Distributed design teams: embedded one-on-one conversations in one-to-many

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Abstract

Engineering design is fundamentally social, requiring a lot of interaction and communication between the people involved. Additionally, good design often relies upon the ability of a cross-functional team to create a shared understanding of the task, the process and the respective roles of its members. The negotiation and bargaining for common ground are essential in the design process. It is important to provide tools and methods so that also geographically distributed design teams are given the opportunity to engage in such social interactions. This paper presents a study of interpersonal communication within the Distributed Team Innovation (DTI) framework; a joint product design project between Luleå University of Technology and Stanford University that investigates the future of collaborative product development. The common object of the work is to design “Virtual Pedals” for Volvo Car Corporation.

In the study, we noticed that one-on-one conversations, held in parallel to a main discussion, were common in co-located teamwork and that they are a natural part of creative teamwork. These conversations were mainly used to clarify things and to discuss vague ideas or personal disagreements. Additionally, they were often used instead of, or as a precursor to, bringing up a topic with the whole group.

In distributed meetings side conversations were discouraged and current systems for distributed collaboration could not provide sufficient support for these subtle interactions. This has important implications for supporting and improving the performance of global teams, and it suggests that the one-to-many channel of today's video conferencing technology is severely limiting.

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Introduction

Engineering design is not a purely technical activity; it is also a highly social process. Technical artefacts are ultimately designed for human needs and purposes, and the design activities involve intense communication and interaction between individuals and groups in complex social settings. Social activity can not be separated from technical results - they are intertwined in the "*…meetings that produce the specifications; the discussions around rough calculations and sketches that create understandings among the participants; the arguments about interpreting test results and prototype qualities that contribute to 'feel' and 'intuition' about aspects of the design; and the debates about whether the design is 'done', if the specifications have been 'met', and if the result is 'good'…*" (Minneman 1991: 63).

Interpersonal communication is the basis for innovation, since these interactions provide for the creation of shared understanding – the starting point from which initial concepts can be further developed into well-designed artefacts. In face-to-face settings, interpersonal communication is a truly interactive process of making sense of each other and the world – a moment-to-moment search for common ground that has been hard to replicate in geographically distributed settings. However, in the light of increasing globalization, it is of great importance to be able to support geographically distributed teams by giving them the opportunity to uncover and utilize the collective knowledge, creativity and meaning that spring from the multifaceted, situated and social interactions that are characteristic of successful design.

In order to make suggestions about the design of computer support for collaborative engineering work, it is critical to first examine the social and interactional dimensions of work. The understanding derived from observations of engineering work practice can then be used to inform the design of appropriate technology.

The object of our research is a joint product development effort between Luleå University of Technology, Stanford University and Volvo Car Corporation. The distributed design team consists of four students from the ME310 course at Stanford and four students from the SIRIUS course at Luleå. The goal of the project is to design "Virtual Pedals", taking into account the fact that the need for mechanical connections between pedals and actuators has disappeared with the introduction of "drive-by-wire" technology.

Our study of co-located and distributed teamwork in this project showed that the design team lost a powerful aspect of co-located teamwork when moving into distributed collaboration. The more or less chaotic, but still effortless, ways in which they interacted locally were almost invisible in the distributed setting. The sense-making process, the collective search for shared understanding, and the subtle interactions that characterized their co-located efforts were in many regards reduced to a formal, rigid process where team members stopped "thinking together" and instead started "explaining to each other". This paper aims to highlight the occurrence and importance of embedded one-on-one conversations in the context of one-to-many settings, and the implications this has for supporting and improving the performance of global teams.

The social dimension of teamwork

Informal communication

In everyday work, informal communication surrounds us in the shape of unplanned, spur-of-the-moment interactions (Root 1998; Fish, Kraut, Root and Rice 1992; Kraut, Fish, Root and Chalfonte 1993; Kraut, Egido and Galegher 1990). Informal communication is interactive in the sense that it depends on the highly unpredictable character of each situation. Agendas or plans are only to be seen as resources for situated action (Suchman 1987), since we always need to respond to the particulars of an event in order to "make things work". The improvisational aspects of communication are easily recognized as natural parts of the everyday work environment. A colleague might ask for your opinion on a design change as you read the newspaper in the lunch room; you get an economical briefing while you wait for a printout; you decide a meeting time with your boss as he happens to walk by your door; you give your new phone number to a business associate as you bump into him in the hallway on your way to a meeting. This kind of casual, everyday interaction is vital to successful co-located collaboration, since you rapidly and continually can seize opportunities to exchange information, monitor progress, and learn about what others are doing (Kraut et al. 1990).

Socially natural groupware

Informal communication, as most social interaction, is "unremarkable" by nature. We adapt to situations as we face them, and we do not become overly amazed or confused by the many different situations we end up in. In face-to-face settings we are very sensitive to the actions and interactions of others, and if anything, it is remarkable how radically things change when we move from the ordinary world into the digital world. Much of our knowledge about people, our sensitivity to their interactions, our ability to improvise in changing situations, is neglected. In the world of computer systems, we are "socially blind" (Erickson and Kellogg 2000).

Undoubtedly, technology is functional in the sense that we have access to text chat, digital voice and video, and shared applications when working in geographically distributed settings. However, in use these systems are far from natural tools that efficiently and smoothly facilitate our work. In this respect, groupware is not "socially natural". (Greenberg and Gutwin 1998) It seems that many of the difficulties with today's technology have more to do with the assumptions that inform system design, than the current limitations of technology. (Heath, Luff and Sellen 1995). A static and inflexible conception of collaborative activity has prevented the evolution of useful environments where people can work and socialize with each other in a socially natural way (Heath et al. 1995).

Method

The research upon which we base this paper was carried out during six months of the seven-month DTI project. Our initial aim was to provide the distributed team with supporting technology that would enable team members to interact and communicate using different modalities. It is important to note that team members were not "forced" to use a particular technology for a particular purpose. Rather, we wanted to provide them with several alternatives, so that they themselves could choose the tools that they found suitable in every situation. Thus, the goal was to study communication as it was played out in a real-world product development activity. Drawing from the concept of ethnomethodology (Dourish and Button 1998), we felt it important to try to understand things in the context in which they occur, without making assumptions about what modes of communication could be useful for successful collaboration. The study was performed using ethnographic methods such as observations, field notes and videotaping. (Blomberg, Giacomi, Mosher and Swenton-Wall 1993) Apart from our intentions to strive for an "inside perspective", ethnographic methods were also suitable since the structure of groups and communication is continually changing. As Gale (1990) points out, *"the effects of technology on a group may take weeks, months, or even years*

before becoming apparent. These sorts of effects cannot be fully explored in a one hour experiment".

Several modes of communication were observed during the study, such as co-located teamwork, telephone conferences, and videoconferences of different quality. Observations of co-located teamwork were carried out during a total of three weeks, while the Stanford team and the Luleå team were meeting face-to-face (two weeks at Stanford and one week in Luleå). Both synchronous and asynchronous distributed collaboration was observed continually throughout the study, even though this paper is focused on side conversations occurring in synchronous collaboration.

It is worth mentioning that the distributed team, during the course of our study, got the opportunity to meet using SMILE! (Johanson 2002), a high-quality videoconferencing system. Equipped with wireless microphones, team members were free to walk around in their team rooms while still communicating with very high audio and video quality. These meetings were mostly very informal, and local side conversations were accepted to a greater extent, compared to other videoconferences and telephone conferences. However, despite the high-quality communication channel that the videoconferencing system provided there are still issues that remain to be solved.
Embedded one-on-one conversations: a hidden potential for distributed design teams?
As noted above, we had the possibility to observe the design team in many different types of synchronous collaboration. The goal is not to make an extensive comparison between these different modes of communication, but rather to share our understanding of the role of side conversations in co-located design, and to emphasize that the potential of such conversations remains unutilized when moving into distributed collaboration.

Parallel conversation

The first example of embedded one-on-one conversations in the context of a group discussion concerns the way in which team members in a co-located, face-to-face setting are able to attend to a main discussion, while occasionally entering into parallel, more or less private conversations with a fellow team member. In the fieldnote excerpt below, the Luleå team and the Stanford team are having a face-to-face discussion about virtual pedal concepts during the Luleå team's visit to Stanford.

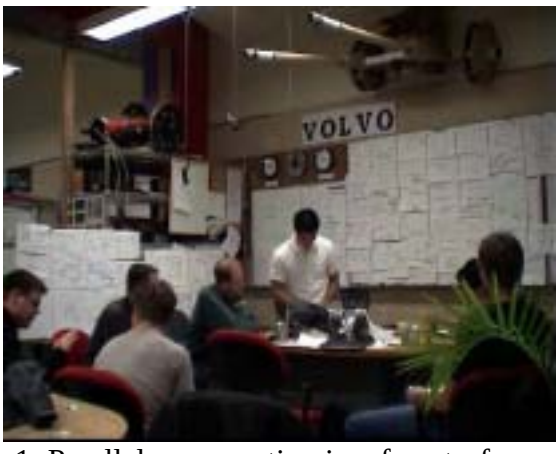

Figure 1: Parallel conversation in a face-to-face setting.

Fieldnote excerpt #1 – Parallel conversation in a face-to-face setting:
…MB (Luleå) is describing a pedal concept. He gestures to emphasize his point, but JW (Stanford) uses the video game pedals on the table to clarify that he has understood MB correctly. SS (Stanford) and BC (Stanford) join in on the conversation and ask MB questions about his concept idea. MP (Luleå) seems eager to speak on the subject and requests the word by standing up, raising

his arm and snapping his fingers. He gets the word explicitly from JP (Stanford), and goes over to the notice board to elaborate. However, MB and JW continue their conversation even though MP is now officially "in charge" of the main discussion. The other members pay attention to MP's discussion … As soon as MB and JW are ready with their side conversation they return to the main discussion...

This example points to an aspect of communication that is natural in co-located settings. During the course of our study, we observed that team members devote most of their attention to the main discussion, but that they also engage in occasional parallel conversations when they feel the need to discuss a matter with someone without interfering explicitly with the main discussion. In this situation, MB was actually hosting the main discussion from the beginning. However, as MP took over the initiative, MB and JW continued to have a conversation in parallel with the main discussion for several minutes.

Although such extended parallel conversations often can be considered impolite and disturbing, that was not a problem in the co-located discussions of this project. On the contrary, parallel conversations of this type were sometimes transformed into a main discussion. The other team members overheard parts of the parallel conversations and found opportunities to take an active part in the discussion, thus gradually bringing it to a main discussion. Few parallel conversations did actually interfere with the agenda; rather they added a creative dimension to the inherent formality of the agenda. Undoubtedly, there are suitable and less suitable times for such parallel conversations, but in the face-to-face sessions that we have observed, team members have had no difficulties making smooth and non-disturbing transitions between a main discussion and parallel conversations.

When working together in a distributed setting, parallel conversations were not as naturally intertwined in the discussions. In telephone conferences, they were very disturbing and team members refrained from having side conversations since they almost always introduced a visible "breakdown" in the communication. Even in high-quality videoconferencing, side conversations were sometimes problematic, as exemplified in the fieldnote excerpt below where attempts to have local side conversations at the Stanford site were considered disruptive.

Figure 2: Parallel conversation in a distributed setting.

Fieldnote excerpt #2 – Parallel conversation in a distributed setting:
…JW (Stanford) is talking to NG, MP and MB (Luleå) over the videoconference. TP, JP, and SS (Stanford) start having a local side conversation. JW is disturbed by continues to talk for a while, before he decides to wait for TP, JP, SS to join the discussion. "OK, I got to wait for these guys…"

… BC (Stanford) leaves her chair and starts a local side conversation at Stanford. JW is disturbed and decides to wait for the others to finish. "Hold on one second…" … "I'm sorry, we're not trying to have separate conversations here…"Why don't we all just focus on having one conversation here, OK?"…

The observations briefly described above point out that although current communication technologies provide improved possibilities for global collaboration, the nature of teamwork shifts with the introduction of such technologies. Change is not always bad, but in the light of creative teamwork, extra formality and rigidity should not be introduced without special consideration.

Instant feedback

In addition to extended parallel conversations in face-to-face settings, we have also observed brief side conversations that are even less intrusive, and which also seem to serve a valuable purpose in design collaboration by enabling instant feedback. Among other things, these brief interactions provide a channel for instant feedback and they thereby promote a quick and iterative process for negotiation of shared understanding. A brief side conversation can be all that is needed to make sure that shared understanding has been reached, as exemplified in the fieldnote excerpt below.

Figure 3: Instant feedback in a face-to-face setting.

Fieldnote excerpt #3 – Instant feedback in a face-to-face setting:
…JP and JL are talking about JL:s concept. MP and NG join the discussion. They take quick turns when talking. MB is working separately, putting up another concept sketch on the wall. MP elaborates on another concept together with JP. On her way back to her seat, JL is having a very brief side conversation with MB. They clarify that they agree on the understanding of the concept …

In this situation, there was a rather obvious informality about the collaboration. Basically, it was a very open discussion about the different concepts that team members come up with. The turn-taking flowed very smoothly, and in contrast to the parallel conversation in fieldnote excerpt #1, there was no one "in charge" of the discussion. The communication was very subtle and nuanced, in the sense that the situation lacked in formality. In a way, it was a chaotic conversation, with team members talking more or less at the same time, in an unplanned, spur-of-the-moment style. If something was unclear or confusing, it was possible to get instant feedback without waiting for "your turn". It is an example of an iterative mode of communication, which enables team members to find common ground through a rapid exchange of perspectives, thoughts, and ideas. Also, such brief conversations let team members discuss vague or crazy ideas that they might not want to discuss with the whole group before consulting a colleague first.

Another type of instant feedback conversation was based on the fact that the Swedish team members were not as fluent in the English language as their American colleagues. This often resulted in brief conversations between two of the Swedish members, trying to make sense of a particular detail of the discussion. “What did he mean by that?” “What is the meaning of that word?” Such brief interactions were undoubtedly crucial for a common understanding.

In our study, this type of instant feedback has been almost non-existent in the distributed settings. Informal, brief conversations and quick-fire responses were replaced by rather formal and extensive turns of speech where team members ask each other questions, and mostly receive elaborate answers. Distributed collaboration was characterized by team members “explaining to each other”, but in a global, cross-cultural product development project, the real creative power might very well lie in the ability of distributed design teams to “think together”.

Discussion

On a general note, the addition of video in distributed collaboration has provided visual cues that help us make valid interpretations of each other’s actions in distributed settings. For example, the visual channel has proven to be useful for interpreting the meaning of pauses in conversation, something that often must be explained in audio-only conversations (Isaacs and Tang 1994). The visual monitoring of remote activities makes it easier to make sense of not only speech, but also of body language and facial expressions. It has been suggested that remote collaborators are likely to have fewer misunderstandings and more effective interactions if they have the ability to communicate richer information more easily (Isaacs and Tang 1994).

However, even today’s advanced videoconferencing systems have not yet been able to recreate the “information richness” that we are used to in face-to-face interactions (Hollan and Stornetta 1992). The physical closeness of people at the same videoconference site tend to make them more aware of their physical neighbours than of their video neighbours, and it is common to address people in the same physical room rather than people at the remote site (Mantei, Baecker, Sellen, Buxton, Milligan and Wellman 1991). Among other things, this means that current possibilities to engage in private conversations within a public discussion is reserved for people in the same physical location.

It has been observed that such private conversations are difficult in videoconferencing, much because people cannot address particular participants and because everyone uses the same audio channel (Isaacs and Tang 1994). In face-to-face interactions it is possible to “open” a second audio channel, and the visual cues enable the other participants to understand who is participating in which conversation when (Isaacs and Tang 1994). In videoconferencing, private conversations are often discouraged, but if they do occur, the other participants tend to wait for the conversation to become more general (Ruhleder and Jordan 2001). In contrast, Isaacs’ observations of a face-to-face meeting with five persons highlighted that the conversation occasionally broke into two parallel conversations and then seamlessly transitioned back to a single conversation (Isaacs and Tang 1994).

Parallel communication can promote broader input and reduce the risk of a few people dominating a meeting (Nunamaker, Dennis, Valacich, Vogel and George 1991), but even in face-to-face settings, side conversations can be seen as disruptive. Even if participants step outside the meeting room, everyone knows who is involved and may even be able to make sense of what they are talking about (Ruhleder and Jordan 2001). In face-to-face meetings, side conversations, note passing, and body language is visible to other participants, and although they are generally discouraged, they may also be integral, very important parts of the overall event (Ruhleder and Jordan 2001).

Our findings have shown that we need to be careful to dismiss side conversations as disruptive elements only. We imply that side conversations are of great importance for the creative stage in product development. Parallel conversations were very common in creative sessions, such as a brainstorm, but were less common in administrative meetings, such as a budget discussion. Maybe the potential of side conversations in distributed collaboration has been lost because the majority of such meetings are characterized by formality and rigidity?

Side conversations are vital in creating a common understanding between team members, and they enable a "chaotic", but efficient, way of working on several ideas at the same time without forcing all team members to work on the same task. Also, these side conversations provide opportunities to explore vague ideas and alternative paths in a quick, informal and iterative way.

A fundamental aspect that must not be forgotten when it comes to distributed collaboration is that the different types of side conversations must be supported in a way that enables cross-site interaction. Even though high-quality videoconferencing makes local side conversations visible and understandable, it is almost impossible to have such side conversations with a remote team member. Hence, it is also difficult to fully utilize the creative power of a global, culturally diverse, design team.

In a co-located brainstorm people are "thinking together" by using fragments of other's ideas, gestures and drawings to create new ideas. This way of working is difficult to achieve in a distributed setting, due to the fact that many of the subtle informal communication channels are lost, and because much of the time is concentrated on making rather formal explanations to each other. When comparing co-located and distributed teamwork activities, it was evident that issues that were considered trivial in a face-to-face setting could turn out to be a major challenge in a distributed setting. For example, one of the team members pointed out the striking fact that they had *"spent two and a half hours in a videoconference, trying to explain to the other team what they had agreed on locally in about five minutes before the meeting started"*.

Shared understanding can sometimes be hard to achieve, since it relies on many different elements of human communication. Fundamentally, our findings suggest that the ability to engage in cross-site side conversations could add an extra dimension to distributed collaboration.

Conclusion and future work

By studying a design team working together over a period of six months, we had the possibility to see how team members communicated in both co-located and distributed settings, and especially how the tools they used for distributed collaboration influenced their teamwork.

In the study, we noticed that one-on-one conversations, held in parallel to a main discussion, were common in co-located teamwork and that they served as a natural part of creative teamwork. These side conversations were usually "private" conversations between two members, in the context of a larger meeting, and they were often used to clarify things and to discuss vague ideas or personal disagreements. In addition they were used instead of, or as a precursor to, bringing up a topic with the whole group, and seem to be very useful to promote shared understanding without having to interfere explicitly with the main discussion.

Future work includes an effort to bring the findings of this paper into the design of appropriate technology, which can better support cross-site side conversations. A starting point could be to introduce instant messaging functionality and parallel audio channels as a complement to the visual channel.

Acknowledgements

Support for this research is provided by the Polhem Laboratory at Luleå University of Technology, the Center for Design Research at Stanford University, and the Stanford Learning Lab. The Distributed Team Innovation project is funded by Volvo Car Corporation and Volvo Aero Corporation. Special thanks to the students in the DTI project.

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