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Sociomaterial bricolage: The creation of location-spanning work practices by global software developers

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ABSTRACT

Context: Studies on global software development have documented severe coordination and communication problems among coworkers due to geographic dispersion and consequent dependency on technology. These problems are exacerbated by increase in the complexity of work undertaken by global teams. However, despite these problems, global software development is on the rise and firms are adopting global practices across the board, raising the question: What does successful global software development look like and what can we learn from its practitioners?
Objective: This study draws on practice-based studies of work to examine *successful work practices* of global software developers. The primary aim of this study was to understand how workers develop practices that allow them to function effectively across geographically dispersed locations.
Method: An ethnographically-informed field study was conducted with data collection at two international locations of a firm. Interview, observation and archival data were collected. A total of 42 interviews and 3 weeks of observations were conducted.
Results: Teams spread across different locations around the world developed work practices through *sociomaterial bricolage*. Two facets of technology use were necessary for the creation of these practices: *multiplicity* of media and relational *personalization* at dyadic and team levels. New practices were triggered by the need to achieve a work-life balance, which was disturbed by global development. Reflecting on my role as a researcher, I underscore the importance of understanding researchers' own frames of reference and using research practices that mirror informants' work practices.
Conclusion: Software developers on global teams face unique challenges which necessitate a shift in their work practices. Successful teams are able to create practices that span locations while still being tied to location based practices. Inventive use of material and social resources is central to the creation of these practices.

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1. Introduction

The aim of this paper is twofold: first, it contributes to theoretical development on global work by showing the nested relationship between workers' use of information technology and their social practices and how this interaction leads to the creation of new work practices. Second, this paper demonstrates how field studies can help us understand the emergence and growth of global work practices from the perspective of workers, thereby building a more nuanced and contextually grounded understanding of global work. Specifically, through an ethnographically-informed study of software developers working on global teams I show how coworkers in the US and Ireland developed work practices that spanned geographically dispersed locations. These practices required workers to use technology in meaningful ways to overcome barriers to communication and coordination such as time zone differences. These location spanning practices not only allowed workers to accomplish their work successfully but also helped achieve and maintain a balance between work and life outside of work. These work practices were *sociomaterial* in nature – they were an ensemble of artifacts and social behavior [47]. These work practices emerged and were enacted in a creative manner; workers made do with whatever tools were available to them, that is, they engaged in *bricolage* [39]. Through a grounded and interpretive reflection I develop and present a concept – *sociomaterial bricolage* – that captures the essence of the findings.

In the rest of the paper I first review the current literature on global work and global software development to establish the context for this research study. In the subsequent section I describe the field study in-depth – including the motivation and guiding principles, design, data collection, and analysis procedures. This is followed by the findings section which describes the use of technology by informants and how this relates to their motivation for

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creating work practices. I then show how the findings can be explained through the grounded theory-developed concept of sociomaterial bricolage. In the subsequent section I reflect on my research experiences with the aim to clarify the connections between the research process and the findings. I then discuss the limitations of the study and outline some ideas for future work.

2. Globally distributed work

Research on globally distributed work and global software development is a vibrant and dynamic area. However, working across distances is highly complex and challenging, and this has been firmly established through various studies [32]. Globally distributed work has a long history dating back several centuries [40] but recent advances in information and communication technologies have changed the landscape decisively by enabling the emergence of novel organizational forms that spread the globe [28]. Although the growth and spread of distributed work in itself is testament to its success, studies continue to show that distributed workers face many critical challenges. Problems occur in global work due to increased complexity of work that requires significant coordination and increased diversity of boundaries faced by workers such as temporal, contextual, disciplinary, occupational, and organizational [1]. These boundaries result in lack of mutual knowledge and common ground, which leads to misattributions and breakdowns in communication and collaboration [16,17]. Interpersonal conflict [30,31] among team members is higher and is coupled with a lack of trust among them [33]. Distribution of teams across locations also makes them prone to subgroup formation based on locations [27] which results in ethnocentrism [18], making it hard to share knowledge and expertise [44].

In particular, since distributed workers are usually unable to share direct experiential knowledge they must rely on interactional dynamics and category membership that are mediated by technology. Communication in these mediated environments is a "leaky process" [17], [p.364] and can contribute to bias, partial information, lack of trust, misunderstandings, and conflict, especially between people who lack mutual knowledge. The consequences of failure to establish mutual knowledge are harsh and include poor decision quality and productivity and less effective conflict resolution. Therefore, technology-enabled global work can be seen as having contradictory effects. On the one hand it facilitates collaboration among people with diverse skills and expertise to tackle significant problems, on the other hand the mechanism for the collaboration – use of technology – and increased team diversity results in interpersonal and organizational breakdowns.

2.1. Global software development

Software development has experienced large shifts due to the inherently digital nature of work that allows decoupling of location and enables coordination through the use of software systems as communication systems [50]. This has led to distributed work becoming the norm for software development but complications in global software development mirror those in other kinds of global work. In particular, increase in locations increases the complexity of work exponentially and, as Crowston et al. [19] point out, presence of boundaries is particularly problematic for software development as the nature of work is such that it requires drawing on knowledge from many domains spread among different developers. Software projects require "a high degree of knowledge integration and the coordinated efforts of multiple developers [19]." These problems are exacerbated when workers are distant and unfamiliar with each other's work and context. In particular, interpretative difficulties make it hard for team members to develop shared mental models of the developing project [26]. The additional effort required for distributed software development results in delays in software release compared to traditional face-to-face teams [29], and can lead to an ineffective team [15]. Yet, even though global software development is prone to problems, its commercial success is a testament to the ability of firms and developers to overcome challenges and deliver products. Recent investigations of the work practices of global software developers show that workers maintain the agility and flow of their practices through the application of situated perspectives and localized practices [2,8]. Boden et al. [8] applied Strauss's articulation work framework to the study of global software teams and found that the work practice of developers could be characterized as a continuous effort to renegotiate the allocation of tasks. Their study also showed that although formal methods can help reduce ambiguity in the development process, these methods or tools are strongly supported by information communication processes. Finally, they found that workers preferred lightweight, flexible, and easy to use tools for everyday communication and that specialized tools were not so common in practice. Avram et al. [2] investigated the use of bug tracking systems across teams of distributed workers and found that local practices were shaped by the need to keep work flowing across the locations even if this mean going against prescribed practices of a project. They argue that the appropriate image of technology in global software teams is of a heterogeneous assembly of systems – a view supported strongly by the CSCW tradition of workplace studies.

2.2. Examining global software work practices in greater depth

The premise for this particular field study was that in spite of problems associated with it, global software development is expanding rapidly and it might be prudent to learn from successful examples of work practices. This goal was triggered by both theoretical and pragmatic motivations. The theoretical support for this idea grew out of recent research in social psychology where scholars are criticizing the field's obsession with studying the failings of human nature rather than learning from the positive aspects of social interaction [37]. These scholars are emphasizing a focus on the situated understanding of cognition and social psychology [55,56]. The tenacity of the human spirit and developers' ability to build software as members of global teams is further supported by recent studies such as [2,8], discussed above, that show that a nuanced understanding of global software development demonstrates the emergence of practices to support dispersed work. At a pragmatic level, the idea for this study came from prior studies I have undertaken, wherein informants often mentioned that in spite of the difficulties they faced, their work was completed as per requirements, met the desired quality, and often exceeded expectations. Informants expressed a desire for a more fluid workplace with fewer interruptions and breakdowns that would support their roles better, but recognized that the overall goal of the projects was achieved.

Given the overarching goal of the study to examine successful global software development and the dearth of studies that focus on the positives, an in-depth examination was warranted to uncover nuanced and descriptive cases. This approach was modeled after scholars working in the tradition of practice-based research. In the last decade, scholars have increasingly called for a focus in organizational studies on understanding the way in which work actually gets done in organizations [5]. The "practice turn," which aims to provide a more nuanced view of work, builds on social theory and advocates a strong focus on people, routines, and situated activity rather than abstract processes [9,22,51,52]. As Schultze and Boland [54] explain, "The objective of a practice-oriented

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approach is to focus on what people 'actually' do rather than on what they say they do or on what they ought to be doing (p. 195)." In relation to examining work, this stream of research – under the umbrella term *work practices* – places at its core a close attention to the actual activities of workers with the aim to understand not just the explicit but also the tacit aspects of work. Conventional views, which focus on narrow tasks and outcomes, conceptualize work as a static slice of specialized labor and jobs as pre-defined activities to be executed without ambiguity. These views overlook the continuous flows of activities that comprise work and focus disproportionally on outcomes rather than on activities through which people produce those outcomes [10–12]. In methodological terms, "[T]he study of practice requires attention to the mundane detail of everyday life so as to uncover the local habits, assumptions, taken-for-granted context and tacit knowledge that members of the social group have difficulty articulating. Ethnographic research methods are particularly well suited to the study of practice [54], [p.194–5]." Therefore, an ethnographically-informed field study was an appropriate mode of inquiry as it allowed for descriptive data collection, which is more approachable for understanding the interpretive aspects of an organization [21].

3. Field study

The field site for this study was a large software and hardware technology organization I have given the pseudonym "Digitech." The firm was founded almost quarter of a century ago in the heart of Silicon Valley on the US West Coast. Digitech expanded its international operations substantially during the 1990s, with a presence in all major markets of the world and development centers across Asia, Europe, and North America. Although the firm saw a rapid growth over the first decade of its existence, becoming one the most well known and well run firms in the world, it never fully recovered from the dot-com bust of the early 2000s.

3.1. Access and initial days in the field

The access to the site was negotiated over several months. Initial contact was made with a Vice President (VP) in the firm through email, followed by a conversation over the phone, a teleconference with the VP and her team, and subsequently a face-to-face meeting with the VP in California. I was asked to prepare a document outlining the research objective and design which was tentatively approved. Subsequently, the VP put me in touch with another contact in the Human Resources (HR) department who became the central contact for all logistical issues and over the period of the field study also turned into a useful informant. This person, whom I will call Stacy, arranged a meeting with a Group Director (GD) who oversaw a large group that was distributed globally. I traveled to California to meet with the GD and his team and to conduct the first stage of the field study. I then traveled to the site in California to collect data. During the visit I went to different offices located in the area, sat in on and observed some group meetings, met with informants, and took field notes. I developed an understanding of the firm and the site but was able to interview only the GD, the rest of the interviews did not pan out. My interview with the GD provided in-depth background and context of the organization, his day-to-day work, description of his team, and most importantly, his outlook on the project I was hoping to accomplish, in particular, his reasons for supporting the study. He explained how he had been with the firm for decades and at one time during his tenure had decided to relocate to another state within the US to make is easy for him to raise his family. The firm decided to support him as a teleworker and he became one of the first employees to take on a distributed role. His experience convinced him that distributed and virtual teams can work together and deliver products and since then he has been a proponent of geographically distributed work. To help us recruit more participants he gave us contacts and ensured that his team, or at least some members, would participate in the study. By following up with those contacts, primarily through Stacy, I was able to schedule a week of field study in California, followed by field study in Ireland, and then another round in California. This research was partially supported by Digitech and in return I shared my research results with the organization. I prepared some specific reports for them and held debriefing sessions with some employees. The timeline for the project reported here ranged from September 2008 to February 2009.

3.2. Research study and methods

The study was conceptualized as an ethnographically-informed qualitative field study that would help uncover how successful work practices emerged and were sustained. The study was designed as an interview-based study supplemented with observations and unobtrusive data collection [45,65]. A semi-structured interview protocol was developed based on techniques identified by Spradley [57] and contained questions about their informants' daily routines, background, interaction with co-located and distributed colleagues, and work practices. The protocol was only loosely followed during the actual field study and the interviews took different directions based on the informants' responses. Observational field notes formed another core component of the research design [42]. Field notes are critical for capturing the context of work – location, décor, services available to workers, and informal and formal interactions. Field notes were supplemented with memos of my impressions of the field site and informants. Overall, the interviews formed the core of the data but the context to understand and interpret them came from the observation field notes and other organizational data. Another feature of the research design was to travel and collect data at different locations. A researcher's first-hand experience with different research sites is essential for capturing contextual knowledge of locations and to build a knowledge base that can be used to interpret the data in a meaningfully.

3.3. Data collection

The field study was spread over 6 months and included interviews with 42 informants and observations on three different occasions at two different locations; one in the US and one in Ireland. The interviews were done either face-to-face (if the informants were at the Ireland location or the US location) or through the phone if the informants were in other locations. Overall, the informants who were interviewed lived across six different states in the US, and in Ireland, United Kingdom, France and Japan. Nationalities represented in the sample included American, Irish, British, French, Spanish, Polish, Indian, and Malaysian. In interviews done through the phone, additional questions about the informants' location were added to the interview protocol. The interviews varied in their length and ranged from 35 min to 120 min. All interviews were first transcribed by a professional transcriptionist and then proofed for any errors by the primary researcher. Informants were formally interviewed once but additional informal conversations were held with many informants. The designation of the informants ranged from intern, developer, manager, to director. The informants represented different teams within the organization and both breadth and depth were a consideration during informant selection – informants represented different teams but at least 70% of team members of certain teams were interviewed. This balance of breadth and depth allowed me to compare and contrast practices across teams while also allowing me to understand work practices of certain teams in greater detail. For instance, I inter-

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viewed a team that worked almost exclusively face-to-face and gave credence to the idea that probably their nature of work allowed for different practices to emerge; testing software versus software development needed different kinds of interaction. A sample of multiple teams also allowed me to assess the role of team managers in work practices.

Observations of the workplace included face-to-face meetings and the physical environment and all observations were typed at the end of each day. Participation in social events such as parties allowed me to get a sense of the culture. For instance, a chance encounter with one of the founders of Digitech wearing a wig at a Halloween party helped me understand the informal culture of the firm often associated with Silicon Valley. I went to lunch and coffee with workers and that gave me an idea of the kinds of informal interactions prevalent in the organization. This was important as often informants in their interviews failed to mention aspects of their work practice simply because they were not salient for them anymore. Furthermore, archival data formed a crucial part of unobtrusive data collection. In particular, as with most software firms, the internal expertise database and people finding software was critical for collecting data and in identifying potential informants. Archival materials such as email and official organizational documents were collected where pertinent. In several cases, I was added to the informants' communication channel, such as IRC (Internet Relay Chat, a form of Instant Messaging). I also asked some informants to show me the system or the software they were developing and what it looked like. Over the time period I spent in the organization, I was also able to look at information on the Intranet such as news and announcements within the organization, internal publications, details of employees and their teams, discussion forums, and so on. Once I returned from the field, I was able to get online information from public data that the firm posted on the web, which included blogs by employees as well as minutes of meetings from some of their open source related projects.

3.4. Data analysis

The data were analyzed through an iterative grounded analysis process [59] and NVivo 7 software was used for coding and analysis. According to the Straussian approach of data analysis for grounded theory, prior knowledge acquired through the literature and/or previous studies can inform future research productively. All interviews were first read and codes developed that captured the primary analytical categories. The overall goal of the initial phase of data analysis was to identify themes that emerged from the data. Once a certain number of themes started to reappear in different interviews, they were grouped under broader themes (categorical coding) that included use of technology, work-life balance, managerial practices, open source experience, and so on. In the next phase, data obtained through observations and participation was analyzed and organized around the themes that were distilled from the interviews. Memos were then written on the themes. These memos identified major players and significant events referred to by the informants. The memos formed the basis for the final writing although I often referred back to the raw data. One critical point about data analysis is that it was not all post hoc, that is, I did not wait to collect all the data before working on the analysis. As I was in the field and collected data, I informally analyzed the data to ensure consistency as well as the ability to explore issues that came up through subsequent data collection.

4. Findings

Consistent with the literature, technology turned out to be a major theme at Digitech and was equally represented in interview and observation data. Informants referred to the use of technology frequently. The use of technology was particularly salient on two teams where developers were dispersed more than other teams in my sample. This prompted me to further probe the use of technology by focusing on the technological practices of these two teams and the data in the rest of the findings section is from informants on these two teams only. I wanted to understand why the practices that the teams used had emerged, why certain technologies were used as opposed to others, and how the technologies were used within the context of globally distributed development. Both the teams were spread across the US and Ireland and one team had additional members in Asia. The members in Asia are not included in my sample.

4.1. Multiplicity and personalization with information technology

Right from the start of the data analysis, it was evident that channel and bandwidth explanations [20,58] – the idea that higher bandwidth medium such as video is better for certain kinds of communication – did not adequately explain the findings emerging from the data. Scholars emphasizing social aspects of technology use were closer in explaining what I was observing in the analysis [23,46,66]. On closer examination involving several rounds of coding, two distinct sets of issues emerged around how workers used technology as part of their work practices: *multiplicity* and *personalization*.

Multiplicity implied the availability of multiple communication technologies for interaction [64]. When informants at Digitech were asked about their use of communication technology, most informants mentioned that they used a variety of media – email, IRC (similar to Instant Messaging), phone, Wikis, Blogs, Intranet, and so on. The most common communication technology in terms of use was email followed by IRC and phone calls.

> "Okay. I think the primary way of communication is through e-mail. We have e-mail list for the different groups ... operations and development teams ... each has their own list. Secondly, we communicate I guess will be next instant messenger which is kind of good for one of small communications like when we need to ask a quick question. We also have a chat room that we use usually. We pretty much use that for - if there is an issue that we need to all get together and work on or maybe we want to have a meeting. That might be a little bit different that we don't want to do on phone. We might do that on instant messenger. And the third way of communicating is with the phone. It is either a conference call or just a one-on-one phone conversation."

Multiplicity afforded being able to connect in different ways but it also allowed different media to be used for specific purposes. Phone conversations were useful as they allowed synchronous communication and allowed reduction in turnaround time. They also facilitated quick updates that put everyone on common ground immediately. IRC often substituted for hallway chatter and informal communication, as these responses illustrate:

> "That's what our guys do, they hang out in the IRC channel. But I actually think it is important... There is some kind of initial socialization that is quite important that we try and have people work here for. We've kind of almost involved a lot of people who are working remotely from the site and maybe not coming into the office every day. We try and make sure that we build social interaction into what we do."

> "I think IRC, for people who work from home, IRC is almost a way of just keeping in touch with everybody, you know, and feeling that you're still part of the team, you're still part of the group because when you're on IRC, you can see that this person

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is logged-in and this person's working. So you know that they're around. I know the engineers who work from home, they're on IRC all the time. It's just they're in the background [and feels like] all the people are sitting near you. You know, that way."

I was able to experience how a team used IRC firsthand (see Fig. 1). I was added to their IRC channel and was able to lurk for a couple of days. In addition, to the daily flow of conversation, many IRC participants asked me questions around my research and field study. The tone and feel of the interaction was similar to that of a hallway conversation or chat.

Many informants noted that when they were new to the organization, they often developed mutual knowledge and impressions about their colleagues, especially of their expertise, by reading and browsing records of mailing lists or IRC transcripts.

"When you read a development mailing list very quickly, you find out who the people who are very experienced and have very good insight are. Sometimes, just from reading the mailing list things that are (discussed are) very, very good for building your own experience. Basically just read the arguments. Just like in everyday life. You're listening to the different sides of an argument and I think it's... find out who the person is who usually gives good answers."

As a researcher, I observed the same pattern in my use of the Intranet and other archival information sources. I often browsed through archives of discussion or mailing lists to "observe" the behavior of my informants. I often did this after my interviews with them as they referred to online events or conversations. In many cases, the informants pointed me to these online resources.

Personalization was the other critical element related to technology use and refers to the option of using technology based on the preference of workers – if not all the time but for the majority of interactions. Personalization went beyond the individual and could be seen as an aspect of a relationship – what two workers preferred to use when they were interacting and even as the level of a team – what a certain team preferred to use as the primary communication channel.

"My interactions with people are primarily all electronic, e-mail or IRC. Occasionally, I might need to pick up the phone and talk to someone. But that's rare. Generally I send someone an email. Find them on IRC. I have whatever conversation is needed and keeping moving on. My manager is located in the Southwest U.S. [and] with him [communication] tends to be more on the phone than electronic although I would say it is probably a 50/50 mix."

"And I think depending on the person, depending on how they like to communicate, or what needs to be done. There is a different method of communications I would use. And usually the phone is – I would not say the last resort but when we really need it is important or otherwise the communication is not working there is always the phone that is available to talk to the person and work things out. But, if you need to get to more than one person [ ] It seems that e-mail is always the best way to go for that."

Personalization of technology demonstrated that rather than the capabilities of a medium, in terms of the kind of communication it enabled, the ability to reach a mutually acceptable norm within a dyad and a team was the primary driver of technology use [46].

Informants reported learning several lessons about communication and technology use from working on virtual teams. For instance, this one informant reported that communicating more or redundant communication was useful for working on virtual teams as it was hard for anyone to assess the value of information from someone else's perspective.

"I think I have learned that [it is important to communicate], even if the things might not seem important. I have learned that [I should] at least send e-mail [about] things that are going on

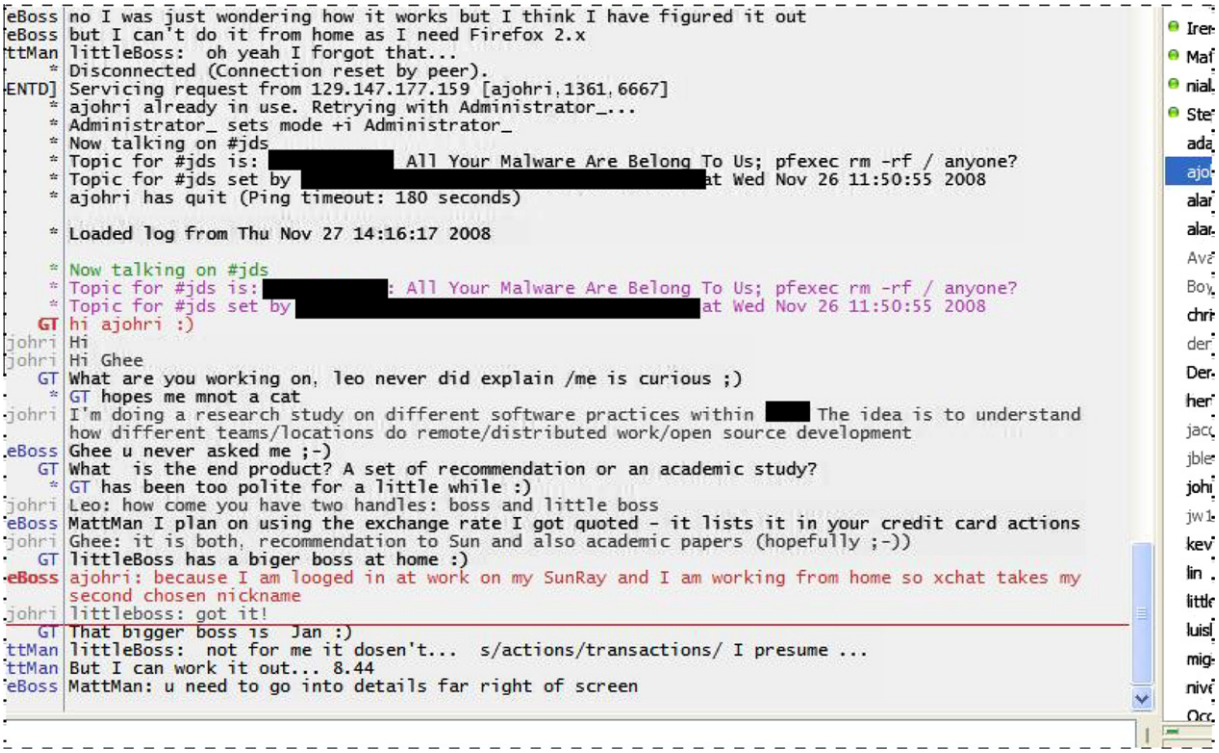

Fig. 1. IRC screen.

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that [ ] potentially might interest other people. One of the nice things about e-mails is that [the recipient] may not pay attention that late [at night] or [immediately] but they can go back and look at it later."

Of course, closely tied with the issue of using technology was the idea of meeting someone face-to-face. Informants universally mentioned that meeting team members face-to-face at least once a year was very useful. Still, many informants also reported that they had never met their teammates face-to-face and they were still able to work productively and had even established good working relationships with their coworkers:

"Sometimes, I found that when you have compatible personalities, it doesn't matter. My [team member] in [another location] is coming on board [soon], I've never met him face- to-face yet. And yet we crack each other up all the time on IRC and e-mails, so I know when I meet him, what he is going to be alike because you get a strong sense of personality. I don't think it's happened that when you get people who are superficially outgoing and enough of your personality reflects through. An e-mail is a restricted meeting but IRC is much less so. So, you can crack jokes a lot and learn what sort of things people are into and what not. You get to know each other surprisingly well. In retrospect, I would say [that you get to know a person] far better that I would have guessed [you could]."

Face-to-face interaction can be seen as just another channel used by workers as part of their practice. Not only was face-to-face interaction limited among workers in different locations, but often at the same location the entire team came to office only on one or two days in the week.

After establishing multiplicity and personalization as key themes around the use of technology for communicative practices, in the next stage of the analysis, I explored why these practices – the need to use multiple media in personalized ways – emerged. It was evident that these practices were there as a response to working as a geographically distributed team but that still did not explain why only a few technologies did not suffice for interaction or why personalized use was so prevalent. Beyond the institutional driver – globalization – what motivated informants to engage in these practices?

4.2. Achieving work-life balance as a critical concern in global development

Further analysis of interviews and observation data showed that working on global teams had significantly shifted the work-life balance of informants and to rebalance their lives they started to develop practices that would allow them to be more flexible with their time. The change was so dramatic that many informants reported that being able to work on global teams allowed them a better work-life balance and lifestyle choice by allowing them to work from home and from geographic locations where they had moved due to personal preferences or partner dependencies. Overall, most informants I talked with saw global development as an opportunity to rethink how they worked and changes they could make to make their lives better.

In addition to better work-life balance, several informants mentioned that working from home made them more productive and efficient. For instance, when I asked one worker who worked from New Zealand as part of a team based in Ireland, why he moved to New Zealand he said,

"For myself, I think it's the balance between your private life and your work. I can work in the day or I can work in the evening. . .take a break in the middle of the day. I cannot do that if I was working in the office. For me, that's probably the most important – balancing life and work. For Digitech, I think, it's probably also important the employees are not stressed.

He further added that,

"My impression is that I can be more productive working from home that working from the office. I probably also work for more hours than if I was working in the office. So when I in the office, I was interrupted very often."

Another developer in the Ireland office who worked from home four days a week cited personal and commute reasons for working from home,

"I am originally from [a city north of the office location] and my wife is a lecturer there. When we got married we bought a house somewhere in the middle. She goes that way and I come this way. Initially it was a concern [working from home] but I talked to my manager and since then we've had a lot more people start working from home"

Similarly, another worker in the US location mentioned that flexible work hours had given him considerable work-life balance:

"I have extremely varied schedule. So typically, I get up, log on and check e-mail. Mostly it is just monitoring and making sure everything is okay and then sort of marking a handful of messages for things that I need to follow up on. Sometimes I have enough time to do that follow up before taking the kids to school. Sometimes I don't. If I do, then I do it, if I don't, then I deal it when I get back from taking the kids to school. Then, often I will take a break in the late morning and go for a bike ride for below one hour. Other days, my work out is over lunch and I go for a run or go for a Frisbee. My team they always aware when I will be gone and I generally say, 'Okay, I am going doing X now I will be back in N hours.' And I can set my IRC so they will know when I will get back. Then when I get back I catch up with whatever I miss, I go through the same thing."

Flexibility in work was well supported by the management at this US location. Many employees did not have offices – as they worked mostly from home – but when they needed to come to the office they could book one of the "flexible office" spaces. Engineers in locations other than the US headquarters preferred the option to work from home as well, as this engineer on the East Coast of the US said,

"I work from home. There is a small office here [in this location] but it ends up working better for me to work from home because I have my work station and all my reference materials here are at home than in the office."

Therefore, flexibility in working was seen as a critical need by workers in order to balance their work and life. This need necessitated the use of information technology – particularly for communication – in ways that would support work flexibility. This is where multiplicity and personalization became important as they allowed informants to find a balance that worked for them as well as for their team members.

The option to work from home was not only beneficial to the employees but also to Digitech. From the perspective of Digitech, giving workers the opportunity to work from home or from cities of their choice resulted in very low turnover with most engineers staying with the firm for a decade or more and feeling fully committed to the firm's future. This allowed the firm to keep its expertise in-house, especially in the highly volatile IT market, and maintain the core engineering prowess for which it was renowned. The engineers, many of whom preferred working for Digitech due to its engineering focus felt rewarded with the flexibility and

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opportunity to work on interesting technical problems. Therefore, Digitech was able to sustain itself as an organization and this sustainability was evident not just in issues related to the environment that working from home contributed to but sustenance of the workforce over time.

4.3. Emergence of location-spanning work practices

Often the real motivation for the emergence of work practices is hard to ascertain. At Digitech the necessity to work with developers in other locations had acted as a trigger to rebalance time spent at work and at home with the consequence that new work practices, that spanned locations, emerged. The use of multiple media for interaction and dyadic and team level personalization of technology use were an integral part of this new work practice. A manifestation of a global work practice was outlined in an interview by the team-leader in the Ireland location. Her overall group was dispersed across the US, Ireland and China. Initially when the team was extended with addition of members in China, the larger team tried to teleconference with all team members participating. The difficulty of finding any time within the day that would work for such a teleconference was immense and therefore the team realized that this was not a feasible solution. The team realized that they could work around this problem by using members in Ireland as brokers as the time difference between Ireland and the US and Ireland and China was more manageable. Team members in Ireland started to play the role of a broker and had a teleconference with testers in China (and sometimes India) and repeated the teleconference – in terms of topics – with the developers in the US. In this way they were able to bridge the unusually large time zone difference between the two continents by serving as middle base and made sure everyone was on the same page. Once implemented, this became a standard practice across other teams within the firm with accommodations for particularities of each team such as the frequency of the meetings.

Over time, this practice changed with teleconferences being supported by extensive email communication before and after the meeting. The team realized that sole reliance on phone conversations had its drawbacks. Even though English was the common language across the firm, different people had different accents and style of speaking which often made it hard to follow them on the phone. During my field study I observed and talked with informants with the following accents: Irish, Spanish, Polish, British, American, Chinese, Malaysian, Indian, and Japanese. This increased the reliance on written communication and therefore email and IRC were often favored over phone conversations. Written communication, as in the case of emails and mailing lists, also had another advantage – they became a useful resource for posterity given their permanence. One team member explained the problem she encountered and how she solved it:

> "[Y]ou have to be sure that people can understand what you're saying over the phone. One feedback I got was that I talk too fast. So, it's very hard actually sometimes because you just naturally talk at your own speed and so sometimes, you have to almost ask a question when you're finished to make sure that people understood what you were saying because you might say at the end of it, "Okay, is that okay with everyone?" and there is complete silence. And you think 'I'm going to have to go back again and maybe repeat it or just go back to the points again' because sometimes, I don't know, sometimes I find people [maybe] didn't hear what you said, or didn't understand what you said."

Over time, other adjustments were made to the practice. The use of IRC among members was increased. Members in a particular location or time zone held their group meetings closer to the time and day of the meeting with the entire team. During the field study, I was able to look at the emails exchanged among the team members and participate in group meetings. The content of the emails and meetings showed that this location-spanning work practice was an integral aspect of the overall work practice of team members. The use of IRC became a preferred tool even within some local teams, which suggests that the co-creation of new practices had second-order effects [57] that resulted in overall innovation in team practices. Fig. 2 presents an analytical model that summarizes the findings from this study.

These findings support the results of recent studies on GSD, especially [2,8]. For instance, the availability of multiple media was critical for open communication and workers emphasized that they preferred lightweight tools [8], therefore IRC was extremely popular. Furthermore, IRC was the only lightweight tool available to most developers given the constraints of the hardware platform developers used which preclude other tools especially consumer tools such as Skype or Yahoo Messenger. Similar to developers in the study by Avram et al. [2], informants often reported that tools such as bug tracking software and code repositories played an important role in their coordination process. Unfortunately, often these specialized software applications became a hindrance as there were strict rules around who can use them in what manner – reflected in the power relations among the developers in the different locations. Overall, this study builds on recent work in GSD and highlights the role of building a nuanced understanding of the work of developers, their tools, and their motivations for global work. This study highlights the co-creation of location-spanning work practices. As a note of caution, the location-spanning work practices were not necessarily long term stable arrangements but involved everyday negotiability to keep them functioning.

5. Sociomaterial bricolage

The work practices that facilitated global software development emerged through a confluence of diverse factors such as the availability of technology, the motivation for a better work-life, the need to work with coworkers in other time zones, and the need to maintain a highly technical workforce. When considering the use of technology, it is important to understand that even though this was a high technology firm, the use of technology was determined by the organizational context to a significant extent; availability of resources shaped the work practices. Workers *made do*

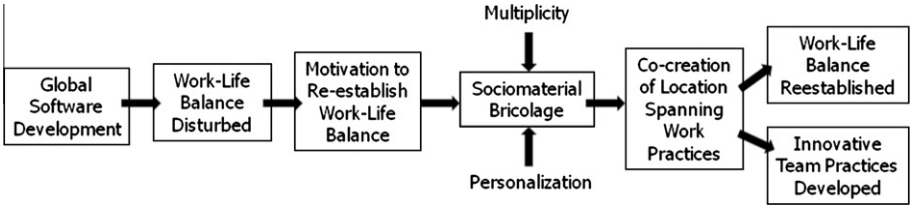

Fig. 2. Analytical model summarizing study findings.

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with whatever was available at hand in a multifaceted manner – this making do with what is available was termed by Levi-Strauss [39] as *bricolage*. Levi-Strauss was interested in how people make do with what they had at hand rather than taking a planned approach which would require developing or acquiring tools that are not immediately available. Orr [48] further argues, "The point of bricolage is the reflective manipulation of a closed set of resources to accomplish some purpose. The set is the accumulation of previous manipulations, one's experience and knowledge, and in literal bricolage, physical objects. This manipulation is done in the context of a specific goal, which influences the process (p. 121, italics in original)."

Bricolage is about the particular and the particularities and in the case of work practices at Digitech it showcases how teams developed their use of technology. Within the context of design, "Bricolage can be described as 'designing immediately', using ready-at-hand materials, combinations of already existing pieces of technology – hardware, software and facilities (e.g., Internet providers) – as well as additional, mostly 'off-the self' ones. It therefore also involves design as assembly [13], [pg. 23]."

The developers at Digitech displayed three characteristics of bricolage identified by Baker and Nelson [3]. First they *made do* – that is, they engaged in action and activity rather than lingering too long over how to create a workable solution. Second, team members *used the resources at hand* to the best of their ability. They stretched the boundaries of what was possible with the resources they had at hand. Even though during the interviews several informants lamented the lack of easy to use videoconferencing tools, they went on about their work without that resource. Finally, the informants were able to *use existing resources for new purposes*. IRC emerged as a tool for informal communication taking over the role often accomplished by water-cooler conversations. In this way team members developed communicative practices that helped them work irrespective of their location – bricolage was essential in helping create location spanning practices.

Yet, technology alone does not determine work practices. Studies of work practices that focus on the use of technology have established the synergistic relationship between the social aspects of organizing and the use of technology [6,67]. Recent work on sociomateriality in particular establishes the inseparability of the technological and the social [47]. Building on the work on actor-network theory [14,38], situated action and human–machine reconfigurations [62], and performativity [4], Orlikowski and Scott [47] argue that artifacts and human actors play equally important roles in work organization and therefore to understand organizing we have to drop the dichotomy between the social and the material, they are inseparable and should be studied as such. This perspective implies that an understanding of work practices requires a focus on the ensemble – technology and developers in action – and not assemblage's individual components. The account I present here differs slightly as compared to the account Orlikowski and Scott [47] are looking for. In this study and in my discussion I have often separated the social and material issues analytically; in practice – for the informants – they were not distinct issues. I have focused on the ensemble but have found it necessary to distinguish between the underlying factors as only by understanding the emergence of the ensemble – and its parts – can we delve into aspects of work practices such as the motivation of their development.

Combining the two perspectives discussed above – sociomateriality and bricolage – provides a unique lens to understand the findings of the study and leads to a grounded concept that I will call *sociomaterial bricolage*. Sociomaterial bricolage encapsulates the idea that practices emerge through the ad hoc use of available artifacts by people often in conjunction with others and while participating in situated activities. The location-spanning work practice developed at Digitech is an instance of sociomaterial bricolage. Coworkers made use of tools available to them to fill the need of working with geographically dispersed team members but also motivated by the need to balance their work and life out of work. Sociomaterial bricolage establishes the overall idea but also conveys that particularities will be present across practices. It also implies that practice developed by a team will not automatically transfer to another team as is and that each team will end up developing variations of similar work practices. The location spanning practices in other firms – and even other teams – will be different and can serve the workers successfully [2]. They might be motivated by factors other than achieving a better work-life balance [34] and/or might use other forms of communication, rather than IRC, SMS might be the informal communication medium of choice.

The concept of sociomaterial bricolage is closely related and builds on other perspectives that have been used to examine the nature of work practices such as articulation work [7], appropriation [49], infrastructuring [60], coordinative artifacts [53], and boundary objects [61]. All these frameworks emphasize the uncertainties of everyday work practices and the need to make visible the tacit aspects of work. Furthermore, these frameworks argue for an interpretive understanding of work built through a focus on both the social and material fabric of work. The idea of technology and organizing, which the concept of sociomaterial bricolage conveys, has also been expressed by many scholars including Suchman [63] who refers to it as heterogeneous engineering. Finally, sociomaterial bricolage builds on work on distributed cognition and activity theory that emphasize the use of tools, a network of people, in how people accomplish things and work and learn. Sociomaterial bricolage reflects the ideas expressed in many of the above mentioned frameworks and further argues for an emphasis on the connection between that 'at the moment activities,' the role of tools, and larger organizational and institutional level motivations affecting work practices. Work practices reflect the ingenuity of the workers in how they use the tools (social and material) available to them within a given physical and political context. Sociomaterial bricolage can be applied broadly to provide an account of organization life that can be a specific physical setting or projects that transcend physical space.

6. Reflection on research experience

6.1. Researcher's prior knowledge and frames of reference

Having discussed the findings of the field study, I now turn to a discussion of the role of the researcher in the field study. Even though this study was designed to be more constricted in data collection than a full-fledged ethnography, it did provide a nuanced and contextualized understanding of the work practices. The reason it was successful in achieving that goal was that I could draw on prior experiences both as a software developer and as a researcher who had studied global teams. Therefore, I already had some understanding of the development of practices across location and knew that data collection at multiple locations was critical in drawing a complete and coherent picture of global software development. I also understood institutional cultural patterns played a stronger role than national cultural factors in determining work practices and diversity of workers in any given location made it critical to look beyond differences and focus on similarities among informants. Previous research experiences had also prepared me to be open to surprise and new ideas and to listen and observe with an open mind.

I was also aided in the data collection process by virtue of having spent significant time in the area where the US offices were located. Even though at the time of the study I did not live there, I

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was well aware of the overall environment – institutional and organizational – and was comfortable with many aspects of data collection such as traveling to the locations, meeting some informants outside the office location when needed, and so on. As a matter of fact, I had to be careful to remove lenses that would distract me from uncovering contextual information and nuance of this particular firm. I believe I was able to achieve this as unlike in other firms I was able to unearth a highly technical core to the organization, one where technical knowledge was given a superior status compared to other functions of knowledge. Many informants in managerial position complained that their technical team members did not pay sufficient attention to them and marketing and sales concerns, or any concern expressed by the user became secondary to technical prowess of the systems and workers. This was quite different than other firms in the area that I had worked with for my research.

And even though I had never visited Ireland before, I was well experienced with traveling to a new location and collecting data. Prior to the trip to Ireland I had not met any informant from that location face-to-face and had only exchanged brief emails with a couple of informants who were helping with the organization of the study. I reached Ireland on the weekend and when I went to the office on Monday morning, no one was present except the security person at the front desk. He let me into the building after I convinced him that I was a legitimate visitor and showed me to my office for the week (luckily I knew the name of the conference room through an email). My prior experience working with similar firms and the concept of a business park had prepared me well for such a scenario. Right after I reached the office I walked around the building and quickly categorized it in terms of the layout. It was a cubicle layout in contrast to the office layout in the US location. Even this office schema I use has developed over time, through studies of firms that assign offices to everyone, as opposed to those where all workers, even the managers, are assigned a cubicle. In the Ireland location many managers were set in cubicles but had larger space available to them as compared to the developers. Overall, frames of reference that researchers develop help them approach an unfamiliar site with some kind of familiarity and ease and over time the researcher one again has to move towards the unfamiliar in order to capture the uniqueness of a site.

6.2. Aligning data collection with organizational work practices

While doing field work, a researcher should attempt to participate in the informants' work practices to the largest extent possible. Participation can occur in two primary ways, through direct involvement in organizational events such as lunch, dinner, or team meetings, or indirectly by modifying research practices to mirror the work practices of informants. During the field visits I participated in several organizational events such as having breakfast in the cafeteria with workers, weekly team meeting, and taking the shuttle from the train station and this helped me develop an understanding of their work environment and experiences. This direct participation was especially useful during my initial days in the field. Immersing myself in the environment and grappling with the environment around me allowed me, the researcher, to bring fresh eyes to their experiences and feel like a newcomer. By going through some of the same experiences as informants, I was able to understand their practices better. Participation was not limited only to face-to-face interaction but also occurred digitally. Through emails, IRC, the Intranet and use of other technology I was able to experience the problems faced by informants, especially interaction around time zones.

In addition to participating directly in organizational events I made concerted effort to align my research practice indirectly with organizational practices. Given my research goal – to build an in-depth understanding of global work – I designed my research so that travel formed a core component of my field study. Even though travel was not necessary and I could have interviewed the informants through teleconferences (which I still ended up doing in some cases), travel provided a contextualized look at locations and workers and gave me a first-hand experience with various issues that are inherent to international travel. Primarily, travel makes the organizational differences among locations clearly evident. For instance, although the US campuses of Digitech were large with around 15 buildings on one campus and 10 in another, in Ireland, Digitech occupied two buildings in a large software park. Therefore, the experiences informants had in terms of their interactions with employees outside the firm were different. A smaller building – and occupancy – was also reflected in the different kinds of employees of Digitech itself with whom the developers interacted. Digitech informants in non-headquarter locations often complained that it was difficult for them to gain access to workers and teams that were based in California but who were essential for their work. Whereas informants based in California also mentioned that it was hard to track down some workers but given that they were in the same location sooner or later they could always track them down. The example given earlier of teleconferencing an informant in Japan is also an example of modified research practice to accommodate an informant and a true representation of the meeting times that many informants worked with.

Traveling to the location in Ireland from my hotel gave me a first-hand experience of commute. The location in Ireland was part of a business park south of a major city. From my hotel I walked to a train station, took a train, boarded a shuttle for the business park, and then walked to the office. This was the commute process for many people who worked in the business park and at this office. I would often run into informants I recognized from Digitech in the shuttle. I experienced many of the time delays that informants talked about. There would be a wait for the shuttle, the traffic from the train station to the business park was so heavy that the shuttle would have to change its route, and the train was often delayed due to track repairs of accidents on the track. Finally, international travel is an experience that simulates well in terms of what many of the informants experienced. They mostly traveled to the US time zones, while I traveled the other way, but they also had to get to work quite soon after landing in a new place. This was my first ever travel to Ireland so it was a new experience for me. For instance, it was my first time in an English speaking European country and I found it easier to manage the logistics on the ground. The use of English on the television facilitated contextual learning as it was easier for me to follow local and international news. This was significant as the economic downturn around the world, and particularly in Ireland, was a major topic of conversation on the TV and among the informants at the time of the field study. During that week a horrendous terrorist attack on a hotel in Mumbai, India, which lasted almost 3 days, formed a large part of the news coverage and many informants asked me about it.

Beyond travel, experiences with technology were also simulated in several aspects of the field study. For instance, scheduling of interviews was representative of the ways in which meetings were often organized among dispersed workers. First, I made use of Intranet to find information about informants, particularly their location. Second, if the location was not the US office I was visiting or the Ireland office, then arrangements were made to do the interview via teleconference. I was able to use the teleconference equipment of the firm to do most of these interviews but in certain cases I had to the interviews once I was back home. I ended up interviewing an informant in Asia at 10 PM my time as that was the only time during the day when the informant was available. Even setting up this one meeting took a while (see Fig. 3). Therefore, multiplicity and personalization were key considerations for me

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On 12/19/08 07:50, Stacy wrote:

Brian-

During this week Aditya Johri, PhD. and assistant professor at Virginia Tech has been conducting one-on-one interviews and observing your team. You name has been mentioned several tim es during these interviews and during Aditya's interviews with the team in Ireland. Aditya thinks it would be valuable to interview you as well. The GD may have mentioned this opportunity to you. We ask to have 1.5 hours of your time for an interview with Dr. Johri either Friday, December 18 PT or sometime in the coming week. Please advise to your availability to both.

Brian wrote:

Hi ...

I heard from my manager.

This is late notice, but I'm more than happy to participate. Do you mean Fri the 19th or Thurs the 18th? Also, you say PT, so I'm assuming that means Pacific time, but what time? Also, I'm in Tokyo so Fri Pacific time during work hours is off hours or Saturday for me and I already work most nights till 2 or 4 AM so Saturday is sleep time. I'm available any time today, Friday Dec 19th Tokyo time, till 6 pm or so. Then Monday the 22nd Tokyo time from 8 am to 9 am and then from 11 am to 6 pm. Tues the 23rd is a holiday in Japan and then I'm taking the rest of the week off.

Brian

On 12/20/08 00:28, Stacy wrote:

Brian-

If you wouldn't mind me forwarding your information to Aditya, I would rather the two of you figure out a time that works best for both you schedules... preferably one that doesn't require you to lose any sleep or weekend time :)

Stacy

Mon, 22 Dec 2008 13:22:11 +0900
Sure, that's fine.

Brian

Quoting Stacy to me:

You are good to go w/ contacting with Brian.

Quoting Aditya Johri <ajohri@vt.edu>:

Hi Brian,

I was traveling back from CA to the East Coast and missed the times you had suggested. Can we try for the first week of Jan. or whenever you are back from vacation. My schedule is quite open so please let me know the day/times that I might work for you.

Thanks,
~Aditya

On 02/06/09 06:55, Aditya Johri wrote:
Hi Brian,

I know it has been a while but I wanted to follow-up and see if you are still interested and have time for an interview. I'm quite flexible next week (except Tuesday 12:30-3:30 U.S. east coast time).

Thanks,
~Aditya

Hello, Professor. How early/late do you work? We are 22 hours away. :) East Coast US and Tokyo is just a terrible timetable (which is my life, by the way). Unless you work very, very late or get up very, very early I can't do this interview. I'm sorry. I just have too many 20 hour days right around the clock accessing people in the U.S and Europe. I have very limited time for non-critical work during my early/late times.

Fig. 3. Email exchange with Brian, an informant in Japan, to set up an interview.

as well during the field study. Personalization was involved in terms of negotiating with informants how they preferred to be interviewed and multiplicity was evident not just in interviews but other data gathering aspects as well. Participation in IRC channel, use of the Intranet, perusal of blogs and wiki, were all used in data collection and analysis.

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Brian

On 02/06/09 20:54, Aditya Johri wrote:
Hi Brian,

I understand time zone complications, I've worked on global teams myself and realize how hard it is. Just give me the options of a few time slots that work for you and I'll see if they'll work for me. I usually work quite late and often quite early as well. Anything up to 1 AM here (which should be next day in Tokyo) should work.

Thanks,
~Aditya

Ok, how about your Wed or Thurs even ing? 10 pm? 11 pm? Either day.

Brian

On 02/10/09 08:02, Aditya Johri wrote:
Thursday evening at 10 PM will work best for me. Thanks.
~Aditya

Ok. Got it. Also, the best way to connect vi phone is on conf call, not direct (this is due to the phones here, which are really quite bad). We can use my number if you want. That number should be free to you.

US: 866-555-5000
Access Code: 5550880

brian

Fig. 3 (*continued*)

6.3. Research practices and sociomaterial bricolage

My research experience itself can be viewed as an example of sociomaterial bricolage. The ensemble consisted of use of tools to collect data, formation of partnerships and rapport with informants, ad hoc use of resources, and, even though it appears and is presented as highly individualistic endeavor, it was a collective effort made possible by people who contributed to it directly or indirectly. The notion of sociomaterial bricolage is also useful as a tool that highlights the contrast between my practices – particularly the use of technology – and work practices of informants in the field. There was a stark difference in the hardware platform we used and consequently in the software that were available to us. The informants were on a platform mandated by their organization – as that is what they developed and sold – and it formed the backbone of their organization. This platform severely limited the interactive and communication technologies available to them and was incompatible with other platforms in the market. The difference in their use and my use of technology became salient during one of the interviews. When asked what future technologies they would want to see, one informant said that there is a need for technology that would allow them to sketch digitally and share their sketches to aid in their design process. In my field study, I was using a similar technology already in the market – a Tablet PC – to draw sketches of the field site (see Fig. 4) and when I demonstrated it, the informant was amazed. This incident impressed upon me the highly different experiences with technologies that I personally had compared to the informants and even the newcomers to the organization had, compared to informants with a long tenure at the firm. These differences were stronger among informants that worked closer with the hardware technology as compared to informants that primarily developed software. Therefore, the use of resources they had – hardware and software – to best fit their needs was even more salient. And even though materiality, in this case use of digital technology, is just an aspect of the concept of sociomaterial bricolage, it diverges significantly from similar practices. On reflecting at my research experience it is clear to me that often I had to "make do" at the field site in terms of the opportunities available for data collection. The primary constraint with an ethnographic field study is the time available to conduct the study and it is clear to me that I should have tried to spend more time doing observations. During the study the usefulness of doing observations was questioned by the informants themselves as most of them worked from home and they were not sure what I would learn from spending more time in the office. If I had to do this again, I would take more time to figure out how to participate more electronically – emails, IRC – and make that the core component of the study.

In their introduction to the special issue on qualitative research on software development, Dittrich et al. [24] highlight that there are multiple ways to undertake qualitative research and that the methods as well as the theoretical framework varies significantly across studies. Furthermore, even epistemologically speaking, qualitative researchers fall somewhere on the spectrum of positivist researchers to interpretive and hermeneutic scholars. These issues that they identify are equally applicable to global software development and it can be argued that there is no 'one way' or 'right way' of doing qualitative research. Ways of doing emerge as researchers undertake field studies develop their own version of the methodology. In other words, researchers themselves engage in sociomaterial bricolage. This is reflected in empirical work on GSD and this study demonstrates the usefulness of undertaking a field study in different locations to account for contextual differences and similarities and to understand the meaning developers make of their own work. This study also emphasizes the importance of focusing on the materiality of work – from documentation to development platforms to hardware used all elements play a role in work practices. Finally, similar to recent qualitative empirical studies of GSD [2,8], I argue for a practice-based perspective that emphasizes examining what workers do and caution that it is essential for researchers to be aware of their own perspective and frames while undertaking a field study.

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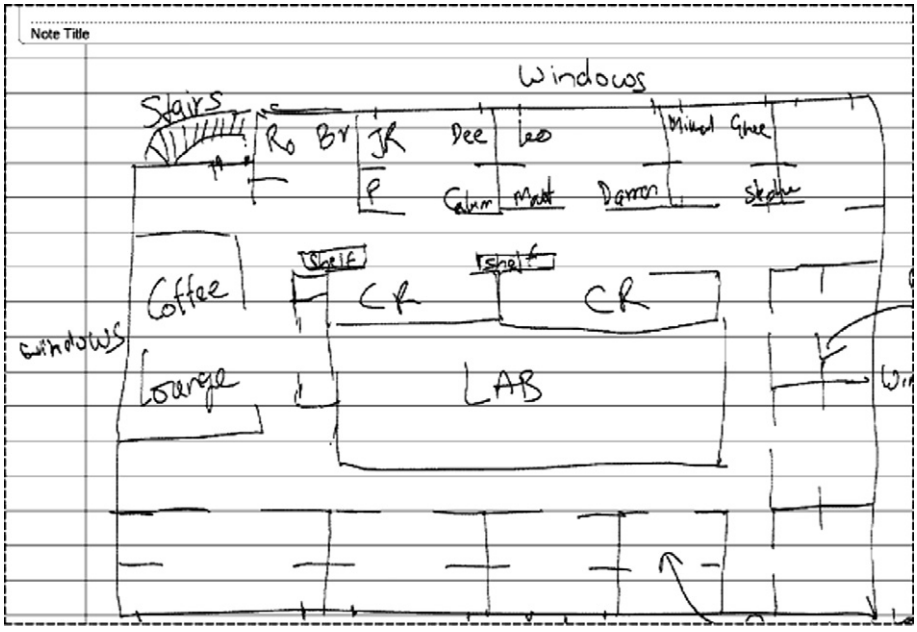

Fig. 4. Sketch of office space in Ireland using Tablet PC.

7. Limitations and future directions

As with any empirical study, there are several limitations of the work reported here. The aim of the study has been to report interpretive and grounded findings from a particular firm, and teams and workers within the firm; therefore, direct generalization of findings to other settings will naturally be limited. In particular, there will be variation in technologies used in other organizations and the motivation for emergence of work practices will vary. As a next step, therefore, it might be prudent to collect data at other firms in order to understand the variation in the emergence of practices. For instance, is negotiation driven by managers or does the introduction of new technology – and the need to innovate – provide the impetus for the creation of new practices. Even though not all aspects of the study will be applicable to other sites, the central ideas synthesized from the data in this study – multiplicity and personalization – and the key theoretical concept of "sociomaterial bricolage" should be applicable to organizations irrespective of their particularities.

There are limitations in terms of specific data collection methodologies. I conducted just one interview with each informant and the opportunity to conduct more interviews might have led to greater depth in the data. For instance, one methodology that could be adopted is the use of "war stories" as outlined by Lutters and Seaman [43] (also see [25]). War stories allow added insights into the complexities of software development and maintenance through elicitation of details that are sometimes glossed over or generalized in interviews. The data analysis technique I use in this paper is inspired by grounded theory, which is just one form of data analysis with its limitations and advantages. Grounded theory allows for the analytical categories to emerge from the data and leads to the development of theoretical ideas and concepts. But grounded theory is limited in its predictive ability and does not aim to confirm hypothesis but to lay the groundwork for future work, as discussed above.

And although I apply the idea of sociomaterial bricolage specifically to the emergence or development of work practices, the concept can be used to shed light on other stages of work practices and future research might test the applicability of the concept across a diverse range of practices. The implications of this work for practice – both of software developers and researchers – are the focus on the use of artifacts and their interaction with social behavior. The use of artifacts at hand in creative ways is another interesting implication. Even though the bandwidth of a particular technology is limited, people will work around that to create practices that work for them in order to accomplish their work successful. The motivation that will drive the emergence of a practice will, of course, differ. Furthermore, sociomaterial bricolage is just one framework that can be used to examine the development of work practices that span locations. Bridging across locations can also occur through knowledge brokering by developers or managers [36,41].

8. Conclusion

In this paper I present findings from a field study describing how sociomaterial work practices emerge among software developers in different geographic locations. Through this field study and the methods I used, I learned that motivation to achieve work-life balance while working on global teams lead to bricolage through multiple media and relational personalization. This study shows that self-emerging communication practices might be the key to successful global development [2,8]. The findings from this study contribute to work emerging in the area of sociomateriality [47] by providing empirical support to the notion that work and materiality are tightly intertwined, especially in organizations that work with information technology, and by outlining the concept of sociomaterial bricolage. In keeping with the aim of this special issue, the field study aspect of this research is noteworthy. The researcher in the field engages in his/her own work practices and often these practices are emergent. Although a well planned study is essential, the ability to adapt to happenings on the field is a highly desirable skill. As noted earlier, in reality field studies of organizations are an attempt to understand the work practices and this can be best achieved through participating in those work practices. This is not always achievable due to resource and time-constraints and therefore the researcher has to use proxies and quick-and-dirty methods. This study also establishes the advantage of different locational perspectives – interviewing and

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observing informants in their own context is crucial to get at locational differences. Location understanding is critical to reach a contextual understanding which is critical to work in global environments [35]. Even a short visit brings a contextual perspective that can shed critical light on the data. Data analysis and data interpretation that takes diverse perspectives into account is essential for developing grounded and interpretive understanding of work practices.

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References

[1] D.J. Armstrong, P. Cole, Managing distance and differences in geographically distributed workgroups, in: P. Hinds, S. Kiesler (Eds.), Distributed Work, MIT Press, Cambridge, MA, 2002, pp. 167–186.
[2] G. Avram, L. Bannon, J. Bowers, A. Sheehan, D. Sullivan, Bridging, patching, and keeping the work flowing: defect resolution in distributed software development, Computer Supported Cooperative Work 18 (2009) 477–507.
[3] T. Baker, R.E. Nelson, Creating something from nothing: resource construction through entrepreneurial bricolage, Administrative Science Quarterly 50 (2005) 329–366.
[4] K. Barad, Posthumanist performativity: toward an understanding of how matter comes to matter, Signs 28 (3) (2003) 801–831.
[5] S. Barley, G. Kunda, Bringing work back in, Organization Science 12 (1) (2001) 76–95.
[6] S. Barley, Technology as an occasion for structuring: evidence from observations of CT scanners and the social order of radiology departments, Administrative Science Quarterly 31 (1) (1986) 78–108.
[7] A. Boden, B. Nett, V. Wulf, Articulation work in small-scale offshore software development projects, in: Proceedings of the 2008 International Workshop on Cooperative and Human Aspects of Software Engineering, CHASE '08, ACM, New York, NY, 2008, pp. 21–24.
[8] A. Boden, B. Nett, V. Wulf. Coordination practice in distributed software development of small enterprises, in: IEEE 2nd International Conference on Global Software Engineering (ICGSE'07), 27–30 August, 2007, Munich, Germany, IEEE Press, S. 235–244.
[9] P. Bourdieu, The Logic of Practice, Polity, Cambridge, 1990.
[10] J.S. Brown, P. Duguid, The Social Life of Information, Harvard Business Press, 2002.
[11] J.S. Brown, P. Duguid, Knowledge and organization: a social-practice perspective, Organization Science 12 (2) (2001) 198–215.
[12] J.S. Brown, P. Duguid, Organizational learning and communities of practice: toward a unified view of working, learning, and innovation, Organization Science 2 (1) (1991) 45–71.
[13] M. Büscher, S. Gill, P. Mogensen, D. Shapiro, Landscapes of practice: bricolage as a method for situated design, Computer Supported Cooperative Work (CSCW) 10 (1) (2001) 1–28.
[14] M. Callon, Some elements of a sociology of translations: domestication of the scallops and the fishermen in St. Brieuc Bay, in: J. Law (Ed.), Power, Action, and Belief: A New Sociology of Knowledge, Routledge, London, 1986.
[15] E. Carmel, R. Agarwal, Tactical approaches for alleviating distance in global software development, IEEE Software 18 (2) (2001) 22–29.
[16] C.D. Cramton, Attribution in distributed work groups, in: P.J. Hinds, S. Kiesler (Eds.), Distributed Work, MIT Press, Cambridge, MA, 2002.
[17] C.D. Cramton, The mutual knowledge problem and its consequences for dispersed collaboration, Organization Science 12 (3) (2001) 346–371.
[18] C.D. Cramton, P. Hinds, Subgroup dynamics in internationally distributed teams: ethnocentrism or cross-national learning?, Research in Organizational Behavior (2005)
[19] K. Crowston et al., Self-organization of teams for free/libre open source software development, Information Software Technology (2007).
[20] R.L. Daft, R.H. Lengel, Organizational information requirements, media richness and structural design, Management Science 32 (5) (1986) 554–571.
[21] R. Daft, K. Weick, Toward a model of organizations as interpretation systems, Academy of Management Review 9 (2) (1984) 284–295.
[22] M. De Certeau, The Practice of Everyday Life, University of California Press, Berkeley, 1984.
[23] A.R. Dennis, S.T. Kinney, Testing media richness theory in the new media: the effects of cues, feedback, and task equivocality, Information Systems Research 9 (3) (1998) 256–274.
[24] Y. Dittrich, M. John, J. Singer, B. Tessem (Eds.), Special Issue on Qualitative Software Engineering Research, Information and Software Technology 49 (2007).
[25] L. Dube, D. Robey, Software stories: three cultural perspectives on the organizational practices of software development, Accounting Management and Information Technologies 9 (4) (1999) 223–259.
[26] J.A. Espinosa, R.E. Kraut, J.F. Lerch, S.A. Slaughter, J.D. Herbsleb, A. Mockus, Shared mental models and coordination in large-scale, distributed software development, in: Presented at Twenty-second International Conference on Information Systems, New Orleans, LA, 2001.
[27] M. Fiol, E. O'Connor, Identification in face-to-face, hybrid, and virtual teams, Organization Science 16 (1) (2005) 9–32.
[28] T. Friedman, The World is Flat: A Brief History of the Twenty-First Century, Farrar Straus and Giroux, 2005.
[29] J.D. Herbsleb, A. Mockus, T.A. Finholt, R.E. Grinter, An empirical study of global software development: distance and speed, in: Proceedings of Computer Supported Cooperative Work, 2000.
[30] P.J. Hinds, D.E. Bailey, Out of sight, out of sync: understanding conflict in distributed teams, Organization Science 14 (6) (2003) 615–632.
[31] P.J. Hinds, M. Mortensen, Understanding conflict in geographically distributed teams: the moderating effects of shared identity, shared context, and spontaneous communication, Organization Science (2005).
[32] P.J. Hinds, S. Kiesler (Eds.), Distributed Work, MIT Press, Cambridge, MA, 2002.
[33] S.L. Jarvenpaa, D.E. Leidner, Communication and trust in global virtual teams, Organization Science 10 (1999) 791–815.
[34] A. Johri, Open organizing: designing sustainable work practices for the engineering workforce, International Journal of Engineering Education 26 (2) (2010) 278–286.
[35] A. Johri, Preparing engineers for a global world: identifying and teaching sensemaking and practice forming strategies, in: Proceedings of 39th ASEE/IEEE Frontiers in Education Conference, San Antonio, TX, 2009, pp. M2D-1–M2D-6.
[36] A. Johri, Boundary spanning knowledge broker: an emerging role in global engineering firms, in: Proceedings of 38th ASEE/IEEE Frontiers in Education Conference, Saratoga Springs, NY, 2008, pp. S2E-7–S2E-12.
[37] J. Krueger, D. Funder, Towards a balanced social psychology: causes consequences and cures for the problem-seeking approach to social behavior and cognition, Behavioral and Brain Sciences 27 (2004) 313–376.
[38] B. Latour, Science in Action, Harvard University Press, Boston, MA, 1987.
[39] C. Levi-Strauss, The Savage Mind, University of Chicago Press, Chicago, 1967.
[40] M. O'Leary, W.J. Orlikowski, J. Yates, Distributed work over the centuries: trust and control in the Hudson's Bay Company, 1670–1826, in: P. Hinds, S. Kiesler (Eds.), Distributed Work, MIT Press, Cambridge, MA, 2002, pp. 27–54.
[41] N. Levina, E. Vaast, The emergence of boundary spanning competence in practice: implications for implementation and use of information systems, MIS Quarterly 29 (2) (2005) 335–363.
[42] J. Lofland, L. Lofland, Analyzing Social Settings, A Guide to Qualitative Observation and Analysis Wadsworth Publishing, 1994.
[43] W.G. Lutters, C.B. Seaman, Revealing actual documentation usage in software maintenance through war stories, Information and Software Technology 49 (6) (2007) 576–587.
[44] A. Majchrzak, R. Rice, A. Malhotra, N. King, S. Ba, Technology adaptation: the case of a computer-supported inter-organizational virtual team, MIS Quarterly 24 (4) (2000) 569–600.
[45] C. Marshall, G. Rossman, Designing Qualitative Research, Sage Publications, 1995.
[46] B. Nardi, Beyond bandwidth: dimensions of connection in interpersonal communication, Computer Supported Cooperative Work 14 (2005) 91–130.
[47] W.J. Orlikowski, S.V. Scott, Sociomateriality: challenging the separation of technology, work and organization, The Academy of Management Annals 2 (1) (2008) 433–474.
[48] J. Orr, Talking About Machines: An Ethnography of a Modern Job, Cornell University Press, Ithaca, NY, 1996.
[49] V. Pipek, V. Wulf, Infrastructuring: Towards an integrated perspective on the design and use of information technology, Journal of the Association of Information Systems (JAIS) 10 (5) (2009) 306–332.
[50] W. Scacchi, The software infrastructure for a distributed software factory, Software Engineering Journal 6 (1991) 355–369.
[51] T.R. Schatzki, K. Knorr-Cetina, E. von Savigny, The Practice Turn in Contemporary Theory, Routledge, London, 2001.
[52] T.R. Schatzki, Introduction: practice theory, in: T.R. Schatzki, K.K. Cetina, E.V. Savigny (Eds.), The Practice Turn in Contemporary Theory, Routledge, New York, 2001, pp. 42–55.
[53] K. Schmidt, I. Wagner, Coordinative artifacts in architectural practice, in: Proceedings of the Fifth International Conference on the Design of Cooperative Systems (COOP), Saint Raphaël, France, 4–7 June, 2002.
[54] U. Schultze, R.J. Boland, Knowledge management technology and the reproduction of knowledge work practices, Journal of Strategic Information Systems 9 (2) (2000) 193–212.
[55] G.R. Semin, E.R. Smith, The interfaces of social psychology with situated and embodied cognition, Cognitive Systems Research 3 (2002) 385–396.
[56] R. Smith, G.R. Semin, Socially situated cognition: cognition in its social context, Advances in Experimental Social Psychology 36 (2004) 53–117.
[57] J.P. Spradley, The Ethnographic Interview, Holt, Rinehard and Winston, New York, 1979.
[58] L. Sproull, S. Kiesler, Connections: New Ways of Working in the Networked Organization, MIT Press, Cambridge MA, 1991.

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[59] A. Strauss, Qualitative Analysis for Social Scientists, Cambridge University Press, 1987.
[60] S.L. Star, K. Ruhleder, Steps towards an ecology of infrastructure: design and access for large information spaces, Information Systems Research (7) (1996) 111–134.
[61] S.L. Star, J.R. Griesemer, Institutional ecology, 'Translations', and boundary objects: amateurs and professionals in Berkeley's museum of vertebrate zoology, 1907–1939, Social Studies of Science 19 (1989) 387–420.
[62] L.A. Suchman, Human–Machine Reconfigurations: Plans and Situated Actions, Cambridge University Press, Cambridge, UK, 2007.
[63] L. Suchman, Organising alignment: a case of bridge-building, Organization 7 (2) (2000) 311–327.
[64] M.B. Watson-Manheim, F. Bélanger, Communication media repertoires: dealing with the multiplicity of media choices, MIS Quarterly 31 (2) (2007) 267–293.
[65] J. Webb, D.T. Campbell, R.D. Schwartz, D.L. Sechrest, Unobtrusive Measures, Sage Publications, 1966.
[66] S.P. Weisband, S.K. Schneider, T. Connolly, Computer-mediated communication and social information: status salience and status awareness, Academy of Management Journal 38 (1995) 1124–1151.
[67] S. Zuboff, In the Age of the Smart Machine: The Future of Work and Power, Basic Books, New York, 1988.

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