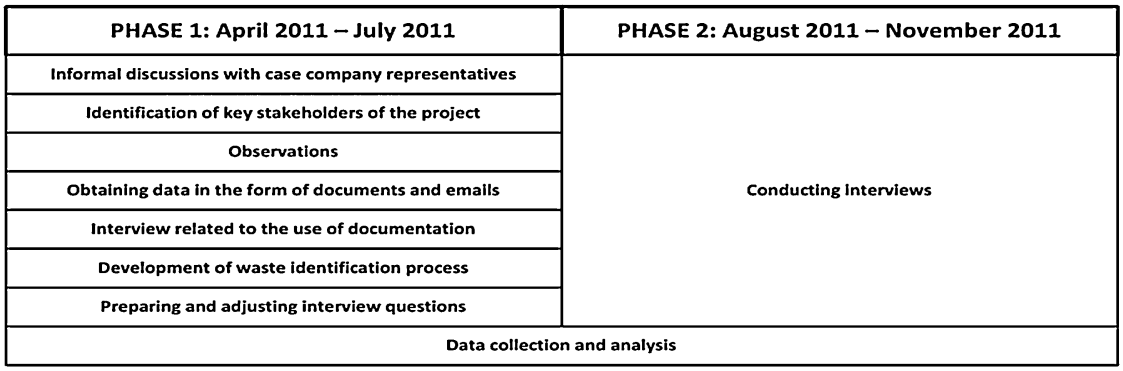

Fig. 2. The timeline of the study along with research activities.

Table 4
The interviewed stakeholders at different sites along with the description of their main responsibilities and their code in this study.

Role	Description of main responsibilities	Code
NorthAmerica 1		
Product Owner	Responsible for providing an overall strategy for the product. Identification and prioritization of new features and steering of development.	ProductOwner
Project Manager	Project planning and defect monitoring. Responsible for timely delivery of the product that meets both quality and financial requirements.	ProjectManager
Personnel Manager	Responsible for coordinating people based on the demands of technical decisions, for example, supporting the growth of peoples' technical competences and well-being.	PersonnelManager
User Experience Specialist	Creating user interface drafts, conducting usability testing and user research. Supporting development teams in usability aspects. Discussing user interface & usability topics with the ProductOwner and the development teams.	UserExperience
Overall Technical Lead	Responsible for technical aspects of the whole project. Responsible for technical architecture of the product and communicating technical details of the requirements to all teams.	MainTechLead
Two Developers	Responsible for developing the software at NorthAmerica 1.	NorthAmerica 1.Dev1 and NorthAmerica 1.Dev2
NorthAmerica 2		
Technical Lead	Responsible for technical aspects of the product at NorthAmerica 2.	NorthAmerica 2.TechLead
Developer and Tester	Developer was responsible for developing the software at NorthAmerica 2 while Tester was responsible for creating automated test cases for the product and worked as a coordinator between the testing services team and other teams working with the project.	NorthAmerica 2.Dev and NorthAmerica 2.Tester
India		
Project Manager	Responsible for delivering the decided contents of each Sprint at India.	India.ProjectManager
Quality Assurance Engineer	Responsible for the quality of the software developed at India.	India.QualityAssurance
Two developers	Responsible for developing the software at India.	India.Dev1 and India.Dev2

of the media when used during the step, and *(5) what were the wastes in communication during the step*.

Questions related to Documentation involved the following topics: *(1) what documents were produced during the development*, *(2) who was involved in the creation and updating of documents*, *(3) what were the benefits and wastes of using documents as a communication tool*, and *(4) how were the documents stored and what issues did this cause*. The **output** from each step was the general overview of communication during the steps (who participated, what was discussed and using what media), the benefits of communication media used

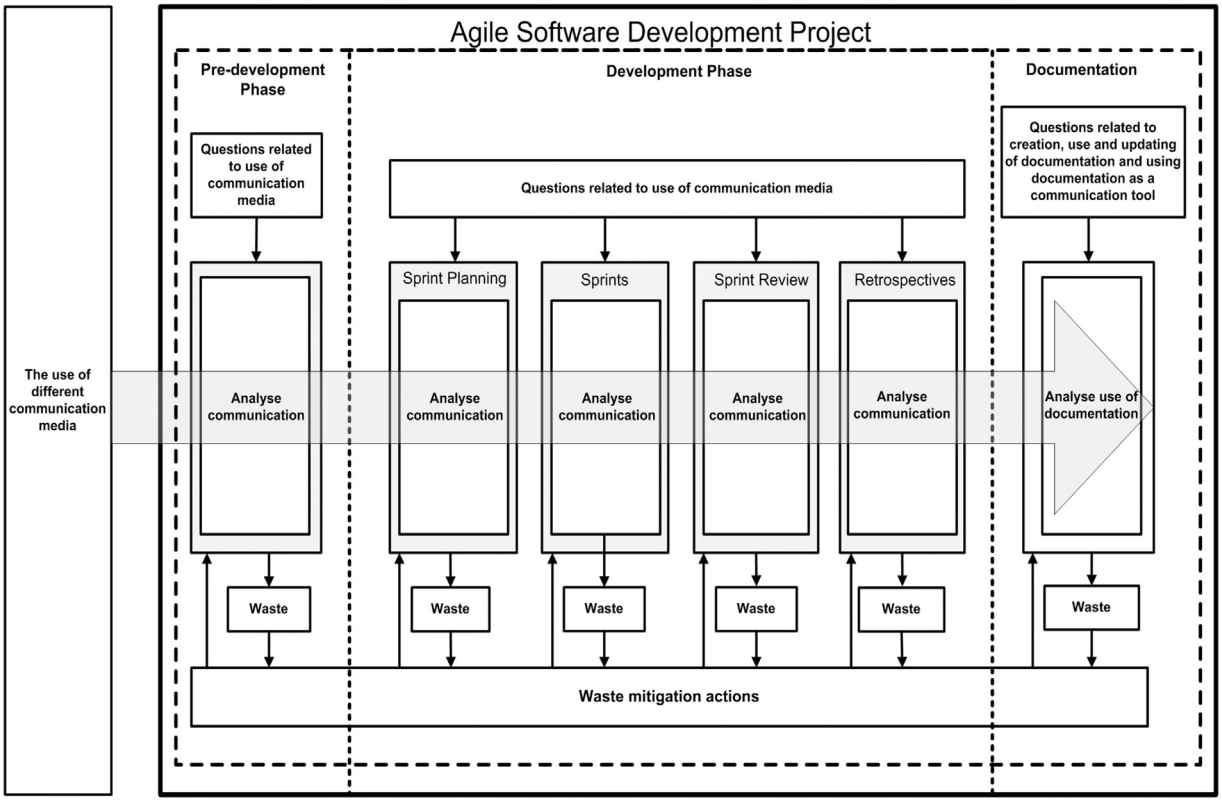

Fig. 3. The waste identification process applied in the study.

in them, and the non-value producing elements of communication from each step. Similar output was acquired from the perspective of documentation. Waste mitigation actions were defined in the *waste mitigation actions* process step.

This approach is derived from a framework described in Pikkarainen et al. (2008). Through their framework, Pikkarainen et al. (2008) analyzed whether the use of agile practices improved or hindered communication between the stakeholders of the organization. While communication hurdles are discussed in their approach, Pikkarainen et al. (2008) do not discuss communication waste. Further, their approach considers the whole organization including management while our approach focuses entirely on the development project level.

3.3. Data analysis

After the interviews, the transcriptions were first read and relevant topics were coded. Prior to the study a set of initial codes ("seed categories" (Miles and Huberman, 1994)) were created. As in Thematic Analysis (Braun and Clarke, 2006), additional categories were added when seen relevant. During the analysis a data reduction process (Miles and Huberman, 1994) was followed in order to focus on the essential data. The notes from informal discussions and observations were analyzed after the sessions from which they were collected. After the coding the tagged questions and resulting answers were grouped into a separate table forming a data display containing the compressed assembly of information, as proposed by Miles and Huberman (1994). The information was complemented with data available from field notes, observations and discussions. Wastes were extracted from the data. We also analyzed if the communication in each phase aimed towards conveyance or convergence and if the used media was capable of supporting these processes. This enabled us to discuss our findings from the perspective of MST.

Our data analysis has similarities to Grounded Theory. Cruzes and Dybå (2011) summarize Grounded Theory from Glaser and Strauss (1967) and Corbin and Strauss (2008) as a research approach that describes methods for qualitative sampling, data collection and data analysis. Grounded Theory includes simultaneous data collection and analysis phases (which was also applied in our study). However, Grounded Theory aims towards a generation of new theories, which was not the aim of our work. Further, in Grounded Theory the codes through which the data are analyzed are not pre-defined. Instead, they emerge from the data. Hence, the similarities between Grounded Theory and this study are limited to overlapping data collection and analysis.

4. Findings

This section discusses the findings of the study categorized by identified development process phases including the use of documentation. The identified communication specific wastes are summarized in each section. Further, we provide generalized descriptions of the identified waste as well as means to mitigate them in this section. In addition, the findings are discussed from the perspective of MST and threats to validity are addressed.

4.1. Pre-Development

Prior to entering the actual development phase, the ProductOwner collected a set of product requirements from real end-users, through the feedback system built into the older version of the product as well as by analysing competitors and market trends in the domain. In addition, internationalization needs affected the requirements. The collected requirements were further divided into 12 different themes that depicted functionalities at a high level.

Table 5
The communication media used during Pre-Development phase.

Communication within NorthAmerica 1	Communication between NorthAmerica 1 and NorthAmerica 2	Communication between NorthAmerica 1 and India
Backlog creation was conducted in face-to-face sessions at NorthAmerica 1.	NorthAmerica 2 did not participate in the backlog creation process with NorthAmerica 1. However, they provided input for themes allocated to them via telephone and screen sharing. Also email was used for exchanging information.	India did not participate in the backlog creation process. They did not communicate with NorthAmerica 1 before the development began.

These themes were split up between the three sites. Each site was given the responsibility to refine the themes to user stories with support from NorthAmerica 1. Table 5 depicts the usage of different communication media during Pre-Development phase.

4.1.1. Findings from NorthAmerica 1

The initial Product Backlog was created in face-to-face brainstorming sessions at NorthAmerica 1. All the stakeholders from NorthAmerica 1 participated in these sessions, excluding NorthAmerica 1.MainTechLead and UserExperience who were not working for the project at the time when these sessions took place. During the backlog creation process the PersonnelManager encountered problems in understanding one of the new product features. This particular feature was described in the initial requirements list in a very general way (PersonnelManager): "*It was a very high-level statement like containers will accept or reject objects*". This caused the PersonnelManager to seek additional information in order to provide accurate information to the ProductOwner about the functionality:

> "I needed a little bit of coaching to help me understand what it really was. I couldn't see how somebody would really use that unless it was simple to use and set up. You really have to understand the details in order to give a good detailed analysis of how something like that could be built." (PersonnelManager)

Also the ProductOwner saw similar challenges in the high level requirements: "*Our requirements documents are sufficiently high-level that it leaves a lot open to interpretation, which has its benefits but also has its drawbacks in that it's difficult to define from the requirements documents specifically what is the exact requirement. At that point it's not really broken down to the story level, sometimes it's just a major theme.*"

The extra effort needed to acquire additional information about vaguely communicated requirements can be seen as wasteful. However, these findings are stemming from the inherent characteristics of agile development since deliberately vague requirements are only clarified as needed. Therefore, these findings are not treated as waste in the context of this study.

4.1.2. Findings from NorthAmerica 2

NorthAmerica 2 did not participate in brainstorming sessions but they provided input for certain themes identified by NorthAmerica 1. These conversations took place via telephone and screen sharing software. The information shared in these conversations was further converged (i.e. more details were provided) via email and telephone. The issues NorthAmerica 2 experienced in this phase emerged from the requirements documentation.

Table 6
The identified communication related waste from Pre-development phase.

Identified waste	Description in the context of the phase
Lack of involvement	The lack of involvement from India to the initial backlog creation process resulted in insufficient understanding of real end user needs. This further caused *extra features*.

> "Some information in the documents that we received wasn't complete. There wasn't enough information in order for us to do the work. So not being co-located, it wasn't as easy as just walking over to someone, asking what did you mean by this." (NorthAmerica 2.TechLead)

The requirements were documented on a high level following agile approaches, so the incompleteness of the information in this case is something that can be expected. In a distributed context, difficulties of engaging in informal discussions over geographical distance are a known issue. Filling in the missing details (i.e. converging on the details) was more laborious, but it did not cause any particular issues.

> "We tried to spend a little bit more time investigating, and then writing up emails or getting telephone calls to try to get that information. It was just getting the information in order to do the proper research. When it was missing it was just harder to get." (NorthAmerica 2.TechLead)

These findings indicate similar issues with conveyance as in NorthAmerica 1; the information provided for NorthAmerica 2 was not conveyed efficiently. However, NorthAmerica 2 was able to compensate the lack of information by converging on the missing details even though it was more laborious due to geographical distance.

4.1.3. Findings from India

India did not participate in the backlog creation process and had no communication with NorthAmerica 1 before they started developing the features assigned to them. India did not report any specific issues that had emerged from documenting requirements at a high level. However, they experienced one particular issue during the development that stemmed from not participating in the backlog creation process.

> "Sometimes it happens that we suggest some features which may be very good for a customer, and sometimes it is accepted. And sometimes it happens that they (NorthAmerica 1) say that the users basically don't require or don't like this feature. So, this basically is a gap because we don't have a clear picture of what the end-user wants, what kind of features the user basically prefers." (India.Developer)

Therefore, there were *extra features* at India resulting from not participating in the initial backlog creation process. In this case, the waste behind the issues was ***lack of involvement*** stemming from India's absence during backlog creation process. A summary of the communication related waste from this phase is described in Table 6.

The requirements were documented following agile approaches, which, from the perspective of MST, rely on convergence instead of conveyance. At NorthAmerica 1, the initial backlog creation process was conducted using media with high support for convergence. This approach was not free from problems. Considering the extra effort for understanding the requirements, this could have been mitigated by more efficient conveyance, e.g. more detailed documentation, which on the other hand is counterintuitive with the propositions of agile development.

Table 7
The communication media used during Sprint Planning phase.

Communication within NorthAmerica 1	Communication between NorthAmerica 1 and NorthAmerica 2	Communication between NorthAmerica 1 and India
Face-to-face meetings	The decisions considering the Sprint contents were agreed via telephone, supported by screen sharing software.	The decisions considering the Sprint contents were agreed via telephone, supported by screen sharing software.

Defective conveyance due to vaguely defined requirements was encountered at NorthAmerica 2 as well, and they had to put more effort in converging on details. In this particular case, more effective conveyance could have helped NorthAmerica 2 to grasp the details better.

4.2. Sprint Planning

Sprint Planning was divided into two separate phases. Sprint Pre-planning meetings were held a few days before the internal Sprint Planning meetings that focused on implementation details. Internal Sprint Planning meetings were conducted independently at different sites without participation from others. The aim of the pre-planning sessions was to achieve a mutual understanding on what should be implemented in the forthcoming Sprint, similarly to Sprint Planning meetings of Scrum. Therefore, the meetings aimed for converging on details of to-be-implemented features. Pre-planning meetings were arranged so that they would fit in the ProductOwner's schedule. If the ProductOwner was not available for a scheduled meeting, the meeting would be rescheduled, if possible, so that the ProductOwner was able to participate. Table 7 indicates the communication media used between the sites during this phase.

4.2.1. Findings from NorthAmerica 1

Sprint Pre-planning meetings between NorthAmerica 1 and NorthAmerica 2 and NorthAmerica 1 and India were held separately via telephone and screen sharing software. These sessions lasted approximately one hour. The internal Sprint Pre-planning meetings at NorthAmerica 1 lasted from five to ten minutes. As it was agreed, the ProductOwner participated in Sprint Pre-planning meetings but not in internal technically oriented planning sessions.

> "I've made a conscious decision not to be too involved in internal sprint planning and try to be more involved in high-level pre-planning. Primarily because I'm not spending enough time in the market, I'm spending too much time with product development. But to be honest, where my strength lies is more in higher-level functionality, what problems are we trying to solve." (ProductOwner)

The internal planning sessions at NorthAmerica 1 were run by the MainTechLead who had extensive knowledge about technical details of the product. The following comment made by MainTechLead indicates a need for extra communication stemming from the ProductOwner's absence in internal Sprint Planning meetings:

> "A lot of times when we were thinking about the tasks that we were given, we come up with a bunch of different ways to do it in the sprint planning. And then we have to go to ProductOwner and get feedback saying we could do it in half the time if we did it this way, is that okay?"

Therefore, ***lack of involvement*** was identified as a source for this additional work. As proposed in agile approaches, this waste could

have been avoided by involving the ProductOwner in internal Sprint Planning at NorthAmerica 1.

4.2.2. Findings from NorthAmerica 2

At NorthAmerica 2, there were challenges resulting from *partially done work* that realized in a form of missing acceptance tests[3] during Sprint Pre-planning meetings: "*All the acceptance criteria should already be done before pre-planning begins. That's* (defining acceptance criteria) *not something that should be in the pre-planning session*" (NorthAmerica 2.TechLead). In the case of such events, NorthAmerica 2 conducted Spikes and re-evaluated the unclear feature. In the case that evaluating the unclear feature required a Spike, either additional information was requested or the feature was postponed to the next Sprint. If the feature could not be postponed, additional effort was added to the estimate:

> "We spike it out and say, get the information from the product owner and we'll work on it next sprint. If it's something that had to be done this sprint then sometimes we'd put a placeholder and say we're gonna do the spike and then we'll allocate five story points to do the implementation." (NorthAmerica 2.TechLead)

Earlier in the project, NorthAmerica 2 tried an approach of contacting NorthAmerica 1 via phone to sort out the problem that way. This practice was discarded since it was not seen productive. (NorthAmerica 2.TechLead):

> "We did try to phone some people to try and get information either during our lunch when NorthAmerica 1 would be available. Sometimes we started planning late so it could be overnight and we'd go to the next day, then late at night we'd try to get some information from them. When we did this at the beginning we'd actually waste the time."

From the viewpoint of communication, the amount of information provided to NorthAmerica 2 was not enough to conduct the work without obtaining additional information that could have been provided in the planning meetings by NorthAmerica 1. In the case of NorthAmerica 2, previously identified waste *partially done work* was identified as a waste. No communication-specific waste emerged.

4.2.3. Findings from India

From India, India.ProjectManager and India.Dev1 participated in these meetings. Similarly to NorthAmerica 1, insufficient time for communication was experienced during Sprint Pre-planning with India: "*I found that we have a very limited time of backlog grooming* (Sprint Pre-planning). *And in that, sometimes it happens that some of the stories were not very clear, and we end up discussing those things for a long time, and then we get less time for each to discuss*" (India.Dev1).

The following provides insights why India saw ambiguity in their user stories. The MainTechLead saw challenges in communication with India: "*It's* (communication during Spring Pre-planning) *more challenging because, it's the different team culture where it's one person* (India.ProjectManager) *doing all the talking, there's not really any conversations.*" Communication with India during the Sprint Pre-planning meetings took extra effort due to the abovementioned:

> "We have to really explain the rationale behind everything so they can understand where we're coming from. But it's harder because you're not talking to the person who's actually going to be doing the work with India. A lot of times you'd ask them a question and they'd just say, okay, sure, we'll do that. And you don't know if they actually understood it. That's why we have to be very careful with them and spend more time in carefully defining not only our questions but all the acceptance criteria." (MainTechLead)

Cultural issues are widely recognized in the GSD literature as a factor affecting communication. In this case, India lacked in-depth knowledge on the technical as well as domain aspects of the project and this was seen as a major issue: "*We really, really struggle with that*" (ProjectManager). This resulted into challenges and the biggest of them was:

> "How do we get them working on more complex features, more complex themes that we don't need to define really in detail. Like for example (a particular theme). We actually had to spend a lot of time defining that here first and then give it to them and we still have to really, really work with them." (ProjectManager)

Similar views to the lack of understanding were experienced also at India:

> "The (person at NorthAmerica 1), he doesn't have any background about the problem. So, he is not familiar or is not at the level of understanding that we have about the specific problem. So to explain the particular scenario or particular feature very clearly is a challenge." (India.QualityAssurance)

Therefore, there was a ***lack of shared understanding*** between NorthAmerica 1 and India that set increased demands for communication and made it prone to misunderstandings. This in turn required a significant communication effort in order to clarify them.

The ProductOwner (or anybody else from NorthAmerica 1) did not participate in the internal Sprint Planning meetings at NorthAmerica 2 and India. NorthAmerica 2.TechLead saw that participation from NorthAmerica 1 was not worthwhile:

> "In order for someone to attend a meeting that's four hours plus, in order to provide input for ten minutes, is not for me a good use of time. I don't see it having as much of an advantage. I wouldn't expect ProductOwner to be in there. ProductOwner's already said this is what I want done, I've agreed, you guys determine how it actually should be done. That's why we have the pre-planning."

India, however, saw benefits if someone from NorthAmerica 1 would have participated in their internal Sprint Planning meetings. India.Dev1: "*Definitely that will be beneficial for us, because sometimes it happens that we require more design or some clarification from* (NorthAmerica 1), *and then we, basically after the* (internal) *Sprint Planning we used to discuss those things in a tech call*[4] (with NorthAmerica 1)." There were requirement-related challenges in India, but due to significant time-zone difference, participation from NorthAmerica 1 was not reasonable.

Issues with technical infrastructure are recognized challenges of GSD and they were encountered also in our study. The following is not limited to this particular phase alone, but applies in all situations and phases in which communication tools were used between NorthAmerica 1 and India. Occasionally, the voice quality was poor and this resulted in challenges: "(NorthAmerica 1) *has had trouble understanding what we are talking about or we have had trouble understanding, in the sense that, because the voice quality is poor, we are not able to be sure what they have to say*" (India.ProjectManager).

Considering screen sharing software, especially over long distances, the increased lag was seen as problematic and it was sometimes significant.

[3] Acceptance criteria were the case organization's term for acceptance tests.

[4] Tech calls are discussed in more detail later in this study.

Table 8
The identified communication related waste from Sprint Planning phase.

Identified waste	Description in the context of the phase
Lack of involvement	The ProductOwner's absence in internal Sprint Planning meetings caused extra work since the most suitable way to implement something had to be agreed with the ProductOwner after the meeting.
Lack of shared understanding	Participants in NorthAmerica 1 and India did not share similar understandings of features being discussed. This resulted from the fact that India lacked deep technical and domain knowledge of the project. Also, it was difficult for India to explain their work clearly for NorthAmerica 1 since NorthAmerica 1 did not share their deep knowledge about the implementation of the features.

> "Over long distances, the lag can be frustrating." (ProductOwner)

> "We have got delays of up to 30 seconds to one minute between when I update a screen at my end and (NorthAmerica 1) is able to see the same screen. And similarly vice versa." (India.ProjectManager)

Further, the connection between the sites was unstable: "*Sometimes connection goes off, so that is also a limitation, while you reconnect, and again start a meeting. So it's sometimes time-consuming also*" (India.QualityAssurance). Despite the same communication tools being used between NorthAmerica 1 and NorthAmerica 2, technical issues were not reported. While it is unclear why communication between these sites was smooth, it can be assumed that possibly a better technical infrastructure and shorter distance between the sites could have contributed to this. The summary of identified communication related wastes is provided in Table 8.

From MST's viewpoint, the lack of shared understanding stems from insufficient conveyance since the information provided prior to pre-planning sessions was sometimes too vague. Similarly to this, missing acceptance tests mentioned by NorthAmerica 2.TechLead indicate defective conveyance. In the case of a lack of shared understanding, the issues of lacking conveyance and also convergence emerged. From a theoretical perspective, mitigation requires conveying information effectively (e.g. documenting acceptance tests properly before they are converged). In order to improve the understanding between the communicating participants, the features that are expected to be implemented should be conveyed (e.g. documented) in detail for the party with the lesser understanding.

4.3. Sprints: communication media related waste

In this section, the wastes related to communication media used during the development iterations are discussed. Table 9 depicts the use of different media between sites. The discussion of communication media between different sites is divided based on their ability to support either conveyance or convergence.

Table 9
The communication media used during Sprints phase.

Communication within NorthAmerica 1	Communication between NorthAmerica 1 and NorthAmerica 2	Communication between NorthAmerica 1 and India
Face-to-face communication, instant messaging (IM), telephone and email.	Telephone supported by screen sharing. Email.	Telephone supported by screen sharing. Email.

4.3.1. Media supporting conveyance

Email was extensively used during development. Email was seen as beneficial for more formal decisions that require a "paper trail", "*Email is really nice, if you need something a little more formal*" (PersonnelManager). Similarly to the PersonnelManager, the NorthAmerica 2.TechLead saw advantages in email: "*To have a summary of results at the end of a meeting is always handy, so to have something via email is something you can go back and refer to.*" There were, however, waste in email communication. Email is not supposed to be an effective medium for convergence, but in the project it was used also for this purpose. According to the PersonnelManager there was *handoff* in emails: "*Sometimes there's several follow-up emails that say, did you really mean this. And you compound that with the delay for each time, it's not as efficient.*"

Other stakeholders recognized *delay* in email as an issue as well: "(the challenge is) *the delay between sending it back and forth. If you would be able to get someone on the phone it's much faster to get some of your responses and explanations*" (NorthAmerica 2.TechLead). Also NorthAmerica 2.Tester mentioned *delay* as an issue in email communication: "*There's a delay in replying.*" The abovementioned is in line with findings related to delayed and complicated problem solving via email. There were also other issues in using email communication in converging information resulting from multiple and conflicting viewpoints presented in email discussions:

> "Somebody would ask him (the ProductOwner) something, but there would be other people on the emails and they'd answer actually you can't do that because technically you can't do it. So, meanwhile, the first email how would you (the ProductOwner) like us to do this. (The ProductOwner) will come back, yes, I'd like you to do that. Meanwhile there's another email that says no, actually technically you can't do it." (ProjectManager)

The ProductOwner did not answer to the latest email that had the newest information, using ***outdated information*** as the basis of making decisions. However, this waste was seen as a minor problem and the discussion converged sooner or later either by email or during a meeting. In this particular case, the reasons contributing to ***outdated information*** from the ProductOwner's side stemmed from his very busy schedule: "*His schedule is packed and I email the* (ProductOwner) *with a question, then I have no idea when I'll hear back from him.*" (UserExperience). Paradoxally, the ProductOwner's busy schedule was the reason why the majority of communication with him was conducted via email:

> "As a general rule, we'd send an email, because his (the ProductOwner) schedule is always very busy." (NorthAmerica 2.TechLead)

From India, communication with the ProductOwner was done via intermediates (mainly MainTechLead) and this was seen as a communication challenge leading to a *delay*: "*Since we don't have direct communication with the product owner, so that's basically a lag for our development. So, it basically hampers the development speed*" (India.Dev1). There was extensive email communication between the sites. Time zone difference combined with the *delay* resulting from waiting for the answer from a relevant person was seen as a challenge within India.

> "Challenges (in email communication), the turnaround time that we get for our queries. Owing to the time differences and having the people who decide what should be done, to answer our queries. So that basically leads to a delay by a day, because we have a time zone difference."(India.Dev2)

The MainTechLead saw challenges in emails sent by India. NorthAmerica 1 and India had agreed that India would prepare a daily email message explaining the current status of their work with possible questions. This information was further discussed

and clarified in a separate teleconference supported by screen sharing software: "*A lot of times their initial email to me, it may not make sense to me. So then, in my morning call, I ask them to demonstrate it, and if I'm still confused I tell them OK, make a video*" (MainTechLead). These daily calls, also referred as "Tech Calls" were held in order to compensate for the problems caused by time zone difference and limited overlapping work hours with India. These calls took place at approximately 7:30 am NorthAmerica 1 time and lasted for approximately 30 minutes.

The challenge experienced by the UserExperience in email communication provides insights to why the email communication with India was ambiguous: "*There's some time that I need to spend just making sure I have the right idea of what they're trying to communicate. There have been some miscommunications about what they were trying to get across. Just the way that the sentences are structured, it's not clear what their meaning is, so you have to kind of guess.*" This language barrier led to poor conveyance.

Requirements-related communication during the Sprints with India took extra effort and was also seen as source of miscommunication (MainTechLead): "*The one thing with India is the implicit requirements that we need to be better at enumerating. This is the biggest instance of miscommunication, they're expecting everything to be very explicit.*" UserExperience stated a similar communication problem with India considering the user interfaces. Everything needed to be specified in detail, since:

> "Otherwise they'll give us something weird. Even if it's just like an OK button, I still need to do a mock-up of that which takes time. Because otherwise it'll be really squished, or the buttons will be on the left side instead of the right side. It's just completely random."

The following comment by the PersonnelManager suggests that, to some extent, the need to document everything explicitly for India resulted from their lack of experience on the product: "*We have usability here, we have people that have worked with this product forever. We know the little nuances and idiosyncrasies of it and why we do things, some history behind things. They don't know that. We do things based sometimes on history.*" Therefore, there was a ***lack of shared understanding*** within India that resulted in miscommunication and increased demands for conveying information.

4.3.2. Media supporting convergence

Face-to-face communication was used during the Sprints within NorthAmerica 1. While it was seen as extremely beneficial due to immediate feedback (i.e. high synchronicity and support for convergence) there were also challenges.

> "You don't have things written down. So you gotta be careful, you gotta take your notebook, write things down. MainTechLead and I will say, I'm pretty sure the ProductOwner said that, but now we gotta check, because we forgot to write it down, or neither of us can remember exactly what he said. It's hard to remember." (ProjectManager)

In this case, relying on face-to-face communication and leaving decisions undocumented led to *relearning*. Undocumented decisions themselves are a source of *information distortion*. According to the UserExperience, face-to-face communication resulted in decisions that were made too fast without thorough understanding of the topic: "*There's no time to think about things, you just have to decide. You don't get a chance to think about all the possible weird cases that could happen.*" The missing details were later *converged* using email or in PlayTime Sessions described later in this paper.

Within NorthAmerica 1, there was occasional Sprint time communication with the ProductOwner via both telephone and instant messaging. Their usage was, however, limited by the ProductOwner's availability. Instant messaging was used occasionally, for example, for quickly *converging* on details and to check if the ProductOwner is at the office; "*We don't use that a ton, just once in a while when I just have a quick question or I need to know if* (ProductOwner) *is there, then I'll ask* (ProductOwner) *that*" (UserExperience). Telephone was used for converging information that would have been more laborious to converge through email:

> "I wanna discuss it (email from India) more, and it's too complicated to write. Or it would take a lot of effort to write an email, so that's when I'll see if he's there and just ask him, what do you think about this. It's just easier." (UserExperience)

4.3.3. PlayTime sessions

The PlayTime sessions were meetings during which the stakeholders of NorthAmerica 1 gathered together to use the latest build of the product together with the ProductOwner for feedback. These sessions were held from two to three times per week and were seen as an essential factor for efficient communication. India was not able to participate in these sessions due to the temporal distance. NorthAmerica 2 as well did not take part in these meetings. The reason for this was that the members of NorthAmerica 2 did not see value in participating due to the fact that the senior stakeholders steering the development and relaying information to them were located at NorthAmerica 1:

> "What I see is that (NorthAmerica 1) has the usability team, and the people who he'd (the ProductOwner) play with and try to get ideas of are there. So long as you have representation there, then that's fine. So, right now I would believe that (MainTechLead) would be our representation in this project, and anything that comes up he'll try to forward to us." (NorthAmerica 2.TechLead)

Similarly to *relearning* that emerged during face-to-face discussions outside PlayTime meetings, important details related to the feedback received from the ProductOwner were sometimes lost during PlayTime sessions:

> "It's a very informal meeting, so there's not someone taking meeting minutes. Sometimes, (the ProductOwner) is using the software and ideas are just spewing out there, and we don't capture them all, and we let them slip. We get the big things but then a lot of the smaller little details we sometimes miss and they come up in a different PlayTime. The second time we definitely write it down because we recognize it the second time." (NorthAmerica 1.MainTechLead)

This comment indicates that the information loss was not permanent due to efficient convergence mechanism that was provided by the PlayTime sessions. The importance of these sessions is illustrated by the comment from the ProductOwner: "*I think it can save a lot of time for development. You know, save them from going down a wrong path if people are there for them to ask questions and, show functionality and ask questions.*"

The developers at NorthAmerica 1 did not see any communication challenges in these meetings: "*I could only think of benefits, I couldn't think of any challenges*" (NorthAmerica 1.Dev1).

The waste identified from this phase is summarized in Table 10.

From the perspective of MST, email was used to converge information within NorthAmerica 1. The findings of this study suggest that convergence via email can cause other wastes than delay, such as ***outdated information*** in the context of this study. However, the circumstances of the project affected the use of email as a means for passing, requesting and clarifying information between the participants. Also media with high synchronicity can cause waste if the information communicated is not documented anywhere. This can, however, be mitigated by efficient convergence strategies, such as the PlayTime sessions described in this study. Also, in situations

Table 10
The identified waste from Sprints phase.

Identified waste	Description in the context of the phase
Outdated information	Email related finding. The ProductOwner did not always make his decisions based on the latest information about the particular topic.
Lack of shared understanding	India's lack of similar understanding with NorthAmerica 1 considering software's domain and design guidelines resulted in increased demands for documenting requirements assigned to them. Otherwise, the way India implemented their features was sometimes not what was expected by NorthAmerica 1.

where participants do not share a similar understanding of the product, efficient conveyance is required (as can be deducted from the tenets of MST). Efficient convergence is required to sort out misunderstandings.

4.4. Sprint Reviews

Table 11 presents the communication media used in Sprint Review sessions.

Sprint Review meetings were held for two different audiences. The Sprint Review meetings focusing on the outcome of each iteration were held face-to-face at NorthAmerica 1 when there was something to be demonstrated to the ProductOwner. Similarly to Sprint Planning and PlayTime meetings, ProductOwner's participation was mandatory and Sprint Reviews were rescheduled when necessary based on the ProductOwner's availability. However, if there was nothing to be demonstrated to the ProductOwner in NorthAmerica 1, Sprint Reviews were cancelled. The study participants from NorthAmerica 1 Sprint Reviews identified no waste.

The Sprint Reviews between NorthAmerica 1 and NorthAmerica 2 and NorthAmerica 1 and India were held via telephone and screen sharing. Similarly to NorthAmerica 1, no waste was identified. However, the challenges experienced with communication infrastructure during other phases were encountered during these meetings. From the ProductOwner's side, there were no communication issues since he was well aware of what was to be presented in each meeting:

> "Typically I know before what's been accomplished just because of my communication with the team. So I have a good understanding as to what's going to be presented." (ProductOwner)

In addition to team specific meetings, the project had joint *Master Sprint Review* meetings hosted at NorthAmerica 1 during which all the teams presented their work to other teams. However, the main purpose of these meetings was to demonstrate the software to the representatives of the case company's upper management who participated in these sessions in order to get the big picture of the project and provide their feedback. Aside from the challenges related to technical communication infrastructure, no waste was identified in these meetings.

Sprint Reviews aim to verify whether the set goals for the Sprint have been met. The demo held for the ProductOwner this session aimed towards convergence, considering the ProductOwner was well aware of the contents to be presented. Interactive media was used during all the Sprint Review sessions. This follows the suggestions of MST due to these medias strong support of synchronicity and, hence, convergence. No specific waste emerged from this phase.

Table 11
The communication media used during Sprint Reviews phase.

Communication within NorthAmerica 1	Communication between NorthAmerica 1 and NorthAmerica 2	Communication between NorthAmerica 1 and India
Face-to-face meetings.	Held via telephone supported by screen sharing software.	Held via telephone supported by screen sharing software.

4.5. Retrospectives

Table 12 summarizes the use of different communication media within NorthAmerica 1 and between sites during Retrospectives.

The teams held internal Retrospectives, but the ProductOwner did not participate in these. The reason for not participating was the ProductOwner's limited time:

> "Mostly it's just time. It's just a function of my time is better spent elsewhere. I'm assuming that if there's things that they need me to do, to help with the effectiveness of the sprint, they'll feed that back to me." (ProductOwner)

Instead, the MainTechLead was in charge of running the Retrospectives and participated in meetings taking place at NorthAmerica 1 and NorthAmerica 2. Due to the significant temporal distance to India, no one from NorthAmerica 1 participated in the India Retrospectives. The Retrospectives were conducted face-to-face within NorthAmerica 1.

NorthAmerica 1 participated in Retrospectives conducted within NorthAmerica 2 via telephone and screen sharing. The participation from NorthAmerica 1 was seen as beneficial:

> "It's much more productive, because we will assign them action items. A lot of the things that we need help with are not necessarily things that we can fix on our own, so we need product management in some way to take an active role in it. So we do need some sort of representation, just as long as somebody is there, I think is important." (NorthAmerica 2.TechLead)

Even though the temporal distance prevented NorthAmerica 1's participation in Retrospectives conducted in India, the potential participation of NorthAmerica 1 was not seen as beneficial, as was mentioned by India.ProjectManager:

> "Would it be helpful for someone from NorthAmerica 1 to participate, perhaps, I mean, they'd be able to see what the team thinks how the sprint went. But would it be greatly beneficial, I doubt it."

Relevant topics emerging from India Retrospectives were communicated to NorthAmerica 1 after the meetings: "*We prepare the document and send a mail* to (NorthAmerica 1). *They also look at it, and they take appropriate action and decision based on it*" (India.QualityAssurance). In summary, no waste was identified from Retrospectives phase at any site.

Within NorthAmerica 1 and between NorthAmerica 1 and NorthAmerica 2, Retrospectives were conducted using interactive media. From the MST's perspective, using media supporting convergence is in line with the propositions made in agile literature.

Table 12
The communication media used during Retrospectives phase.

Communication within NorthAmerica 1	Communication between NorthAmerica 1 and NorthAmerica 2	Communication between NorthAmerica 1 and India
Face-to-face meetings.	NorthAmerica 1 participated via telephone supported by screen sharing software.	No involvement from NorthAmerica 1. The conclusions from India Retrospectives were sent to NorthAmerica 1 as an email.

In the case of India, the discussions were conducted without participation from NorthAmerica 1 and action points were afterwards conveyed to NorthAmerica 1. This information was then converged later.

4.6. Waste found while discussing documentation

Documentation was used as a source of product related information. The initial themes and the user stories were stored in a dedicated Product Backlog tool. In addition, a wiki was extensively used during the development and the project had a dedicated network drive in which, for example, user interface illustrations were stored. In the wiki, there were separate "sub-wikis" for different teams. Based on the data, the following documentation-related waste was identified.

Keeping documentation up to date was seen difficult: "*The challenges are keeping them up to date at all times*" (MainTechLead). In many occasions, documentation was seen as a task of lesser priority and it had to be done later, if at all: "*The documentation usually doesn't get done later. So that's a big challenge. And it happens. We have out-of-date documentation, no question*" (PersonnelManager). This was seen as common problem that created issues for the project.

> "An outdated document or incomplete document is always the problem." (NorthAmerica 1.Dev2)

> "If the information is out of date, then it's not useful, or it might mislead you to the wrong place." (NorthAmerica 1.Dev1)

Hence, there was ***outdated information*** and it was also found that if documentation was done later, some of the important information was forgotten and not included in the documentation: "*I need to complete that* (development task) *first, then I create the document. So, sometimes it happens that you may miss some information or you may miss some knowledge to share in that document*" (India.QualityAssurance). This is time related information distortion.

In addition, ***restricted access to information*** was found for the project wiki at India:

> "We don't have overall access for all the pages. This limits us for the pages which we are working at. If we need designs from other team's page, we inform this to (MainTechLead), and (MainTechLead) sends our read-only access to that page[5]." (India.Dev1)

Relevant information was scattered across different documents stored at the project wiki: "*I can look on the wiki and I can show all sorts of implementation, design documents, detail design documents, functional specs, that sort of thing. But nowhere in one document are all these things concentrated in one spot*" (PersonnelManager).

This was seen as resulting from the fact that there was no uniform approach to update the project wiki: "*There's no process that says you must do it* (updating information) *this way. If people don't sort of look at it and follow that same form, you can get stuff in there that gets lost*" (PersonnelManager).

This comment indicates that finding relevant information was also difficult. The comment from NorthAmerica 2.Dev supports this: "*The search feature is terrible. It's almost unusable to search it, I find, unless you actually can find someone who can tell you where it is, it's hard to find documentation.*" Information was sometimes also fragmented. It was mentioned that information related to features they were implementing was documented in the wikis related to the earlier versions of the product, which in turn can make finding the relevant information difficult: "*Some information is documented in* (the earlier version) *wiki. For new people that join* (the project), *he doesn't know where to search for the information*" (NorthAmerica 1.Dev1). Further, the organization of the wiki caused problems in form of limited visibility to interrelated features implemented by different sites:

> "There's the documentation for features which exist and the usability wiki pages, which are linked to ours, but we don't necessarily see the changes that they're doing on their wiki pages, so we don't get that visibility. Something that may affect us may be documented in another team's wiki page, but you don't know to look there." (NorthAmerica 2.TechLead)

Therefore, the abovementioned issues can be considered as ***scattered information***.

Table 13 summarizes the communication waste found while discussing documentation.

From the perspective of MST, documentation is an efficient medium for *conveying* information. In this case, the identified waste indicates also defective *conveyance*. The ability of documents to convey information would improve if they would be kept updated, made readily available for every participant, and stored cohesively.

Table 13
The identified waste found while discussing documentation.

Identified waste	Description in the context of the phase
Outdated information	The documentation was outdated and was missing relevant information. This resulted in defective conveyance of information.
Restricted access to information	India did not have access to all information stored in project wiki. The access to relevant information had to be obtained via NorthAmerica 1. This waste is different from ***limited access to information***, which is related to the existence of information. In the case of this waste, the relevant information exists, but is not available.
Scattered information	Relevant information was scattered across several documents and it was difficult to find. This consumed resources.

4.7. Proposed corrective actions to the identified waste

Table 14 discusses the solution proposals for the identified waste in the context of this study. We provide generalized descriptions of the wastes and the corrective actions are derived from both empirical findings and existing recommendations found from literature. The actions stemming from literature are indicated by appropriate references.

4.8. Threats to validity

According to Yin (2003), validity of case studies can be approached from the perspective of construct validity, internal validity, external validity and reliability. In the following, we discuss the validity of our study based on this classification.

Construct validity: in order to improve construct validity, multiple data sources were utilized during the study. In addition, every action related to the study was documented in a form of field notes and a research diary, thus establishing a chain of evidence (Yin, 1994). Finally, ambiguities in data were validated, when possible, with the informants as suggested in Yin (1994). We also applied *investigator triangulation* proposed in Stake (1995) and discussed results and interpretations with colleagues, in this case between the researchers of this study, to prevent the problem of *multiple realities* (Kaplan and Duchon, 1988; Goetz and LeCompte, 1984).

[5] This comment is an edited version of the original. Grammatical errors are removed and the comment is edited for readability.

Table 14
Proposed corrective actions to the identified waste in the context of the case project.

Waste	Generalized description derived from the findings	Proposed corrective actions for the case company in the context of the project
Lack of involvement	The absence of key stakeholders from the process phases where their participation is essential to acquire information and provide input for the development and/or receive feedback.	Active collaboration and communication between all project participants is emphasized (Beck, 2000). Therefore, all the teams should be involved in the development process from the beginning. In addition, the stakeholders should participate in activities requiring their presence.
Lack of shared understanding	The communicating participants do not share similar understanding and expertise on the topic being communicated. This creates increased demands for communication and makes it prone to misunderstandings.	Considering the tenets of MST (Dennis et al., 2008), unclear topics should be communicated in as much detail as possible using media supporting conveyance. In this particular case, detailed specifications should be written for India and the information should be converged actively. Effective convergence strategy was applied with India by daily Tech Calls. This approach is in line with the recommendation of using domain experts communicating daily with distributed teams (Summers, 2008).
Outdated information	The topic that is being communicated or required is not based on the latest information about it.	In the context of email, this waste was a minor problem in this study and the waste was mitigated either in subsequent emails or in a meeting, such as the PlayTime session. In this case, the mechanisms for mitigating this waste were adequate. Considering documentation, ensuring that it remains up-to-date should be paid attention. This could be achieved by adding documentation related aspects as a part of the acceptance criteria in order to complete a task.
Restricted access to information	Relevant information is not readily available for all parties that need it.	Provide appropriate access rights to all participants from the beginning of the project.
Scattered information	The information related to the product or the project is dispersed in several locations which make it difficult and time-consuming to find.	Establish uniform policies to store and document information and follow these guidelines.

Internal validity: issues related to internal validity arise mainly when causal relations are examined. According to Robson (2002), causal relationships are often used as a tool in explanatory studies when seeking an explanation of a situation or a problem. Case studies are primarily used in exploratory studies, which aim to understand what is happening and seeking new insights (Robson, 2002). However, due to limited time reserved for the study, the effects of proposed solutions were not verified. Also, it could not be observed if the solutions would have generated additional waste themselves.

External validity: the results are drawn from a particular context in which the Product Owner is collocated with senior project members that work as intermediates with the distributed teams. Results can be valid only in this or similar contexts. However, the context itself is an important factor in case studies (e.g. Benbasat et al., 1987). In addition, interpretive case studies do not seek generalizability (Orlikowski and Baroudi, 1991).

Reliability: in order to improve reliability of the study, every action and item (e.g. codes and interview questions) related to the study was documented and, if necessary, updated as the study proceeded to form a chain of evidence.

There were additional limitations. The waste mitigation approach presented in this paper does not take into account against what criteria the improvements should be measured. Metrics such as defect rates, the amount of change requests, and perhaps the most essential agile metric, Velocity (Schwaber, 2004), could provide some guidelines for assessing the impacts of the waste mitigation actions. As mentioned earlier, waste identification can be seen as a challenge in software development since waste is not so visible, nor as well understood as in the manufacturing industry. In addition, the use of Media Synchronicity Theory was limited to conveyance and convergence processes alone, and the use of different media was observed through them. However, the purpose of this study was not to study the theory itself, but use its main concepts as the lens for analysing communication.

Theoretical saturation of data is a measure that is reached after new themes, insights or issues are not emerging from the data that is being gathered (Strauss and Corbin, 1998). The lack of practical guidelines that assist the estimation of sample sizes (e.g. the amount of people to be interviewed) has been criticized, e.g. in Guest et al. (2006). In order to answer to this critique, Guest et al. conducted a study in which they concluded that saturation was reached during the first twelve interviews they conducted within a homogenous sample, i.e. the participants were chosen according to common criteria. In our study, the participants were considered homogenous for all being software professionals that worked on the same globally distributed agile software development project. A total of 14 people were interviewed during the study, so considering the results presented in Guest et al. (2006), the data seems to be saturated. Whether saturation was achieved during data collection is unknown, due to limited availability of the participants. However, convenience sampling is commonplace in software engineering studies due to limited stakeholder availability for interviewing (Lethbridge et al., 2005).

5. Discussion and future work

In addition to the identified communication wastes, the issues previously encountered in globally distributed environments, also encountered in this study, can be considered wasteful. Challenges with *language barrier* have been discussed in Layman et al. (2006), Uy and Ioannou (2008) and Kajko-Mattsson et al. (2010), and problems with technical communication infrastructure in Ågerfalk (2004), Williams and Stout (2008) and Therrien (2008). Communication delays resulting from temporal distance are widely reported as challenges in distributed environments (e.g. Holmstrom et al.,

2006; Ågerfalk and Fitzgerald, 2006; Conchúir et al., 2009; Sarker and Sahay, 2004; Ågerfalk, 2004; Boland and Fitzgerald, 2004). We deliberately excluded these from being communication specific waste, since these challenges are well-known issues in global software development. Also, some communication media are inherently wasteful. For example, email has a built-in delay resulting from its asynchronous nature, where resolving even simple matters can take a significant time converging when communicated via email (Carmel and Agarwal, 2001). Similar findings were present in our study as well. Despite these downsides, email is a dominant communication tool in globally distributed settings and it was extensively used in this project as well. The Product Owner had a very busy schedule and this resulted in using email as the main communication media between him and the rest of the development organization. Hence, certain conditions may dictate the use of a medium that is not necessarily the best possible option given the communication requirements.

This study indicated that some of the wastes presented in Poppendieck and Poppendieck (2007) and Mandić et al. (2010) were also found in this study. Considering the impacts of these wastes and the wastes related to communication, their realization did not create any problems that would have seriously jeopardized the project. The only major challenge was the communication with India, but this caused only increased demands for conveying and converging information. Since the case project had established an efficient communication strategy with India in a form of daily calls, this mitigated the effects of waste identified from communication with them. Considering the findings of this study, they are in line with the findings made by Ikonen et al. (2010) who concluded that software projects can be successful despite existing waste.

For example, ***scattered information*** required more work to obtain the necessary, and available, information so that misunderstandings stemming from ***outdated information*** in email discussions were corrected at some point during the development. ***Outdated information*** in the context of documentation was, however, more permanent in nature. Even though seen as a challenge, it did not create any enduring problems throughout the development. However, if documents are used to convey information and convergence on this information is defective, making decisions based on ***outdated information*** can possibly have serious effects. ***Restricted access to information*** did not create major problems since India was able to obtain the information after requesting access to it. However, in the study reported in Korkala et al. (2010) the required information remained restricted from the organization needing it due to bureaucratic reasons. Therefore, even though the problems in this study were minor, ***restricted access to information*** can have more severe impacts on the project. ***Lack of involvement*** was encountered in two phases of the project. Within NorthAmerica 1 it caused communication overhead due to ProductOwner's absence in internal Sprint Planning sessions and with India it resulted in *extra effort*. India was not able to participate in PlayTime sessions due to temporal distance. From this viewpoint, ***lack of involvement*** was also a *type 1* waste. Existing literature shows that ***lack of involvement*** can have other effects as well. Korkala et al. (2006) studied four agile development projects with varying customer involvement during the development. The results show that, while customer's involvement during development decreases the amount of defects, these defects could have been avoided by increased, regular customer feedback.

The most significant pattern related to waste was the communication challenges between NorthAmerica 1 and India. Considering the interaction between NorthAmerica 1 and India, ***lack of shared understanding*** emerged as the most significant waste encountered during Sprint Pre-planning sessions and during the Sprints. The increased need for communication was identified by NorthAmerica 1 representatives before the study was even initiated. In addition, a ***lack of involvement*** in the case of India could have contributed to ***lack of shared understanding*** since India was not properly aware of end-user needs. A previous finding from Korkala et al. (2010) supports this: the lack of domain knowledge combined with unelaborated requirements provided by an uninvolved customer organization caused problems. In addition to a significant gap in knowledge of the domain and the knowledge related to the product itself, barriers in language and culture contributed to impacts of this waste by increasing the difficulty of communication. Therefore, our finding provides additional evidence on the importance of understanding cultural distance (Noll et al., 2010). Further, the identified waste can fall into both waste categories. As an example, ***restricted access to information*** can be a *type 1* waste that cannot be removed due to company policies. This further emphasizes the context-dependent nature of the mitigation strategies. Practices from agile development methods, suggestions for MST, and more rigid policies for ensuring that documentation remains updated and information is readily available for all, can provide guidelines for mitigating the effects of waste. While the policies are presented as empirical solutions, they follow the suggestions of Boehm and Turner (2003) about balancing agility with more discipline when seen necessary.

In general, the project was able to maintain active communication and followed the agile principle of face-to-face communication when it was applicable. PlayTime sessions with mandatory Product Owner participation can be seen as a factor contributing to the agile principle of active customer involvement and fast feedback and guidance from the customer side. Considering communication in the project as a whole, it was active and involved all the participating sites using interactive media when possible. This can be seen as a communication policy following the agile recommendation of interactive and active communication. In addition, the effective communication strategy within the project helped to mitigate the effects of identified wastes.

There are several opportunities for future research. It would be useful to evaluate if the communication wastes identified in this study are valid and if other wastes can be identified. This could be studied by applying the approach presented in this work in other contexts as well. We believe that this would further help companies to identify communication waste in their development efforts and to provide them tools to mitigate them. The proposed waste identification process requires additional research as well. In this particular case, we applied the process in the context of a single development project. Applying this approach in the context of a larger development programme consisting of several development projects would be a potent arena to test and further develop the waste identification process. In addition, identifying wastes and the ways of mitigating them could potentially have significant impacts for both industry and research. It would be interesting to apply the presented approach to identify wastes from areas outside communication, such as requirements management and defect correction, or from other levels within an organization.

Suitability of the mitigating process should be studied further since we were not able to verify the impacts of proposed improvement suggestions. It would also be very interesting to study communication wastes in globally distributed environments through other processes and approaches as well, since this could provide additional evidence on the validity of the findings presented in this work. Socio-technical congruence (Cataldo et al., 2006, 2008) could be used as such a process. According to Perry et al. (1994) the amount of communication developers engage in during the development is significant and communication on its behalf is a central mechanism for coordination (Kraut and Streeter, 1995). Socio-technical congruence focuses on the "fit" between task dependencies and the individuals' coordination activities. From the perspective presented by Kraut and Streeter (1995) this translates

to how and what people communicate. According to Cataldo et al. (2006), congruence reduces the time required to perform different tasks while the use of different communication channels are chosen to better fit the task at hand. In addition, when there is a proper fit between the ways of coordination and the needs for coordination, the time for resolving modification needs is significantly reduced (Cataldo et al., 2008). Hence, socio-technical congruence framework supports more effective communication, as does our approach. Therefore, applying socio-technical congruence could provide more insights to communication in globally distributed agile development and could perhaps validate whether the waste identified in this study are valid in software engineering.

6. Conclusions

Communication has been widely recognized as one of the key elements contributing to the success or failure of a software development project. Nowadays, implementing software in a globally distributed fashion is a common approach and this creates additional challenges for communication. For example, temporal, cultural and geographical distances (Noll et al., 2010) and their combination (Holmstrom et al., 2006) introduce challenges to the success of distributed efforts. More traditional plan-driven development approaches rely on formal communication (e.g. detailed extensive documentation) for conveying information, while agile development approaches emphasize informal communication relying on face-to-face interactions instead. Effective communication is difficult to achieve in distributed plan-driven efforts alone and agile approaches create additional challenges since significant geographical and temporal distances can prevent face-to-face, or other interactive communication.

Existing literature has approached this challenge by attempting to create suggestions establishing and maintaining effective communication in globally distributed agile development projects (e.g. Layman et al., 2006; Kircher et al., 2001; Danait, 2005). While they are valuable contributions to the topic, they do not provide companies the means to analyze and improve communication in their globally distributed agile efforts. To address this shortcoming, we conducted a case study within a North American software intensive company that was implementing a product across three sites in a globally distributed fashion. We constructed a waste identification process through which communication between the key stakeholders was analyzed, using the concept of waste from lean manufacturing (Ohno, 1988) and Lean software development (Poppendieck and Poppendieck, 2007). In addition to finding waste already identified in literature (Poppendieck and Poppendieck, 2007; Mandić et al., 2010), we identified five wastes that were specific to communication and presented the case company solution proposals for tackling them in the context of their project. While the improvement actions are dependent on the context, these wastes can provide companies an idea of what could be the non-value adding elements in communication within their globally distributed agile projects.

We defined three research questions through which we approached this work. The answer to the sub-research question aiming to identify the waste in communication within globally distributed agile development projects is the five wastes of communication. These wastes are ***lack of involvement***, ***lack of shared understanding***, ***outdated information***, ***restricted access to information*** and ***scattered information***. The second sub-question aimed to identify means for identifying waste. The answer to this question is provided in a form of the waste identification approach described in this work. Companies and researchers can use this approach by applying the same actions conducted in this study. Next, we describe how the waste identification approach could be conducted based on this study. The answer to the main research question will be provided after this description.

First, the project from which the communication waste is to be identified and mitigated is selected. The next step is to identify the key stakeholders that would participate in the waste identification process. After this, the development approach taken in the chosen project and the key steps in which communication takes place is identified. In this study the chosen development approach was Scrum and the all the key steps of this method (Sprint Planning, Sprint, Sprint Review and Retrospective) were present. In addition, we analyzed communication before the implementation phase begun, with communication related to documentation included in the analysis. Also appropriate inputs through which communication is analyzed and waste is extracted should be identified. In this study, we used a set of questions to attain a cohesive view of communication, including both positive and wasteful aspects. In addition, the documentation provided by the case company supported us to understand the development approach. Hence, the companies or other instances should apply all the data seen relevant for understanding communication within the chosen project. Reaching saturation in the data collection (i.e. analysis of the data collection did not reveal new information) was used as the measure for obtaining all information necessary for understanding communication and identifying waste. The main output from the steps is the communication wastes. Finally, the measures for removing or mitigating the wastes should be identified and these measures incorporated into the process. In our case, these measures were either empirical or derived from literature. This process should be conducted at regular intervals.

The main research question of this study is to identify how waste identification can improve communication in globally distributed agile software development. The answer to this question is that waste identification, when completed in a structured manner, can point to non-value producing communication elements and the waste can then be mitigated. The results of this study provide companies an idea of the potential wastes that may be present in their globally distributed agile efforts, as well as a technique for mitigating their effects.

For the research community, this study contributes to the field of communication in globally distributed agile software development by presenting and discussing five wastes specific to communication. Also, the presented waste identification approach is the initial step towards a systematically validated approach for analysing and improving communication in a globally distributed agile development context.

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