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Methodological Reflections on a Field Study of a Globally Distributed Software Project

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Abstract

Context: We describe the methodology of a field study of a globally distributed software development project in a multinational corporation. The project spanned four sites in the U.S. and one in India, and is a representative example of the complexities and intricacies of global corporate software development.
Objective: Our goal is to provide the rationale behind the methodological choices and derive insights to inform the methodology of future studies of global software engineering teams. The paper also aims to provide an illustrative case of a typical geographically distributed corporate software project with an in-depth description that emerged by applying the methods.
Method: We reflect upon the reasons for choosing each of our methods, viz., non-participant observation, site visits, interviews, and an online questionnaire. We then discuss what we learned from the experience of applying the methods.
Results: During and after the study, the discussions surrounding our methodological choices along with the methodological observations yielded important insights. The dynamics of software engineering practice and the geographical distribution of the project impacted factors such as access, costs, and cultural and linguistic diversity, and influenced the choice of methods. Our experience makes a case for methodological breadth and plurality in order to gain a broad understanding of a global project. This understanding can then be linked to the specific research questions under consideration.
Conclusion: The in-depth contextual description of the project that emerged from our methods highlights the utility of our methodological approach and provides an illustration of the complex nature of these projects. Our systematic reflection also yielded several methodological insights and provides important implications for future empirical studies of global corporate software development. Our experience can serve as a useful resource in methodological choices for research on globally distributed software engineering teams, or collaborative knowledge work in general.

Keywords: Geographically distributed collaboration, Global software development, Methodology

1. Introduction

The nature and the scope of collaboration in knowledge work have changed substantially during the past decade. Traditionally, co-workers would generally be co-located and would collaborate face-to-face. Today, however, networked information systems make it possible for collaborative activities to be distributed physically as well as temporally. Software engineering

endeavors have been particularly quick in embracing these changes and formed project teams distributed across the globe. Building on this, a significant portion of software development is currently being transferred from North America and Europe to countries such as India, China, Egypt, and the Philippines. Such transfer involves setting up international branches or outsourcing work abroad.

These changes promise a host of potential benefits for organizations. Expected advantages include tapping talented workers regardless of where they reside, taking advantage of lower labor costs, saving time and money on employee travel, and shortening product development periods by spreading work across time zones [1]. However, realizing this potential is not without technical and social challenges. Physically and/or temporally distributed collaborative endeavors fall short of matching the richness and seamlessness of face-to-face interactions. Cultural differences can impede communication and differences in time zones can add coordination problems. The physical and temporal separation also results in impoverished awareness of the activities of colleagues.

To tackle these challenges, it is first necessary to understand the intricacies of how globally distributed software development teams carry out their work. As Avram and Wulf [2] point out,

> "[...] while many experimental studies on problem-solving in teams have been performed, as well as interview studies with management referring to problems in distributed coordination and management, extensive participative field study material on actual workplace practices is relatively meagre. Thus, despite of occasional empirical studies of distributed software development activities over the years there is still a dearth of well-designed studies in Information Systems, Software Engineering and CSCW that provide good examples of field research in the area."

In an effort to reduce this gap, we describe and analyze the methodological aspects of a field study of a global software team. Discussions about methodological issues were an integral part of our research from the beginning. These discussions helped unpack the rationale behind the methodological choices we made when conducting the study. The experience of following the methodology to conduct the study led to several important methodological insights that can be utilized to inform the methodology of future studies.

In addition, the paper also provides a typical case that highlights the intricacies and complexities of globally distributed corporate[1] software engineering projects. We found that the dynamics of software engineering and the geographical distribution of a project can impact factors such as access, cost, and cultural and linguistic diversity, and, in turn, influence the choice of methods. To offset some of the issues encountered, we argue for the use of multiple diverse methods in order to gain a broad understanding of the project that can then be linked to the research questions at hand.

Our research objective was to understand a major challenge faced in collaborative endeavors, viz., the tension between the team members' needs of awareness regarding an individual's activities, and the individual's desire for privacy [3]. Scoping our methodology to look broadly at *all* work practices of the project members was instrumental for uncovering contextual links that enabled a deeper understanding of our specific research questions.

[1]Most open-source software projects are also globally distributed. However, they operate with fundamentally different philosophy, incentives, motivations, and goals compared with corporate software projects. These differences necessarily limit the applicability of our discussion to studies of globally distributed *corporate* software engineering projects.

The rest of the paper is organized as follows. We first discuss related work and describe the workings of the software project that were uncovered by our methodology. Next, we describe in detail our empirical methods along with the rationale behind our methodological choices. We then present the methodological insights that we gained and discuss their applicability and utility for future studies of global software teams. We conclude by outlining the implications of our findings.

2. Related Work

Geographically distributed collaboration has long been an important topic of study particularly within the field of Computer-Supported Cooperative Work (CSCW). Early studies of distributed collaboration focused on the researchers' own experiences of being part of a distributed workgroup (e.g., [4, 5, 6, 7]) and on the evaluation of technologies designed to bridge distances (e.g., [8, 9]). The Internet boom in the 1990s enabled the formation of global scientific collaborations [10] and of distributed project teams in organizations [7].

One of the most commonly studied domains of global collaboration is distributed software development. This type of collaborative endeavors received attention from CSCW as well as software engineering research communities as is evident from the workshops and conferences devoted to Global Software Development (see e.g., [11]). From this research, the work directly relevant for our purposes mainly includes empirical field studies such as [12, 13, 14, 15]. *In vitro* methods such as laboratory experiments simulating distributed software development (e.g., [16, 17]) are less relevant given the limitations in generalizing the findings to actual software engineering practices [18].

Many of these field studies not only described example cases of distance collaboration (e.g., [19, 20, 21, 22]), but also attempted to compare distributed software projects with traditional co-located work in order to uncover opportunities to improve the efficiency and effectiveness of computer-supported collaborative work (e.g., [23, 24]). Other studies aimed at designing and deploying systems to bridge the shortcomings of geographical separation (e.g. [25, 26, 27, 28]) and reported on the experiences of teams that used these systems (e.g., [29, 30]). More recently, researchers have also started to study open-source software projects (e.g., [31]).

Although many of these studies examined distributed projects as a whole, some of them were conducted with a narrower scope. They focused, for example, on knowledge sharing (e.g., [32]), cultural differences (e.g., [33]), and communication and media use (e.g., [34]). Similarly, research has also focused on organization size (e.g., [35]), specific job functions (e.g., [36]), specific phases software engineering (e.g., [37]), and specific empirical techniques such as analyzing software repositories (e.g., [38]).

Numerous quantitative and qualitative methods have been employed in these field studies. These include surveys (e.g., [23, 34]), ethnographic methods such as interviews and observations (e.g., [32, 35]), data mining of project repositories such as the Integrated Development Environment (IDE), source code management, and bug tracking systems (e.g., [23, 38, 39]), and analyzing communication archives of emails, instant messaging, and other digital communication (e.g., [31, 14]). As Espinosa et al. [40] point out, the existence of multiple boundaries in such global software development projects presents challenges for conducting studies and analyzing the data, no matter what methodology is followed.

The work presented here extends prior research in four ways:

1. We not only describe the methods we employed but also provide the rationale for our choices. We also discuss alternate methods and highlight the methodological insights gained during the study.
2. We discuss the advantages of a multiple-methods approach such as ours that included four separate methods.
3. We present a broad understanding of the workings of the project as a whole. This, in turn, yielded richer answers to our specific research questions regarding the reconciliation of privacy and awareness.
4. We treat *all* systems and tools used by the collaborative workers as part and parcel of the context within which the software engineering activities took place, rather than limiting the investigation to specific systems.

3. Setting

To set the stage for the discussion that follows, we describe the setting of "Project X," a software development project in a large multinational telecommunications corporation. The description also serves to illustrate the operation of a typical internationally distributed corporate software development project.

The project involved approximately 125 employees spread across five different geographical locations: four in the U.S. and one in India. The project was tasked with building a middleware platform that would provide its services in the form of a well-defined API (Application Programming Interface). The goal was to utilize the API as the framework underlying every higher-level application software built by the corporation. As a result, the task of Project X was not only complex and challenging, but it also held organization-wide significance due to the involvement of a variety of stakeholders.

3.1. Software

Project X was conceived with the explicit goal of unifying disparate pre-existing pieces into a homogenous, streamlined platform, in order to reduce code duplication across the corporation and to simplify the task of those building higher-level application software. During the course of our study, the platform comprised eighteen modules integrated into a single release. Due to the interdependencies between the modules, frequent cross-module collaboration was required in all phases, viz., architectural design, development, testing and integration. The amount of dependency, and thus the extent of the cross-module collaboration, varied from module to module. A few modules were relatively independent while some others were heavily reliant on several other modules. For instance, the module tasked with the installation of the release needed to handle the installation of every module and thus depended on *all* other modules. Collaboration was also required during knowledge transfer phases whenever there was a change in the individuals or team responsible for the development of a given module.

Collaborative activities that involved planning and coordination typically spanned the entire scope of the project. For instance, management (from multiple managerial levels) worked together on planning project activities, tracking progress, making adjustments, and using estimates and forecasts to set future goals. Similarly, the Source Code Management (SCM) unit provided services to all members of Project X to help manage the repositories of its source code. Representatives of the higher-level software applications that would use the Project X platform (dubbed as "adopting products") were also consulted for requirements and feedback.

3.2. Workflow

Project X releases were arranged in *release cycles* of about three to four months. Every successive release incorporated new features, and fixed bugs from previous releases. Each feature or bug was treated as a Modification Request (MR) in the SCM system. As in any software project, each release cycle involved coding new features, fixing bugs, testing software units, integrating them, and testing the integrated release. During a release cycle, the management team tracked the progress of the current cycle and also developed the detailed plan for the next one. In accordance with the organizational culture, the deadline for the final delivery of a release was never changed. This rigidity also applied to the various "internal" deadlines within the cycle. If the planned features could not be finished by the deadline, they were either pushed to the next release or were included "as is" despite the existence of known bugs. Such "rollovers" often had a cascading effect on subsequent release cycles.

3.3. Personnel

Due to its size, scope, and complexity, Project X required contributions from a variety of people: developers, testers, systems engineers, architects, managers, SCM support staff, managers, and internal customers (i.e., representatives of the "adopting products"). Each manager typically "coached"[2] a team of individual contributors.

It should be noted that not all of the project members spent 100% of their time on Project X. While most developers, testers and lower-level managers worked solely on Project X, other contributors were involved in (multiple) additional projects. The percentage of time that these individuals spent on Project X varied from merely 3-4% to more than 50%. Additionally, the time spent was also dependent on the current phase within a release. Some phases required greater contribution from specific individuals. For instance, in some stages Systems Engineers worked nearly full-time on Project X while during the rest of the period, their effort could be an order of magnitude lower.

Personnel changes also affected the operation of Project X. For instance, just prior to the beginning of our study, teams from Europe had moved out of Project X. It was also not uncommon for the module assignments to be reshuffled among the various existing teams in different release cycles. A team that worked on a particular module during one release could find itself assigned to a different module in the next cycle. It was therefore difficult (even for the management) to pinpoint exactly who was involved in Project X, in what capacity and to what extent. In fact, we initially spent a great deal of time merely compiling a list of project members and their specific duties.

3.4. Locations

All of the personnel mentioned above were geographically distributed across five main locations: four in the U.S. (in three different time zones) and one in India. The number of people at each location varied from a handful to more than thirty. Interestingly, team[3] membership was independent of location. It was not uncommon for a team to be geographically distributed. In addition, a limited amount of telecommuting was common in the U.S. In a couple of cases, individuals worked out of their "home offices" the majority of time, coming to their workplace only as needed.

[2] The organizational culture was to refer to one's manager as a "coach."

[3] We loosely define a team to be a group of individuals coached by the same manager.

Figure 1: Physical layouts of the Indian site (top) compared with those of the U.S. sites (bottom)

Notably, each site was shaped by its own history. For example, the U.S. West Coast site previously belonged to another company that had been acquired by the multinational corporation. Many of the Project X members at this site had already been working together for several years as employees of the previous company. Moreover, the sites also differed in features such as the office size, the height of cubicle dividers (see Figure 1), and the presence of a cafeteria. For instance, the lack of a cafeteria at the mid-U.S. site prevented Project X members from interacting over lunch as was typical at the East Coast site. The U.S. sites were spacious (see bottom right picture in Figure 1), while the Indian site was densely packed (US: 419 sq. feet / person, India: 144 sq. feet / person). These architectural features had a noticeable impact on preferences, attitudes, and work practices (see Section 5.2).

3.5. Collaborative Tools and Practices

Project X members used several communication and coordination tools for seeking awareness of the activities of their colleagues as well as for providing awareness of their own activities:

Email: Email was used extensively by every project member, not just for communication but also for knowledge management and as external memory. Features of email such as vacation auto-replies and read-receipts were used for providing and seeking awareness of activities.

Instant Messaging (IM): IM was used a great deal by some members of the project. In other cases, the use of IM was sporadic, if at all. IM was generally utilized for:

- communicating in situations that required quicker turnaround, more interaction, and less "record keeping" than email,
- avoiding phone calls to be able to multitask,
- circumventing comprehension problems in oral communication resulting from different accents,

- checking if someone was available for a phone or face-to-face meeting, and
- communicating on the "back-channel" during meetings and conference calls.

Shared calendars: Sharing one's calendar was the organizational norm. Those involved in multiple activity spheres [41] (for example, those working on multiple projects, such as managers) used calendars far more than others. The default sharing configuration indicated whether or not someone was busy without showing the details of the scheduled activity.

Microsoft Project®: A Microsoft Project®project plan was used to track progress by sending reminders, seeking status updates, adjusting estimates, etc.

Telephone: Phone use for one-on-one calls was typically limited to urgent situations or matters for which written communication was unsuitable. More significantly, the telephone was critical for conference calls involving multiple people at different locations. Sometimes, participants from the same site gathered for conference calls in a local meeting room. When people joined conference calls from their offices, they frequently multitasked and only attended to those parts of the calls in which their participation was required.

SCM system: The SCM system generated reports and statistics that were used to monitor project progress and make estimates for future planning. Each module was assigned a separate trunk within the repository and each developer working on a module was responsible for his or her own branch within the trunk. This limited the ability of others to see the changes in other modules before the integration phase. Awareness of such changes, however, was important due to module interdependencies. In addition, developers were typically reluctant to merge code of their branch with the trunk if they felt it could be perceived as "half-baked" or "incomplete." They did not wish to be judged as incompetent based on visible unpolished code, nor be responsible for breaking the build with their committed changes. As a result, intermediate "development" versions of the code were sometimes "privately" shared outside of the SCM system with the developers of dependent modules.

Document repositories: Documents produced by project members could be shared with others via a Microsoft Sharepoint®repository and an internal system for organization-wide distribution. These systems allowed one to share one's work with appropriate team members to seek comments. It also served knowledge management and organizational memory purposes.

Internet Conferencing: In addition to telephone conferencing, there was occasional use of Internet-based conferencing such as Web-based conferencing tools and Microsoft NetMeeting®, as well as of remote desktop connection such as VNC (Virtual Network Computing).

We found that the above awareness and interaction capabilities and affordances that these tools offered were taken into account in the process of privacy management (see Section 5.1 for a discussion).

4. Study Methodology

The rich understanding of the intricacies of Project X presented in the previous section was enabled by the methodology we followed. No single data source or data gathering technique

could have provided the coherent description in Section 3. For instance, without visiting the sites we could not have uncovered the differences in local factors such as cafeterias and office layouts as discussed in Section 3.4. The individual project members were largely unaware of the work practices and work environments (technical as well as physical) of Project X members with whom they did not collaborate directly. Thus, details of work roles in Section 3.3 and the list of collaboration tools in Section 3.5 could emerge only after talking with Project X members in different job roles.

Our methodology also allowed us to recognize and analyze the five types of boundaries – geographical, functional, temporal, identity, and organizational – outlined by Espinosa et al. [40]. These boundaries show up as situational characteristics and interpretive influences in the privacy management framework that emerged from the analysis of our data (see Section 5.1).

In this section, we provide details of the methodology along with our rationale. Our research objective was to investigate how individuals engaged in geographically distributed collaboration satisfy their awareness and privacy needs. We chose to follow an interpretive [42] methodological approach for the following reasons:

- to understand these research issues from the perspective of our informants,
- to avoid limiting our investigation through preconceived hypotheses, and
- to understand the broader context of collaborative work practices and its relation to our research questions.

At the same time, we did not exclude other perspectives since we believe that methods must be chosen as appropriate for the research questions at hand. We concur with Orlikowski and Baroudi [43] and Mingers [44] on the benefits of adopting a plurality of research perspectives. Sigfridsson et al. [45] reported that such a mixed method approach was essential to illuminate the details of work practices. Therefore, later on in our investigation, we also employed a survey questionnaire, which is typically considered a positivist method.

The bulk of the study was conducted over a period of approximately 10 weeks during which the primary author was based at one of the Project X locations as a summer intern. An initial hour-long conversation with the head of Project X helped us gain the basic understanding of the project needed to devise a methodological plan. Thereafter, we used the methods described in the following subsections.

Two points must be emphasized:

1. To avoid biasing the participants, the advertised goal of the research was to "study collaborative work practices." The focus on privacy was not revealed to anyone outside the research team (not even to the head of Project X)[4].
2. We did not provide a definition of privacy in any questions on privacy that we posed to study participants. Instead, we asked *them* to explain what the term meant to them in the context of their tasks and work practices. Our intention was to avoid imposing any specific notion of privacy on the participants. Instead, we sought to uncover the various contextual meanings that they associated with this concept as well as the practices they engaged in to meet their privacy needs.

[4]At the end of the study, we sent a "closure" email to all participants that described the real research goal.

4.1. Non-participant observation

Our exploration started with non-participant observation of the meetings of the Project X management team. These meetings lasted about 60-90 minutes and were mainly used to formulate a detailed plan of upcoming activities. Managers from all project sites and several hierarchical levels participated in the meetings. Typically, about six to eight participants from the site where we were situated gathered in a conference room, while those from other locations joined in via a Web-based conferencing system. This system allowed one to use the phone for audio and the Internet for watching or delivering presentations. The system also showed a list of all meeting participants, with a visual indicator for the person(s) currently talking. In the (physical) conference room, the presentation slides were also projected on a large screen. Moreover, the individual participants sometimes engaged in "back-channel" IM conversations.

We observed five such meetings. During three of them, the first author was present in the conference room. For the two others, he participated "remotely" using the Web-based conferencing system, once from his office and once from an off-site location. The former was chosen to experience the situation faced by those who called in from their offices while the latter was meant to recreate the experience of telecommuters. These observations helped us gain further understanding of the organization and the activities of the project. This understanding was used to guide further methodological choices.

Our rationale for observing the meetings was threefold: (a) to facilitate our access to the project by getting introduced to the management team (see Section 6.1), (b) to gain an understanding of the larger context, organization, and workflow of the project (see Section 3), and (c) to compensate for not shadowing individual project members (see Section 6.7) by observing a group as it engaged in actual work practices.

4.2. Site visits

During the course of the study, the first author was based at one of the sites of Project X on the East Coast of the U.S. He also visited three of the other sites: one in the mid-U.S., one on the West Coast of the U.S., and one in India. We decided that in-person visits to the sites were necessary in order to experience and observe local and contextual factors that cannot be easily uncovered without first-hand observation, especially given the intricately contextual nature of our topic of investigation – privacy. The insights gained during these visits turned out to be important in analyzing our data and interpreting our findings (see Section 5).

About a week was spent at each of the three sites conducting interviews with individual contributors (see below) as well as observing site-specific factors such as architecture, layout, work practices and culture. Photographs of the sites (see Figure 1) were also taken in order to share the observations with the other researchers. Additionally, we procured site-specific information such as the total floor space, office sizes, and occupancy. Although we did not visit the fourth site (also located on the East Coast of the U.S.), we interviewed two contributors from this site while they were visiting the site at which the first author was based.

4.3. Semi-structured interviews

Across all sites, we conducted individual semi-structured interviews with fifty-two Project X contributors. The interviews lasted about 90 minutes on average. The topics of the questions were derived from our research objectives and were divided into three main themes: general work practices, needs for awareness and privacy, and opinions on enhancements to existing collaborative tools. We tailored the questions to the context of Project X, using information from

our initial conversation with the head of Project X observations of the management meetings mentioned above. Additional understanding gained from the first few interviews helped us extend and refine the initial set of questions. This revised set was then used with little modification for the remaining interviews.

We selected interviewees in such a way as to achieve broad coverage across the different job functions (see Section 3.3) at the various sites. To avoid biasing others, interviewees were asked not to discuss the conversation with other employees in the corporation (including their managers). The interviews were audio-recorded for later transcription and analysis. Six individuals refused to being audio-recorded, so we took detailed handwritten notes instead. The first author served as the main interviewer and conducted the majority of the interviews. For some of the interviews at the East Coast site where the first author was based, one of the other authors accompanied him as a secondary interviewer.

Whenever possible, the interviews took place in the office of the interviewee. In shared office or cubicle situations, we used nearby conference rooms or empty offices. The goal was to interview people as close as possible to their regular work areas, so that they could point out relevant information and artifacts on their computer screens, in their offices, and along their hallways[5]. This was important because prior research has found that it is not uncommon for individuals to reconfigure their workplaces to suit their preferences and practices [46].

Transcripts of the interviews were analyzed using the grounded theory techniques – open, axial, and selective coding – in an inductive manner to allow the salient concepts and theory to emerge from the data [47, 48]. Our application of these techniques does not adopt a strict Glaserian or Straussian methodological stance of grounded theory. As described below, we combine techniques from both as appropriate. This approach is typical of how grounded theory is employed in research in the information fields [49].

We began with open coding, which is "the analytic process through which concepts are identified and their properties and dimensions are discovered in data." [48, p.101] Categories that emerged from open coding were further refined into ten higher-level categories by selective coding around our core variable of interest (privacy) by "delimit[ing] coding to only those variables that relate to the core variable, in sufficiently significant ways to be used in a parsimonious theory" [50, p.61]. We used the knowledge gained from the managerial meetings and site visits to inform the selective coding process. For example, our observations of different workspace layouts were useful in identifying and labeling the "space" and "site" as categories that influence privacy management. We then employed axial coding which involves identifying relationships between categories [48]. This resulted in grouping the higher-level categories into two main concepts. Finally, selective coding was used again to explicate the story line that ties the concepts together in terms of the core concept of privacy management. This resulted in a framework that illustrates how privacy management operates in the collaborative work context (see Section 5.1).

4.4. Online questionnaire

Based on the understanding gained from the above activities, we next formulated a questionnaire. It was administered online a few months after the completion of the other methods described above. It aimed at delving deeper into the important aspects uncovered during the interviews and site visits, viz., interruptions, urgency, trust, team dynamics, and customization

[5]Several interviewees did comment on features of their work environment during the conversation. A few also showed us information on their laptops.

of technology to fit personal preferences and practices. The questionnaire enabled us to reach those whom we had not been able to interview, and thus to raise the coverage of Project X members. We also wanted to leverage the potential of the online questionnaire in providing a less intimidating outlet than an in-person interview for answering questions on sensitive issues such as privacy [51].

In addition to questions regarding the details of Project X and of individual work practices, the questionnaire used scales from the literature for measuring privacy concern [52, 53], team trust [54], interpersonal trust [55], and self-monitoring [56] and asked for demographic information. The questionnaire was made available to all Project X members (125 at the time of questionnaire deployment). We obtained 90 valid responses, yielding a response rate of about 74%. When the questionnaire was administered some of the original interviewees no longer worked on Project X due to attrition or organizational restructuring. Thus, we were able to gather questionnaire responses from only 30 of our 52 original informants.

5. Study Findings

The application of the methodology we chose for studying Project X resulted in two major contributions regarding our research questions on privacy and awareness. While these findings are not the focus of the paper, we include a brief summary of what our approach was able to uncover. For further details, the reader is referred to the respective publications [57, 58].

5.1. Privacy Management Framework

Figure 2 shows the framework that emerged from our analysis of the interviews coupled with findings from the non-participant observation of managerial meetings and the site visits [57]. It presents privacy management practices in collaborative work as dependent not just on a number of situational characteristics but also on a hierarchy of personal interpretive influences that an individual applies to the situation. As can also be seen in Figure 2, the interpretation applied by an individual to the situation at hand leads to privacy management action(s), or lack thereof. Moreover, these actions themselves form a feedback loop that contributes to the reinforcement and/or evolution of the interpretive influences over time. Privacy is known to be a context-dependent and highly personal concept [59, 60]. The framework captures the former aspect in terms of the situational characteristics, and the latter through the interpretive influences.

Our analysis revealed five key situational characteristics that were deemed important when reconciling privacy and awareness needs: Issues, Relationships, Temporality, Technology, and Space. A multiple of these often came into play in any given situation. In other words, all situational characteristics were subject to interpretation simultaneously. While these characteristics set the stage, the privacy management action(s)[6] of each individual further depended on his or her interpretation of the situation. We identified five major influences that guided this interpretation: Self, Team, Site, Organization, and Cultural environment. We also noted that the above influences could be arranged in a hierarchy beginning with the most inward influence (self), and growing progressively outward toward the larger environment one is embedded in. The framework incorporates the details of the setting described in Section 3. For example, the location affected the situational characteristic "Space" as well as the interpretive influences of "Site" and "Cultural environment." For a more detailed description of each of the components of the framework, we refer the reader to Patil et al. [57].

[6]The framework also treats inaction, i.e., deciding not to act, as an action.

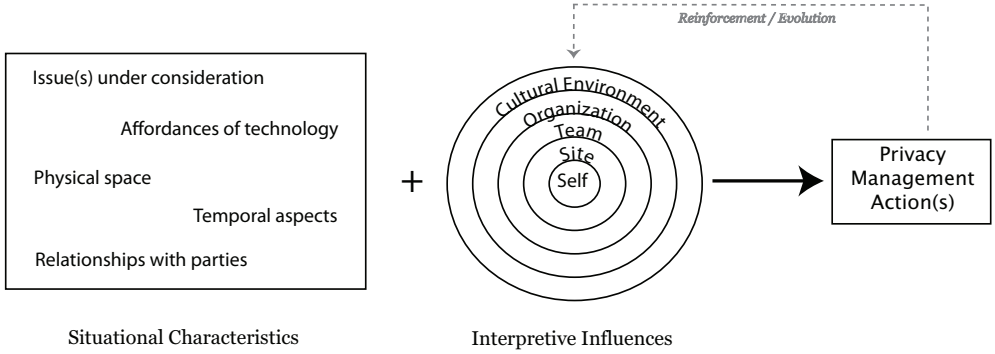

Figure 2: Privacy management described in terms of interpretive influences applied to situational characteristics

5.2. U.S.-India Differences

We divided the questionnaire respondents into two groups: those who worked at the India site (India) and those at any U.S. site (US). The dataset comprised 35 individuals in Group India and 52 in Group US. Based on prior research [61], we expected lower privacy concerns from Group India than Group US. True to these expectations, we found that Group US reported significantly higher efforts than Group India in protecting the privacy of personal information from third parties ($p < 0.01$). However, the questionnaire also asked respondents to rate how concerned they were about privacy with regard to various categories of people with whom they interact in the course of their work (on a 7-point scale from "completely unconcerned" to "extremely concerned"). In this case, we were surprised to find that those in Group India expressed higher privacy concerns than those in Group US. for those categories of contacts that one typically works closely with, viz., local and remote team members, manager, and local and remote Project X members. In a similar vein, those from Group India expressed a higher desire for privacy management tools (India 5.1, US 4.27, $p < 0.033$).

Our analysis suggested the following plausible explanatory factors for the differences in interpersonal privacy concern: physical characteristics of the workplace, the nature of interpersonal relationships, participants' conceptualization of privacy, intra-team competition, and management style and hierarchy. More details regarding each of the factors are provided in Patil et al. [58]. To uncover these factors, we needed to combine the insights gained from all of our methods as well as draw upon findings from prior literature. For example, the influences of physical workplace characteristics was suggested by the differences in workspace layouts observed during the site visits (see Figure 1), the findings from the interviews regarding the influence of space and site in privacy management, data collected from the facilities departments at the sites, and prior literature [62, 63, 64].

6. Methodological Findings

The study was successful in our research objective of shedding light on practices surrounding privacy and awareness issues in distributed collaboration. Concurrently, we also gained a number of methodological insights, both from discussions among the research team about appropriate methodology to study collaboration in globally distributed software teams, and from the actual experience of using these methods in practice.

Some of these discussions centered around aspects that are common to all studies that utilize a particular method, e.g., how to avoid leading questions in an interview, or select appropriate scales for a questionnaire. Each method has its own extensive body of research regarding its strengths, weaknesses and applicability, discussed in numerous textbooks (see e.g., [65, 66, 67]). We will therefore not discuss these further, but focus instead on the distinguishing characteristics and factors of the globally distributed software project that impacted our methodological choices.

Given that most of these aspects appear to be common to all globally distributed software engineering efforts, we believe that our discoveries can serve as a useful resource when designing and conducting empirical studies of global software teams. It should be noted that several of these considerations, such as Incentives (see Section 6.1.1) and Project Phase (see Section 6.1.3), could come into play for *any* software project. However, almost all of them are exacerbated in geographically distributed projects, which are typically larger in scope, both in terms of locations and project size. For instance, researchers have to gain access to not just one but several work locations (see Section 6.1), and deal with significant increases in travel costs (see Section 6.2). If the project is distributed across nations then researchers must also contend with cultural and linguistic issues (see Section 6.3).

6.1. Access

Our first challenge was to gain access to the project. We talked with upper management (including the head of Project X) in order to "pitch" the study. In exchange for access, we had to promise a report with recommendations for improving the effectiveness and efficiency of the project. This top-level clearance was however not enough to grant us access to each of the five sites; we also needed buy-in from the relevant managers at each site. We found that the following other factors were equally instrumental in obtaining access:

6.1.1. Incentives

Aligning the incentives of the organization, the management, the project members, and the researchers posed further hurdles. For instance, a few individuals viewed participation in the study as a low-priority chore and were reluctant to devote time to it (e.g., one participant stopped the interview halfway and never scheduled a time to finish it despite repeated reminders). Similarly, we discovered that one manager was not overly thrilled with the upper management's decision that Project X participate in the study because it required his team to devote time to the interviews instead of "getting work done." This underscores the importance of not only securing buy-in from the top echelons, but also communicating to each project site and each project member the value of the research for the individual site, the project under study, and the organization as a whole.

6.1.2. Affliation

Although the study was carried out collaboratively by the corporation and a university, the first author was employed full-time by the corporation as a summer intern during the first phase of the study (i.e., the non-participant observation, site visits, and interviews). During the administration of the questionnaire and the analysis of the study data, he was employed as an affiliate. Being an organizational "insider" was critical for access; many of the study participants would probably not have devoted the same time and attention to an external researcher. Moreover, we noticed that the interview participants took the organizational affiliation into account when divulging information deemed sensitive or confidential to the corporation. At the same time, we

ensured that no prior professional or personal relationship existed between the interviewer and the informants. This was greatly helped by the fact that the interviewer was a summer intern and was therefore new and unknown to the other employees. This unfamiliarity was helpful in ameliorating discomfort in discussing sensitive issues. Thus, individuals who can bridge different research entities are valuable for successfully conducting research projects that involve multiple organizations.

6.1.3. Project Phase

As discussed in Section 3, the phase of the project impacted the amount and nature of work and consequently the levels of stress that the project members experienced. We thus needed to schedule time with the project members during periods in which they were not racing against project deadlines. Knowing the temporal rhythms of the workflow was useful for maximizing participation in each research method. We discovered these rhythms partly when observing the managerial meetings (see Section 4.1) and partly when talking to the participants. As software development typically proceeds in phases, we learned that methodological planning could benefit from being sensitive to these phases.

6.1.4. Vacations

Another factor that impacted participants' availability besides the project phase was holidays and vacations. This issue is exacerbated in a global team because one needs to consider local holidays and typical vacation periods in each of the countries involved. For instance, we needed to reschedule our visit to India because we were made aware that the originally planned dates coincided with a two-week festival during which many employees are on vacation. Similarly, we were unable to interview a few of the participants in the U.S. because our site visits coincided with their summer vacations.

6.2. Costs

A major factor that drives methodological choices is the cost of envisaged research methods in relation to the value of their results. In order to justify the research and gain access to the sites and project members (see Section 6.1), the anticipated organizational benefit must be higher than the cost of the research. Therefore, the research team needed to be cognizant of the total costs. In addition to expenditures that apply to any empirical study (such as researchers' time spent conducting the study, analyzing the data, and reporting the results), there are two other types of costs that have a significant impact when studying globally distributed software projects:

Travel Costs: Due to the high costs of travel to the remote sites, we could only visit them once for a week each. This, in turn, limited flexibility. For instance, as mentioned above, we could not interview those who were on vacation during our visit. Similarly, we could not observe the impact on work practices of local factors such as snow (which impacts the mid-U.S. site) and monsoon (which impacts the India site). In contrast, at the U.S. East Coast site at which we were based, there was considerably more leeway in scheduling or re-scheduling interview times as well as conducting follow-ups, if needed.

Opportunity Costs: Knowledge workers in software projects earn high salaries. Since participation in the study was not part of their performance appraisal, the opportunity costs[7] of

[7]Opportunity cost is the cost of the alternative actions that one could have taken instead of the chosen action.

participation are quite high both for the project members and the corporation if critical work is neglected due to participation in our study. The opportunity costs for individual participants partly depended on the type of work that he or she carried out during "business hours" (from 9 am to 5 pm local time), during which all our interviews and observations were conducted. The opportunity costs were quite high for those who used these hours for critical work, and lower for those who scheduled critical work during evenings and weekends (since they could then work long hours without interruptions [68]).

6.3. Cultural Sensitivity and Linguistic Issues

In order to study collaborations that span multiple countries, researchers must be able to discern the impact of cultural and linguistic differences. This can be achieved in two contrasting ways:

- Individuals unfamiliar with the country or the culture may be able to make observations that could otherwise be treated as mundane, unimportant, or uninteresting. For example, we spotted the presence of deities and other religious symbols on the cubicle walls and computer screens at the Indian site[8]. This practice might have been easily left unnoticed by a researcher living in India, due to its commonality in Indian workplaces and society.

- Individuals who do have familiarity and experience with the country or the culture could come up with explanations for findings by relating them to the cultural context and social practices. For example, we were able to relate the interview and questionnaire responses of our participants to local factors such as family obligations, commuting and traffic situation, job market conditions, and the technical infrastructure available at home [58].

In our case, the first author who conducted all interviews and field observations at the India site, was born and raised in India. However, he had been living in the U.S. for the past nine years. As a result, he could serve in both of the above capacities for the U.S. and also for India. The same was true for another member of the research team who had also grown up in India prior to moving to the U.S. The other researchers were American and European. This cultural diversity was extremely useful for filling both of the above roles for the Indian as well as the American sites.

Despite this diversity, we needed additional clarification from other "cultural insiders" to understand a surprising finding from our questionnaire data, namely that employees at the India site exhibited higher privacy concerns compared with their colleagues from the U.S (see Section 5.2). In order to validate and refine our explanations as well as discover new ones, we consulted with two independent parties: an Indian knowledge worker from the India site external to Project X, and an Indian knowledge worker from another Indian firm who had previously worked in the U.S. In contrast to the Indian members of our research team, the individuals we consulted lived and worked in India and could provide additional insight due to their full immersion in the culture.

Besides cultural peculiarities, language may also play an important role in research on global collaborative projects. For instance, in many non-English-speaking countries, day-to-day affairs are conducted in the local language; English is used only when necessary for cross-national communication and business matters. Moreover, non-native speakers of English often find it easier to express themselves in their native language. As a result, research methods employed at such

[8]This is particularly noteworthy because India is a constitutionally secular country.

sites ought to use the local language to the extent possible. Fortunately, we could conduct the interviews and administer the questionnaire at the India site in English since it is an official language of India and is widely understood and used among Indian knowledge workers. However, we did note during the interviews that the English proficiency of many individuals at the India site was lower than that of their U.S. counterparts (regardless of whether those in the U.S. were native or non-native speakers of English). It is possible that lower command of English impacted their understanding of the questions in the interview and questionnaire, especially when dealing with an intricate concept like privacy.

We therefore suggest forming research *teams* with representatives from each culture and conducting research in the local language(s) to the extent possible. Achieving this, however, increases the costs of the research (see Section 6.2) and must therefore be balanced with the expected benefits.

6.4. Dynamics of Software Engineering

Various types of organizational dynamics, which are particularly salient in fast-moving sectors like software development, need to be taken into account when making methodological decisions:

Organizational restructuring and business changes: Organizations often restructure their workforce and/or projects, resulting in new work division across sites and changed work assignments for individuals. Teams join or leave projects. As mentioned, teams from European sites had transitioned out of Project X just before our study began (see Section 3.3).

Employee turnover: Employees are laid off by organizations, or leave of their own accord. Similarly, new employees join. For instance, during the course of our study, some employees quit the company, and we were therefore unable to obtain questionnaire responses from all of our interviewees (see Section 4.4).

Level of project involvement: An individual's involvement in the project can vary from a small percentage of their work hours to full-time. Moreover, the level of involvement may be dependent on the phase of the project cycle (see Section 3.3).

These factors keep software projects in constant flux and can make it difficult to gather a stable picture of their characteristics, including team membership, roles, and relationships among individuals. For instance, the number of Project X members at the India site almost tripled during the course of our study. Therefore, it is important that the methodology not just capture a global software project at a given point in time, but also track its evolution as a result of corporate dynamics. In our experience, a detailed understanding of the project emerges only over a longer term (ranging from a few weeks to a few months). Given the dynamic nature of these projects, one methodological challenge is to accommodate changes in the project that occur over the study duration.

6.5. Methodological Breadth

As described in Section 4, we applied several diverse methods over a period of time to study Project X. Despite the challenges involved (see Section 7), this methodological breadth provided several advantages:

- The application of multiple methods allowed us to leverage their different strengths. For example, the conversational form of semi-structured interviews enabled us to probe deeper with follow-up questions and clarifications. On the other hand, the anonymity of questionnaire responses allowed us to ask sensitive questions (e.g., items of the self-monitoring scale [56]) that may not have been answered candidly in a face-to-face conversation [51][9].

- As mentioned in Section 4, the description of Project X was not obtained directly in such the cohesive form in which it is presented in Section 3. It emerged gradually over the course of the study by combining data obtained from the various methods.

- The data collected with some methods was useful in understanding and explaining the findings from other methods. For instance, had we not conducted in-person site visits, several important site-specific differences might have gone unnoticed. The meaning of the term "cubicle", for example, was completely different at the mid-U.S. site and at the India site due to local differences such as the height of cubicle dividers, the number of people per cubicle, the area of the cubicle etc. (The top half of Figure 1 shows the cubicles at the India site while the picture at the bottom left shows cubicles with doors at the mid-U.S. site.) Similarly, we were able to explain the differences between privacy concerns in India and the U.S. that were reported in the online questionnaire with the differences in the layout and physical features of the work places that we observed at the respective sites [58].

- To avoid bias, our methodology was designed to study collaborative practices in general (see Section 4). Understanding the broader collaborative context allowed a deeper analysis of the relationship between privacy and awareness expectations and practices, our research question in a stricter sense. For example, the interviews revealed close camaraderie between the software developers at the U.S. West Coast site, which had developed from working together for several years. This history had a great impact on their awareness and privacy expectations regarding each other. Similarly, the visit to the mid-U.S. site uncovered that the lack of an on-site lunch cafeteria had a negative impact on awareness.

These observations suggest that studies of complex global collaborations such as corporate software projects can benefit from the use of multiple diverse methods. As Mingers [44] suggests, "research results will be richer and more reliable if different research methods, preferably from different (existing) paradigms, are routinely combined together." Further, our experience also shows the importance of paying attention to routine work practices regardless of whether at first sight those practices appear irrelevant to the research questions.

6.6. Data Sharing and Ownership

Since part of the research team was from a university, a research agreement needed to be worked out between the corporation and the university to cover issues such as access to study participants, and the ownership and sharing of data and intellectual property. This required approval from the office that oversees human subject research at the university as well as the legal offices of both organizations. This process was tedious and time-consuming, and no data could be collected or analyzed until a legal agreement had been worked out. Although not directly

[9] Some questions, such as questions regarding income, were deemed too sensitive to be included even in the questionnaire.

relevant to the study design, the delays and compromises required in negotiating collaborative agreements may limit when and how some of the methods can be used. These issues could become even more difficult to work out if researchers and the study settings fall under different national jurisdictions, which may well be the case when studying teams that are globally distributed. Thus, research teams spanning multiple organizations must budget for potential delays and for compromises in the research methodology and data sharing.

6.7. Alternate Methods

Several alternate methods might have been substitutes of or compliments to the methods we discussed in Section 4. Specifically, we considered utilizing the following additional methods:

Participant observation: An individual who worked on Project X could have served as an observer of the project, to validate and refine our observations based on first-hand experience. However, due to the demanding and time-consuming nature of Project X, it was not possible to recruit a project member willing to take on this additional commitment.

Analysis of project deliverables: Computational analysis of the various deliverables produced by the project, such as requirement specifications, code, bug fixes, documentation, managerial reports, project plans, etc., could have revealed patterns not easily discernible otherwise. Although we had access to the project plan and document repositories of Project X, the learning curve for deciphering the jargon, conventions, and organization of these materials was prohibitively steep. In fact, even Project X members frequently spent a great deal of time making sense of them.

Shadowing: Apart from attending management meetings (see Section 4.1), we did not observe people while they were engaged in their work on Project X. In-situ observation, especially when coupled with the analysis of logs of computing activities, might have helped uncover discrepancies between participants' responses and their actual behaviors. We decided against shadowing since it might have made the participants concerned about employer surveillance. Moreover, shadowing would have been possible only at the work places because it was impractical to observe people while they were telecommuting from home. Shadowing also poses challenges because a large fraction of human interactions in a global project are mediated by technology. As a result, shadowing captures mainly the interaction of the shadowed individual with the technology rather than with the party with whom the individual interacts. Moreover, it leads to a one-sided view of the interactions because the other party to the technology-mediated interactions cannot be observed.

Focus group: The results of a collective discussion of a focus group composed of Project X members could have complemented the individual perspectives we received from the questionnaire and interview responses. Difficulties in scheduling a time suitable for most participants coupled with the costs of traveling to each site a second time to conduct the focus group prevented us from leveraging this option.

As the above discussion points out, we excluded these methods based mostly on practical considerations, such as access (see Section 6.1), and costs (see Section 6.2). In a few cases, we faced methodological obstacles, such as potential concerns about surveillance, or impracticality of observing technology-mediated interactions.

7. Implications

The discussion above holds several implications for the selection of methods when studying globally distributed software engineering projects.

Firstly, despite the availability and use of technologies to bridge distances, the geographical distribution will always remain an important impediment in such collaborations [1]. Therefore, when making methodological choices, it must be kept in mind that globally distributed teams will differ from co-located ones. For instance, shadowing, which is often useful for analyzing co-located collaborative practices, may not be as effective when studying distributed collaboration because a majority of the collaborative activities are computer-mediated and cannot be observed directly. Instead, it might be more illuminating to study project outputs and/or usage logs of collaborative tools.

Secondly, as should be evident from Section 3, corporate software engineering projects are complex; they involve multiple job functions, processes, phases, and tools. Adding geographical distribution to the mix further increases their complexity. Investigating any research question requires that the methodology uncover the multiple connections that typically exist between the various parts of a project. These connections are the glue that holds the project together and enables its day-to-day practices. A narrower focus risks overlooking important details. For instance, if we had limited ourselves to studying developers and testers, we might not have discovered the tactics used by management to bridge the routines of these individuals with the larger goals and operations of the project. On a related note, as mentioned in Section 6.5, we found that an understanding of typical work practices not just helps avoid bias but also proves illuminating regardless of the specific research question.

Thirdly, as discussed in Section 6.4, the methodology ought to take into account the dynamism and evolution inherent in software engineering projects. This may require that studies be conducted over a sufficiently long period of time, or that they be repeated at appropriate intervals. Methodology should also be sufficiently flexible to accommodate changes in the project that occur over the duration of the study.

Fourthly, our experience illustrates the leverage and benefits that can be achieved by using multiple diverse methods to uncover the intricacies of a project (see Section 6.5). Not only did the methods provide different strengths and findings, but they also facilitated the discovery of relationships between the findings. For instance, our initial inclination was to conduct phone interviews with project members at remote sites without an actual visit to the site. However, the addition of site visits allowed us to uncover the important role that architecture and physical features play in shaping collaborative work practices and expectations. As Section 6.5 points out, this understanding also helped us explain some of our findings.

On a more practical note, we also point out the opportunities for building better tools for conducting such studies and analyzing the collected data. We utilized a plethora of tools for taking field notes, recording the interviews, transcribing the recordings, analyzing the transcripts, creating and deploying the online questionnaire, and analyzing the questionnaire responses. In addition, we also needed to plan and schedule our interactions with the participants. While each of the tools was effective for its specific purpose, it was often cumbersome to integrate the data collected by the different methods, and to relate information and analyses generated by the various tools. For example, it was not straightforward to relate the interview answers of the participants (qualitative) with their subsequent questionnaire responses (quantitative).

For example, it was not straightforward to relate the qualitative interview data with the quantitative questionnaire data for those project members who participated in both components of the

study. Researchers can benefit from tools that are able to integrate the disparate methodological components involved in studying global teams.

8. Limitations

Before we conclude, we also point out the limitations of our study. All insights and implications are necessarily derived from the methods we employed. As described in Section 6.7, several other methods exist that may yield additional insights. However, we could not utilize them due to various constraints, including the distributed nature of the project under study. Another limitation is that the project we studied was carried out wholly within a specific corporation. Software projects undertaken by other organizations, or ones that involve multi-organizational collaboration may be somewhat different. The specific differences will need to be taken into account when applying our findings.

9. Conclusion

We described a large software engineering project distributed globally across several sites of a multinational corporation. The in-depth contextual description that emerged from our study not only represents an illustrative case of the complex nature of these projects but also highlights the utility of our methodological approach. To benefit future studies, we detailed the methods we employed, viz., non-participant observation, site visits, interviews, and an online questionnaire. A systematic reflection also revealed several methodological insights regarding the conduct of empirical studies of global corporate software development. We discussed how the dynamics of software engineering and geographical distribution of a project complicate issues such as access, costs, and cultural and linguistic sensitivity. These insights yielded several important implications for conducting future studies. These include the choice of methods and the benefits of incorporating longitudinal multiple-method approaches. Our experience could serve as a useful resource when making methodological choices for research on globally distributed software engineering teams, or collaborative knowledge work in general.

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