Abstract
Successful teamwork in geographically distributed teams is highly dependent on tools that support informal communication, such as opportunistic and spontaneous interaction. Such informal communication is responsible for much of the information flow in an organization. This paper presents how informal communication was supported in the Distributed Team Innovation project, a joint product development effort between Luleå University of Technology, Stanford University and Volvo Car Corporation. A web-based Contact Portal was created in order to support informal communication and information sharing in a distributed engineering design team. The Contact Portal has been a valuable asset in the project, primarily because it combines several information channels; e-mail archives, awareness cameras, diaries, instant messaging, and SMS etcetera in one place. The Contact Portal was a natural starting point for initiating and maintaining contact with remote team members. The small window of opportunity made it difficult to continuously plan and hold formal meetings (videoconferences and telephone conferences), so the opportunistic interactions have been an important part of the information sharing in the project.

Keywords: Distributed engineering, Informal communication, Awareness

1 INTRODUCTION
Engineering design is fundamentally a socio-technical activity; not only because technical artefacts ultimately are designed for human needs and purposes, but primarily because design activities involve immense communication and interaction between individuals and groups in more or less complex social settings. Social activity can not be separated from the 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’….’[1].

Design usually proceeds by the production and use of formal structures, such as requirements documents, concept evaluation methods, and review meetings. These structures are by definition formal, but nevertheless socially constructed by creators and participants. However, there are also aspects of design that goes beyond the formality of prescribed product development processes. The highly informal, accidental, spontaneous communication that characterizes everyday work has an impact on design that sometimes is even greater than that of formal communication [2]. The ability to share information and resolve problems in a quick and unplanned way is considered a key aspect of successful communication within organizations [3,4,5].

As product development teams tend to become globalised, there is a growing interest in providing these distributed teams with a sense of proximity and ‘togetherness’ that co-located teams are used to [6]. Different locations and time zones complicate communication and decrease the opportunities for informal encounters. While many systems for distributed collaborative work have focused on extended, formal meetings using videoconference technology [7], there is still an urgent need for technology that supports brief, informal, unplanned and lightweight interaction [8].

The object of the research is the Distributed Team Innovation (DTI) project, 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.

Previous research within Distributed Engineering at the Division of Computer Aided Design has focused on the synchronous collaboration with broadband videoconferencing and distributed Virtual Reality. [9] This paper aims to acknowledge the importance of informal communication in distributed engineering design collaboration. We describe the findings of the DTI project in relation to previous research and use this knowledge in the participatory design of a Contact Portal that supports the distributed teams in their search for common ground.

2 RELATED WORK
In order to set the stage for the research, it is important that we expand on the concepts of informal communication and awareness, their significance for successful group collaboration, and the numerous ways in which these concepts have guided the design of computer support for collaborative work (CSCW).

2.1 Informal communication
In everyday work, informal communication is omnipresent. It is easy to notice the spur-of-the-moment, unplanned interactions that occur in the midst of our daily work activities [3,4,5,10]. Informal communication is interactive in the sense that it relies on the highly unpredictable character of each situation. No matter how hard you try to stick to agendas or plans, these should merely be seen as resources for situated action [11],
since you always need to respond to the particulars of an event in order to 'make things work'.

The improvisational aspects of communication can be recognized in a myriad of interactions in the work environment. A colleague might ask you for a quick advice as you pour your coffee 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 exchange information, monitor progress, and learn about what others are doing [10].

Kraut et al. [5] divided informal communication into four categories, based on the degree of preplanning:

1. Scheduled: Conversations that are scheduled in advance by both parties.
2. Intended: Conversations that are not planned in advance, but sought out by one party.
3. Opportunistic: Conversations that are anticipated by one party, but occurring by chance.
4. Spontaneous: Conversations that are unanticipated by either party.

When working in a co-located organization, there are many possibilities for informal communication, and issues can be discussed and resolved spontaneously rather than waiting for a suitable, and scheduled, time to make a formal decision [12]. Also, co-located groups can communicate with each other more frequently and intermittently, which further decreases the formality of communication by minimizing the need for formal openings and closings [13].

Another feature of informal interactions is that they are brief. In a study of informal workplace communication, Whittaker et al. [14] found that 50% of opportunistic face-to-face interactions lasted less than 38 seconds, and that they lasted only 1.89 minutes on average. The cycle of communication is fast; problems are dealt with as they come up, and information is exchanged as a natural, effortless and integral part of everyday work. Fundamentally, the iterative style of informal communication enables people to reach well-founded decisions and find common ground more rapidly than through conventional meeting structures.

As industry is cutting lead times, a concurrent product development process is enabling companies to speed up time-to-market, while still increasing quality. They are able to reach the right decisions quickly, and more importantly, they are able to correct mistakes rapidly because of the iterative, nonsequential process that is similar to that of successful workplace communication. However, the informality of the local workplace has not yet made its way into the distributed workplace of global engineering design teams.

The telephone is still the most commonly used tool for remote opportunistic interaction, much because of its intuitiveness. However, since there is no way of knowing in advance if the recipient is available to accept the call, informal telephone communication is not as straightforward as face-to-face conversation. Research on business phone calls has shown that between 60% and 70% of the phone calls do not reach the intended recipient [4,6,14,15]. In order to make use of the powers of informal communication, it is critical that participants achieve a sense of co-presence so that they can become aware of one another and interact easily and effortlessly throughout the course of their work. [7]

2.2 Presence and awareness

Co-presence in the local workplace facilitates impromptu interactions between colleagues, and the concepts of presence and awareness relate to the ways in which we become aware of other’s whereabouts and activities as we walk around in our work environment, overhear conversations in the hallway, or glance into the room of a colleague [16]. Presence and awareness is experienced through the informal, everyday interactions between people that work in the same physical space – a general sense of who is around and what they are doing [17]. This understanding of other’s activities enables you to set the context for your own activities, goals and motivations [18,19].

A common problem with distributed teamwork is that team members have difficulties coordinating meetings. Knowing when to reach someone, an awareness of availability, is a crucial aspect of distributed collaboration. Another problem is that it is hard to know what others are doing in a project where the members are geographically separated. Extra effort is needed to keep each other updated and ‘on the same page’, and an awareness of activity, or work, must be continuously maintained. Also, since distributed team members often have different deadlines and requirements, it is very important that everyone has a good understanding of where in the project they are - awareness about process [20].

Fundamentally, awareness of others facilitates communication and collaboration with others, and thus it is certainly a basis for engaging in social and collaborative activities [21]. However, achieving a sense of presence and awareness in distributed teams is not easy. Apart from the barriers of geographic distance, ‘physical remoteness’, and different cultures, there are also differing travel schedules, holidays and work hours to think about. In addition to that, time zone differences make delays in communication, more or less, an inherent feature of global collaboration. [22]

Informal communication in local workplace settings is often preceded by ‘sightings’ [4,5]: you see a colleague walk past your door, and you remember the budget proposal you wanted to discuss with him; you notice a co-worker putting on her jacket, and you decide to take the opportunity to brief her about an important e-mail before she leaves for the day. Opportunistic communication is very much about finding a good time to interact, and as we continuously scan our environment, glance into other’s offices etcetera; we are able to establish these connections easily and rapidly. This is the essence of ‘lightweight’ communication and it needs to be supported in the technology that is intended to facilitate distributed collaborative work.

2.3 Enabling technology

Traditional ‘heavyweight’ groupware with high quality audio and video is not ideal when it comes to enabling informal communication. Such systems require the user to start up specific software applications (which first of all have to be installed on the computer), and then go through a login procedure to connect to the remote site, etcetera. Hence, systems used for informal communication are mainly based on lightweight technologies, such as web cameras and instant messaging applications.

Awareness

Enabling technologies for group awareness can be based on iconic representation of people, digital images or live video. One of the benefits of using a video channel is to convey non-verbal cues from gestures and body language.
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‘Peepholes’ [23] is a low cost community technology, which uses iconic presence indicators to represent the activities of the users. Technologies that use video can be based on images that are grabbed from video cameras [23], or on live video feeds used to create a shared community with members located all over the world. Technologies such as CRUISER [18], Montage [6] and Piazza [24], contains a ‘glance’ feature, which resembles the ways in which co-located team members take a quick look into an office as they walk by. Vic [25] and mStar/Marratech [26,27,28] are functioning as electronic corridors where users easily can become aware of each other and initiate spontaneous communication.

The above projects are all proprietary software, based on several conferencing standards. Greenberg [29] proposed a lightweight solution with low-end web cameras with a web interface to create a similar solution. Another approach, WebSmile [30], tries to combine both high quality videoconferencing (with proprietary software) and a web-based interface.

In this paper we present a web-based solution for informal communication, to be used as a complement to the high-end conferencing systems more suitable for formal communication.

**Instant messaging (IM)**

Instant Messaging (IM) technologies are used to notify users of the online presence of persons on their contact list. These systems enable users to, among other things; send instant messages, share files, and chat. Well known IM technologies are ICQ [31], AOL IM (AIM) [32], and Yahoo! Messenger [33], which are used by millions of users today (ICQ currently claims to have 128 million users).

'It is interesting that a lightweight technology consisting of no more than typing text into a window succeeds in providing enough context to make a variety of social exchanges vivid, pleasurable, capable of conveying humor and emotional nuance.’ [34]

Instant messaging encourages informal expression [34, 35,36], since people tend to be less careful about their spelling and grammar, when compared to e-mail communication. Normally, instant messages will not be printed, forwarded or cited. You are also free to exchange unfinished, ‘crazy’ ideas, similar to the way you discuss in a co–located brainstorm. IM is often used within a community (a small group of people that you know well or are planning to get to know well), so detailed explanations of background or formal presentations are unnecessary.

**Mobile solutions**

There are few true mobile solutions for global presence and awareness. Most of the systems support multiple fixed locations, and the mobile systems are mainly designed for local mobility, such as the Hummingbird [37] and the Proxy Lady [38] systems, which support peripheral and proximity awareness by scanning the surroundings (> 100 meters) for similar devices.

The main problem with true mobility is that the awareness systems demand a constant network connection, such as GPRS or other wireless network solutions. Hubbu [39] a mobile instant messenger relies on the Minstrel modem, which is not commonly available in Europe.

3 METHOD

The research described above influenced the initial design of the DTI project site, but since the distributed team consisted of relatively few members, there was also a great opportunity to further adapt these general research concepts in close collaboration with the users. Rather than seeing users as passive sources of information, techniques for Participatory Design [40] have been used to actively involve users in the system design. Ethnographic techniques [41], such as observations, video and tape recordings, informal interviews and field notes have also been used to gain a better understanding of the work activities that the system is supposed to support. The qualitative approach was combined with quantitative data derived from system log files. During the course of the project, the system was continuously improved in an iterative design process.

4 DESIGN AND IMPLEMENTATION

The distributed team of students were mainly working together from the Distributed Team Room (DTR) at Luleå and the Loft at Stanford. These collaborative environments are equipped with tools suitable for synchronous collaboration, including a conference telephone, the Smile! [42] broadband videoconferencing system, wireless headset microphones for high quality audio transmission, and the eBeam [43] electronic whiteboard system for creative brainstorming and joint activities involving drawings or notes.

Although these technologies are very valuable and useful for different types of synchronous collaborative tasks, they are far from sufficient substitutes when it comes to supporting the informal aspects of face-to-face interactions. The time/location matrix (Figure 1) often used in the area of CSCW does not represent the ways in which people collaborate in practice. In reality, people do not keep to one type or style of collaboration. They continually and effortlessly move across time, place, and formality. However, many technologies for collaborative work are developed only to fit the situations and activities implied by a single cell in the time/location matrix. [16]

<table>
<thead>
<tr>
<th>Same time</th>
<th>Different times</th>
</tr>
</thead>
<tbody>
<tr>
<td>Same place</td>
<td>Asynchronous</td>
</tr>
<tr>
<td></td>
<td>(project scheduling, coordination tools)</td>
</tr>
</tbody>
</table>

**Different times**

| Distributed synchronous (shared editors, video windows) | Distributed asynchronous (e-mail, bulletin boards) |

Figure 1: Time/location matrix.

In the context of informal communication, this calls for a heterogeneous approach to CSCW systems. It is becoming increasingly recognised that CSCW systems should be combinations of different systems rather than monolithic applications [44]. Hence, the system developed in the DTI project is designed in the form of a web-based portal, where information from several sources is combined and presented in one place to facilitate quick informal interaction between team members.

4.1 Contact Portal

A web-based Contact Portal was implemented using Windows2000 Server, Active Server Pages (ASP), and Microsoft Access. The Contact Portal combines information from different sources, such as: awareness information from web cameras at Stanford and Luleå; presence and location awareness from ICQ; instant messaging functionality from ICQ; and a Short Message Service (SMS) for instant messaging to mobile phones. The Contact Portal also has links to a shared document
server, a shared multimedia archive, a diary archive, a to-do list, and related e-mail archives.

One of the major advantages of using a web-based approach is that people do not have to be present in the, usually few, rooms that are equipped with technology for videoconferencing and other synchronous interactions. All that is needed is a web browser and a connection to the Internet, and there is no need to download and install plug-ins or other software. The system can also be used in heterogeneous environments with different computer platforms, such as Unix workstations, Windows computers and Personal Digital Assistants (PDA). In the following sections, we briefly introduce the components of the web-based system for informal communication.

**Awareness cameras**

With the aim to enhance the sense of working in a shared physical environment, continuously open video links [45] were integrated into the Contact Portal. Above all, it was important that team members could become aware of the activities in the two project rooms, without having to use specific applications for videoconferencing. By incorporating visual awareness information in the web page, the teams only needed a quick glance to know if, or when, it was a suitable time to initiate interaction.

Four standard USB cameras, two at Luleå and two at Stanford, were used (connected to Win2000 machines) together with one dedicated network camera (AXIS 2100) [46], which unlike the USB camera includes a built-in web server and connects directly to a network as a standalone unit. Also, a VIP (Virtually-In-Person) camera was used to monitor activities at Stanford.

**Instant Messaging (IM)**

The web-based version of ICQ, which contains an awareness representation feature (a green flower icon if the user is online and a red icon if the user is offline), was implemented on the web page. For example, a person working in the Loft could easily see if someone from the Luleå team was online in the Distributed Team Room, and an ICQ session could be quickly initiated by clicking on the icon. Also, since every team member had a separate ICQ identity, it was easy to find out if someone was online from home, or from any other space connected to the Internet.

**Diaries**

In order to further facilitate informal information sharing between team members, a diary feature was implemented, which lets the team members write more or less informal notes about their activities. The idea was to enable members to easily share information about their own work activities and track the progress of other’s work. After a form was filled out on the web page, the diary entry was added to the database and automatically logged with a timestamp. The students could then read the diaries on the website whenever it suited them, and by reading previous entries they could easily see how the project has progressed over time. Another reason for using these informal diaries was, as noted earlier in this paper, that we wanted to provide team members with a feature that enabled informal expression, without putting too much effort into spelling, grammar, or formal introductions [34,35,36]. Also, the user did not need to care about document formatting, since the diaries were formatted dynamically when requested from the web server.

**Short Message Service (SMS)**

Due to the availability and use of mobile phones in Sweden, such technology is becoming increasingly ubiquitous, meaning that it is a kind of ‘personal technology’ that people bring with them without considering it as an extra effort (compared to PDA’s and laptops that you usually do not take with you if you are going for a quick coffee break).
As a complement to e-mail and IM, a Short Message Service (SMS) was used as a tool for meeting initiation and informal communication. A key reason for implementing the SMS feature was the immediacy of the message delivery. As with IM, SMS are sent without delay, and they also have the added benefit that people bring the terminal with them at all times. SMS can therefore be sent 24 hours a day, regardless of where the recipient is located. Messages can be sent without interrupting the recipient, and if a message arrives at an inconvenient time, recipients can ignore it until they are ready to converse. If the recipient is sleeping and has turned off the phone, the message will be delivered as soon as they wake up and turn on the phone.

Furthermore, SMS enables users to leave stickup notes if synchronous communication is not possible at the moment, which is considered a useful feature in the event of a failed attempt to initiate communication [47]. The diary, ICQ, and SMS functions give you a possibility to leave a message in a way which resembles the ways in which you leave messages through a third person in face-to-face interaction [7]. Also, when people work in the same room, they can work asynchronously just by leaving things in a prominent place in a room [7,16].

4.2 Mobility

The system supports multiple fixed locations (the students at home, in the lab or at the concept lab). However, since both the Luleå and the Stanford campuses have wireless network (IEEE 802.11b) infrastructures, a student could be available using a PDA or a laptop with a wireless connection. To achieve a true mobile solution, the use of SMS on the GSM mobile phone network was used.

SMS services are also available via IM services such as ICQ, but due to the reliability of these services a commercial service was chosen. With this approach SMS could be sent to individuals or groups, and all messages were also logged in an archive.

By using the web-based approach, the same content could be presented in different ways depending on the user’s computer type and screen size. The original Contact Portal in Figure 2 corresponds to the Pocket PC version shown in Figure 3 and Figure 4. The portable devices used in Luleå were a laptop and a Compaq iPAQ, both equipped with WaveLAN.

5 RESULTS

The collected data, qualitative as quantitative, was analysed in order to find out how the different communication channels have been used throughout the DTI project. Previous research created a frame of reference that was used when analysing the flow of informal communication.

5.1 Awareness cameras

Through participant observation and videotaping, the usage of the awareness cameras was studied in a qualitative way. The main advantage with the cameras was the possibility to glance into the remote project room. Is anyone there? Are they busy? Our findings show that the team members did not waste time on unnecessary phone calls, or instant messages, if they already were certain that no one was going to answer.

Another interesting use of the awareness camera was when team members used them as a way to confirm that their remote colleagues correctly interpreted the meaning of their written messages and verbal utterances.

One example is from a rather tense situation, where one team was not sure if the other team was dissatisfied or annoyed about something. The teams were communicating via instant messages, but they had difficulties ‘reading between the lines’. The team was in need of positive feedback on an intended joke, and they monitored the recipient through the awareness camera. When they noticed that their remote team member laughed at their joke, the ‘ice was broken’ and the following communication flowed more easily. By combining the written or spoken word with non-verbal cues from the awareness cameras, it was easier to reach a shared understanding without being too explicit and formal.

5.2 Instant Messaging (IM)

All instant messages were logged, and categorized into five different types; project work, awareness, media switching and parallel conversation, meeting coordination, and other unspecified messages. The majority of the messaging sessions started with a negotiation of availability (e.g. ‘Are you free now?’) so those messages were incorporated into the awareness category.
The normal use for IM is to use an account per person, but in this project group identification was used because the students always worked on the same computers (e.g. ‘Luleå–desktop’ and ‘Luleå–laptop’) in their respective project room. However, they used individual accounts when they were using the system from home. The messages to and from one account were logged. From October 2001, to March 2002, 1129 instant messages (in 161 sessions) were sent to or from the Luleå-desktop account.

Figure 5: Total number of IM sent and received on one account (the desktop computer in the Luleå team room).

One notable moment is the use of IM between December 5th and December 6th when 130 messages were exchanged. This was due to an important deadline where a lot of coordination needed to be done before the presentation. In this case, several communication channels were used in parallel, since a telephone conference or videoconference only could support one conversation at a time. Due to time constraints, team members needed to discuss multiple issues at the same time. Thus, side conversations between remote team members had to be done via some other media. Between mid December and end of January very few messages were sent due to holidays and the Luleå team’s visit to Stanford in January.

The IM was categorized and grouped into five different types of messages:
1. Project work, 53%.
2. Awareness (casual conversation and negotiation of availability), 20%.
3. Media switching and parallel conversation in another media (e.g. videoconferencing and IM), 16%.
4. Meeting coordination, 9%.
5. Other unspecified communication (system messages, etc), 2%.

Project work
More than half of the instant messages concerned communication directly related to the joint project. This involves asking quick questions, giving short clarifications of previous work, and briefing other team members about recent project achievements. As in the example below, messages were kept short, without background information or formal introductions because all users already were aware of the context.

From: Penn to Luleå-desktop
Time: 2002-02-21 09:05 CET
Message: We’ve got 4–6 prototypes that we’re building quickly and testing tomorrow, then we’re putting them on a matrix.

Awareness
One fifth of the instant messages were used for maintaining awareness and a ‘sense of connection’ with remote team members. These messages often contained a greeting, or some other informal invitation to talk. Conversations were often initiated by such messages, but the recipient could easily decline with a quick comment, or by not replying at all. Such response was not considered impolite, but it was assumed that the recipient was busy or in other ways unavailable.

From: DTI to Penn
Time: 2002-02-28 18:46 CET (9:46 PST)
Message: Hi Penn how are you. Do you have time for a little chat before the chocolate drink for breakfast.

Media switching and parallel conversation
16% of the instant messages were used to handle the issues involved with setting up technologies for formal meetings. Instead of ‘connecting’ directly with the remote site through videoconference or a telephone conference, it was common to initiate conversation with instant messages, and then switch to another media type as soon as the formal meeting was about to start. The instantaneity of the messages provided an easy way to troubleshoot the ‘formal’ conferencing technologies, if these did not work as expected. As noted earlier, instant messages were also used in combination with conferencing technologies, which enabled team members to have parallel discussions going at the same time.

Luleå: is it the same phone number we called you at the last time?
Stanford: yes
Luleå: allright, we’ll call in a couple of minutes
Stanford: OK, everyone is ready here at Stanford...

Meeting coordination
9% of the total amount of instant messages was used to coordinate or reschedule meetings. In the following example, a Stanford student was at home and noticed that someone was active on the Luleå computer. Since all team members could use the Contact Portal from home, they often confirmed meetings before going to the project room. For example, if one member is going to be 10 minutes late, the awareness of this delay provides the possibility to reschedule the meeting on very short notice.

From: Jonathan (from home) to Luleå-desktop
Time: 2002-02-21 22:33 CET
Message: …i’m heading over to the loft in 20 minutes. If anyone else is around, we’ll give you a ring.

From: Luleå-desktop to Jonathan
Time: 2001-11-27 22:34 CET
Message: …we were actually leaving now but if we can talk in 20 min, we can wait.

5.3 Diaries
When reading the IM log files, it can be very hard to follow a discussion, because the instant messages are loosely coupled, fragmented pieces of information that needs to be interpreted with knowledge of the situation in which they occurred. Therefore, instant messages are not suitable for information that may be of importance later on in the project, or information that must be...
understood by all team members. ‘Why did we make that decision?’ ‘Who did he call to get that information?’ However, since formal documentation is cumbersome to produce and maintain, the web-based diaries provided an easy way to produce records of informal information.

Written by: Holger
Time: 2001-11-26 23:51:04 CET
Message: Today we bought a force feedback wheel and borrowed a webcam for our critical function prototype. After a couple of hours with some measuring and connecting problems we could run Monster Truck Madness with a power supply as brake and throttle pedal. Next step is to control it with Lab-View.

5.4 Short Message Service (SMS)

SMS can be seen as a mobile instant messaging technology, and it was primarily used for communication when team members could not become aware of each other through the use of the Contact Portal (awareness cameras, ICQ). By sending an SMS to all members in the group, you are sure that all members get notified immediately. The messages were grouped into three main categories: stickup notes, meeting coordination, and immediate contact initiation.

Stickup notes

This was a way of making sure that every team member pays attention to an important, but not urgent, issue. It was considered less cumbersome than calling each member.

From: Mats
Time: 2002-03-07 11:12:35 CET
Subject: Picture
Message: Hi! Have you seen any picture from Stanford of their concept? It’s Thursday now. I haven’t received any e-mail.

Meeting coordination

Since e-mail and instant messaging require access to a computer, it is not certain that all team members are online and check their e-mail/ICQ on nights and weekends. Therefore, SMS was used to coordinate meetings during ‘offline’ times.

From: Marre
Time: 2002-03-06 00:20:07 CET
Subject: Meeting tomorrow
Message: Hey guys! We’ll have a short meeting tomorrow at 10:00. Holger: we know you have a lab, but it would be great if you could come for a while.

Immediate contact initiation

In very urgent situations, or when all other communication channels had failed, SMS enabled team members to initiate immediate contact.

From: Jon
Time: 2001-12-06 12:06:00 PST
Subject: Video
Message: Hey guys, where’s the video? I just tried calling you. Scott and me are going to lunch in 5 min, so please send it.

5.5 Window of opportunity

One of the major problems in the DTI project was the nine-hour time difference between Stanford and Luleå. The ‘window of opportunity’ was very small and made informal communication difficult. In an ordinary workday (08-18), the window of opportunity is only one hour (Figure 6).

In order to make synchronous collaboration possible, the work hours were often extended so that team members more easily could find opportunities for interaction. However, since it was impossible to extend work hours every day, global communication was highly dependent on the ability to make use of the ‘windows of opportunity’ that came up on short notice. Therefore, instant messages and SMS were often used to check the availability of the ‘late night team’.

From: Luleå-desktop to Jonathan (at home)
Time: 2001-12-06 10:47 CET (01.47 PST)
Message: call us through NetMeeting

From: Jonathan to Luleå-desktop
Time: 2001-12-06 10:47 CET (01.47 PST)
Message: no, i'm going to be, and my girlfriends already asleep so that would wake her. i am just finishing up a long email to you all. just read that and we'll talk tomorrow.

6 DISCUSSION

The findings in this project highlight the importance of informal communication in the creation of shared understanding in distributed collaborative engineering design. Although the possibilities of videoconferencing and similar technologies must not be underestimated, it is also very important to be aware of and acknowledge the subtle, opportunistic interactions that lay the foundation for successful collaboration.

Throughout the project, team members have shown that continuous contact and communication is more important than the structure of such communication. Spoken language and written language have different form and function, and it is interesting to notice that the informal communication of the DTI project has so much in common with the informal interactions that are characteristic of the local workplace.

Awareness cameras can be used to provide non-verbal cues to written language, and the risk of misunderstandings decrease since words can be combined with visual expressions of emotion. Also, instant messaging technologies provide possibilities for parallel communication that earlier was possible only in local teams. Most importantly, the technologies and approaches described above are well fitted when the goal...
is to communicate across distance, time and formality. The combination of technologies allows distributed team members to become aware of opportunities for collaboration, and to initiate and maintain communication in a quick and easy way, using lightweight technology.

7 CONCLUSION AND FUTURE WORK

A web-based Contact Portal was created in order to support informal communication and information sharing in a distributed engineering design team. The Contact Portal has been a valuable asset in the project, primarily because it combines several information channels; e-mail archives, awareness cameras, diaries, instant messaging, and SMS etcetera in one place.

When observing the system in use, we found that the Contact Portal was a natural starting point for initiating and maintaining contact with remote team members. The small window of opportunity made it difficult to continuously plan and hold formal meetings (video and telephone conferences), so the opportunistic interactions have been an important part of the information sharing in the project. The web cameras provided an awareness of other team members’ presence, and also gave visual augmentation to written communication. Instant messaging was widely used for opportunistic and spontaneous interaction, but also for meeting coordination and media switching. In urgent matters of intended communication, or when all team members must be notified at once, SMS was preferred. Diaries where used as an easy way to create and store records of informal information that might be of use in the future.

Future work includes improved support for mobile opportunistic interaction, using technologies that allow you to be online all the time, such as GPRS (General Packet Radio Services). Another area of interest is mobile videoconferencing, using the scalable version of Smilie in combination with the Contact Portal on a PDA. Due to the high network requirements for mobile conferencing, a wireless broadband solution such as Telia Homerun [48] or UMTS (third generation mobile communications systems) [49] must be used.

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9 REFERENCES


