Using Ambient Displays and Smart Artefacts to Support Community Interaction in Distributed Teams

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Abstract

In this paper we point out the current changes and future trends of organizational concepts and explain their influence on workplace awareness and communication. We then elaborate the changing requirements for awareness and informal communication in distributed teams. Finally, we present two artefacts that support informal awareness and community interaction and describe their evaluation in a living-lab situation.

Keywords

ambient displays, distributed teams, informal communication, CSCW, awareness, community support, HCI, collaboration

INTRODUCTION

Two major trends are currently changing the world of employment: Employees are more and more organized in teams, while at the same time new office concepts allow higher personal mobility. The benefits of both developments are unquestionable – as long as all team members are working in the same office space. Teams sharing the same physical environment generally benefit from increased informal awareness through higher mobility of the team members within the shared workspace. When looking at distributed teams the situation fundamentally changes. The increased mobility of the distributed team members usually leads to poor communication and lack of group cohesion, which has considerable negative effects on the performance of those teams.

In the following sections we present the benefits of teamwork and show why informal communication and workplace awareness are essential for successful teamwork. We illustrate the current changes in office concepts and organizational structures and describe their influences on distributed teams. We then present our solution.

WORKING IN TEAMS

Besides the introduction of flat hierarchies and the decentralization of decision making, the organization of employees in teams was one of the most important organizational changes in the last decades (Hammer & Champy 1993). Since work became more complex and jobs required more specialized knowledge, the role of teamwork is increasing ever since. Teamwork in general brings many benefits, for example distributing the workload, reinforcing individual capabilities, increasing participation and involvement, improvement of decision making, generating a diversity of ideas and well being of the workers.

Helmreich & Foushee (1993) analysed the relevance of team performance in aviation and came to the result, that the breakdown of cooperation within teams is the main cause for many accidents. Even if these results are not of equivalent importance for all businesses, teamwork has to be seen as one of the major building blocks for the accomplishment of most projects.

The Importance of Communication and Awareness for Teamwork

The precondition for the successful completion of a task is the existence of a shared mental model, which serves as the basis for a common understanding of responsibilities and information demands of the single team members (Cannon-Bowers et al. 1993, Orasanu 1990, Salas et al. 1994). As a consequence, missing or insufficient communication leads to the inability to build up the required shared mental models (Orasanu & Salas 1993). Several Studies (e.g. Donchin et al. 1995), proved that the communication amoung team members has a strong influence on their performance.

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Besides explicit verbal communication, especially implicit communication in form of mutual awareness is an important requirement for a shared understanding and knowledge about ongoing and past activities within the team. Thus, it is not surprising, that numerous studies about informal communication, e.g. by Heath & Luff (1992) or Whittaker et al. (1994), and design recommendations for work places (Tanis & Duffy 1990) come to the conclusion, that informal awareness about ongoing activities in the local work environment as well as a sense of community are vital aspects of work. Like Gutwin & Greenberg (1999) and Sonnenwald & Pierce (2000), most authors recurrently stress the importance of workspace awareness in computer-supported teamwork. Workspace awareness is essentially based on informal communication (Whittaker et al. 1994) – elements of para- and non-verbal communication that employees perceive through simple physical proximity to their colleagues. According to Nardi et al. (2000) people who are aware of each other experience a common communicative arena, a virtual "space" in which a series of conversations can take place. Mutual awareness usually leads to informal interactions, spontaneous connections, and the development of shared cultures-all important aspects of maintaining working relationships (Dourish & Bly 1992).

Furthermore, awareness and informal communication do not only support a more efficient processing of project related tasks, they also improve personal experience and knowledge, which again have positive effects on the human capital of the organization. Besides these more productivity-oriented benefits, teamwork also promotes the involvement and participation of individuals and contributes to the well-being of the employees.

NEW OFFICE CONCEPTS

Since the introduction of office work in the beginning of this century, work environments are subject to a constant change towards higher organizational flexibility and personal mobility.

The starting point of this trend was the Larkin Building designed by Frank Lloyd Wright in 1904 which is also considered as the first office concept (Levine 1996). For decades it typified the state of the art of office buildings, where tasks were processed according to the production line concept, mobility was restricted to documents and foremen. This situation did not change much until Robert Probst introduced the "action office" concept (Stone and Luchetti 1985) in the 1960s. Probst introduced office landscapes with movable walls and furniture, where employees could dynamically adapt the environment to their current requirements. At about the same time the Schnell brothers came up with their approach to support the flow on information through mobile workplaces in open-plan offices. Both developments have to be considered as the predecessor of the "individual office" (Gottschalk 1994) and the cube farms of the 1970s, where separated workplaces were installed in open-plan offices to support communication as well as awareness. The experiences with these concepts lead to the "combined offices" (Puell 1990), an office concept that unites individual and open-plan offices in one office landscape. At the beginning of the 1990s the concept of mobility changed fundamentally with the introduction of the hot-desking concept, where employees and personal office utensils get highly mobile (Churchill & Munro 2001).

Observing the prevailing developments, one has to assume that future office environments will allow a much higher level of personal mobility as today's office concepts do. The most promising new development at the moment might be the business club concept, a derivative of combined office (Engel 2000). A business club consists of three areas: (1) a business centre with meeting rooms, cafeteria, personal lockers and a secretary's office, (2) a team centre with individual office desks, group spaces as well a team meeting room and, (3) a business lounge with a combination of relaxation and work zones.

Leaving the Office Desk Behind

Regardless of the predominant office concept, a continuous trend towards higher local mobility can be observed in most companies. Even if employees are within the office building they spend considerable time away from their own desk, working in meeting rooms, other offices or in the hallway (Lamming et al. 2000). According to estimations white-collar workers spend between 25% and 70% of their daily working time in conferences or meetings with colleagues (Eldridge et al. 1994), (Whittaker et al. 1994) .

To get a better understanding of the interdependency between mobility and teamwork, we will distinguish between to forms: local and remote mobility. With the term local mobility we will refer to the mobility of an individual within a building or organization, which is mainly determined by the organizational structure and the design of the work environment. In contrast, remote mobility describes the fading linkage of employees to a fixed workplace as a result of general globalization trends and technological development of networked mobile devices. In the following section we will have a closer look at local mobility and show how the increase of local mobility in workspaces effects teamwork.

How Local Mobility Supports Teamwork

The advantage regarding the collaboration of the team members has to be seen in an increased awareness about activities and occurrences in the surrounding of the own work place. Findings by Bellotti & Bly (1996) led to the assumption, that the relevant information is received passively, as soon as a team member is in physical proximity to the activity. They come to the conclusion, that local mobility is imperative for the communication within teams and at the same time supports informal communication and awareness about local colleagues. Based on the work of Kraut et al. (1993) also Whittaker et al. (1994) come to similar results and additionally stress the fact, that informal communication plays a key role for the collaboration within companies.

Regarding the working method of many teams, higher mobility seems appropriate and natural: creative processes can't be initiated on command, they are independent of time and place. As a matter of fact, the most creative and inspiring ideas are usually not born while sitting at the office desk (Sonnentag 2001). Peliz̈aus-Hoffmeister (2001) argues in the same way and sees the most important benefits of higher mobility in the broader wealth of experience and the additional opportunities for new relationships.

NEW FORMS OF ORGANISATION

General globalization trends are observable everywhere and do not only force large companies to rethink their organisational strategies. To be competitive in today's economy, companies have to pass on this requirement of higher flexibility to their employees (IGM 2001), (Ester et al. 2002) .

The tendency towards higher personal flexibility together with the increased dynamic in the economical environment leads to changes in the organizational structure of most companies. Organisational concepts, like the "ad-hocracy"-concept of Toffler (Toffler 1970), were employees with specific knowledge are temporarily organized in short-term teams, gain significant importance. These changes are not limited to the reformation of the organizational structure within the company, but also effect the relationship among different companies. The number of organizations that consist of a dynamic network of companies which temporarily cooperate for the production of goods or the marketing of services is constantly increasing (Barnatt 1995).

The increase in efficiency can be explained – among other things – by a better information flow, which is caused by the disintegration of the traditional, hierarchical structures. Field studies by Cummings & Cross (2003) corroborate this fact: "If members regularly interact with one another and share what they know, they are likely to develop and calibrate an awareness of each other's expertise."

Through the continuous evolution of work environments and the increasing demand for higher mobility, the maintenance of workspace awareness is getting an even bigger challenge: Certainly employees are more and more organized in teams, but the chance that they are at the same time at the same place is constantly getting smaller. Already today, in many companies hot-desking is a common form of work organization, which means that through the organizational concept alone only part of the team is present, while others work in their home offices or "on the road". Besides this, company-overlapping teams, where team members collaborate from remote locations, become more and more popular (Potter & Balthazard 2002).

According to estimations of the IDC institute for the United States 55 million employees will be mobile by the year 2005 – this corresponds to 37% of the working population in the US (Amler & Matting 2001). A closer look at large American IT companies reveals that this form of work organisation is already reality today. Sun Microsystems, for example, employs around 35.000 people worldwide. Internal studies from Sun show that usually 10.000 of them are not at their desks. A study by Mansfeld (2002) comes to the conclusion, that in most companies employees are only for 40% of their time within the building and if they are present they are only at their desk for 50% of this time.

THE PROBLEMS OF DISTRIBUTED TEAMS

Teams working under these conditions benefit from higher flexibility compared to traditional teams, but again lose this advantage due to the missing workspace awareness. Lurey & Raisinghani (1999) address this topic in an empirical study and came to comparable conclusions: On the one hand, they confirm the trend towards the formation of virtual teams, but in which the interpersonal relations are reduced to a minimum. On the other hand, their study shows that exactly these relationships between the team members have the strongest effects on performance and work satisfaction. Besides poor or missing communication, also lacking group cohesion, which is often experienced in virtual and distributed teams, has considerable negative effects on team performance (Blake et al. 1989). Studies by Inzana et al. (1994) also verify that local teams have higher group cohesion and generally achieve better results than distributed teams.

Local mobility leads to shorter and irregular attendance times of local team members at their individual desks. Since personal resources for the support of distributed teamwork, like email or phone, are in most cases only

accessible at the stationary workplace, the enhancement of local collaboration is mostly paid at the expense of poor collaboration with remote team members (Bellotti & Bly 1996) . This contention can be backed up by a study by Whittaker et al. (1994), where 2/3 of all attempts to contact a remote team member were not successful due to its local mobility.

Likewise, lacking awareness about the location and current activities of distant colleagues result in an interruption of the "reciprocity" and the "rhythm" of the collaboration between remote and local team members, which is essential for the success of the collaboration (Churchill & Wakeford 2001). If this evolves to a permanent situation, "discontinuities" and "breaks" will emerge which inevitably will lead to isolation and with that to community destroying processes (Pelizäus-Hoffmeister 2001) .

Hence, the challenge for remote team members is twofold: to stay informed about local activities and to maintain the team spirit with the local colleagues. Local team members profit from the fact, that information about environmental conditions and current activities are continuously available in a shared work environment and are picked up passively by those present. At the time of the information reception it is mostly not predictable, which of the passively perceived information will be an important resource for future activities. Since communication links with distant team members have to be intentionally initiated from both sides, the substitution of local presence with traditional communication devices is very limited and will never accomplish the same results.

REQUIREMENTS FOR SUPPORTING AWARENESS IN DISTRIBUTED TEAMS

In the previous sections we illustrated the importance of informal communication and awareness for team performance. As explained above, in local teams the required information is usually picked up passively while passing by each other or during informal communication in the hallway. Consequently, there is no additional effort necessary to maintain awareness. While email and chat-tools are appropriate ways to communicate task-related information, these traditional desktop-based solutions are not suitable to support awareness among members of a distributed team working in new office landscapes. Based on the introduced organisational and environmental changes, we will now elaborate the requirements of distributed teams working under these conditions.

If teams are distributed over different locations, the awareness information has to be communicated somehow. This leads to several problems: First, the collection and communication of the necessary information requires additional effort. Second, the more personal information is communicated, the more privacy concerns will arise. And last but not least, the more information is communicated to team members, the higher is the chance of interrupting or disturbing their work process. Hence, the challenge is to collect information with as low effort as possible and present it to remote team members in a subtle and non-distracting way without causing privacy concerns.

To do so, we designed a system supporting workplace awareness and informal communication while meeting the following user requirements:

- **Presence and Availability Information:** Gaver et al. (1992) define awareness as the pervasive experience of knowing who is around, what sorts of things they are doing, whether they are relatively busy or can be engaged, and so on. Especially the information about presence and availability about remote colleagues are of high value during the daily work process. This is also confirmed by the findings of Nardi et al. (2000), who evaluated the use of buddy lists. They showed that people found it valuable to simply know who else was "around" as they checked the buddy list, without necessarily planning to interact with anyone.

- **Avoiding Interruptions:** Interruptions are routine in the workplace. They enable informal communication but often disrupt concentration (Dabbish & Kraut 2003). Furthermore many interruptions result in the discontination of the interrupted task beyond the duration of the interruption itself. So the major goal is to offer possibilities to exchange information while supporting the choice of an appropriate moment.

- **Delivering Peripheral Awareness:** Awareness information is usually delivered as a persistent secondary task, requiring users to rapidly and frequently switch between some other primary task and the notification task. Although this additional information is valuable, users typically wish to avoid needless distraction by dynamic information displays - favouring calm and elegant peripheral awareness interfaces (Cadiz et al. 2003).

- **Reducing Information Overload:** Dabbish & Kraut (2003) showed, that information about the workload of a co-worker generally helps to find a less disturbing moment for an interruption. But if this

information is too complex, it distracts the person who plans to initiate the contact and interferes with his own work.

- **Easy and Intuitive Interaction:** The acceptance of awareness supporting systems is strongly determined by the effort users have to undertake to provide relevant information to their team members. According to Huang et al. (2002) the required effort for the input action on the users' side has to be comparable to the amount of effort the user is already exerting to share information in real life.
- **Privacy Protection:** As a basis for the development of the artefacts we carried out an extensive survey investigating potential privacy concerns of employees regarding workplace related information. The survey showed, that very few participants were willing to provide general information about their location (8.4 %) or activity (7.6 %), even if the information is usually available to local colleagues. The willingness to provide this information was significantly higher, if the participants could decide to which persons the information will be disclosed.

USING AMBIENT DISPLAYS AND SMART ARTEFACTS TO SUPPORT COMMUNITY INTERACTION

We will now present two artefacts and illustrate how they can be used to support awareness and community interaction in distributed teams. The first artefact is a public ambient display that communicates information about the presence and availability of individual team members between remote sites. The second is an individual mobile device, which enables users to individually control their appearance in a smart environment. The living-lab-evaluation scenario along with the Hello.Wall pattern language has been introduced in (Prante et al. 2004).

Hello.Wall

The Hello.Wall artefact (Streitz et al. 2003) is an ambient display that emits awareness information via different light patterns between distributed team members. With the Hello.Wall (see Figure 2 and 3) we designed a piece of unobtrusive, calm technology exploiting humans' ability to perceive information via codes that do not require the same level of explicit coding as with words. It stays in the background, only perceived at the periphery of attention, while one is being concerned with another activity, e.g., a face-to-face conversation.

We further aimed at making the type of information and the way of its communication context-dependent. The service provided by the artefact should be location- and situation-based depending on the proximity of people passing by. We distinguish between two different zones and their respective modes dependent on the distance from the Hello.Wall:

- **Ambient Zone:** People in the ambient zone contribute to the so called "ambient patterns" continuously displayed at the Hello.Wall without being identified.
- **Notification Zone:** People entering the notification zone are recognized via their Personal Aura artefact (see below) and the environment reacts to their local presence, e.g. by indicating their availability to remote colleagues.

Personal Aura

A further goal was to design an easy and intuitive interface which puts users in control of their appearance within a smart environment and allows them so signal their presence and availability to remote colleagues without causing privacy intrusions.

In real life, every person adopts different social roles, depending on the present situation and current social environment. Besides these general social roles, every employee has several professional roles which constantly change during the day. For example, the same individual can be a member of team A, project manager of project B as well as a contact person for external customers during his daily work routine.

With the concept of the Personal Aura (PA) we adopted this natural behaviour and designed an artefact enabling persons to indicate their "professional role" and "availability" to remote team members. The artefact consists of two matching parts: the reader module which is able to "emulate" different identities or professional roles, and the ID stick containing a unique identity and optional personal information (see Figure 1). Each person has multiple ID sticks symbolizing different professional roles. If people want to signal their availability to remote team members they do so by simply connecting a specific ID stick to the reader module.

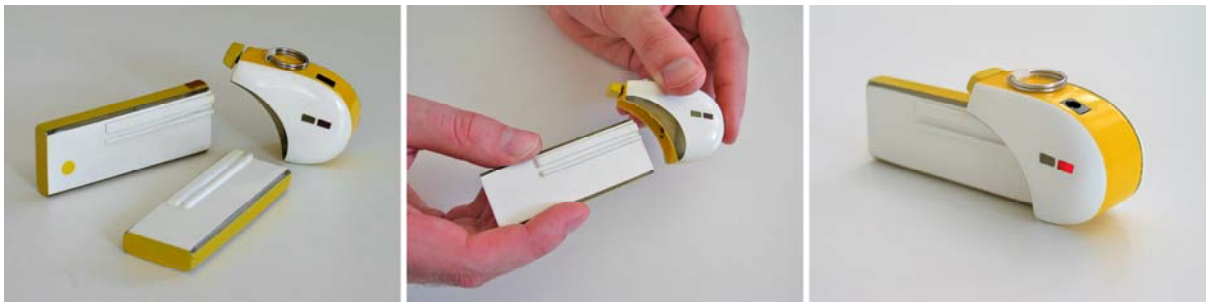

Figure 1: Personal Aura with reader module and two ID sticks (left), connection of reader module and ID stick (middle), active Personal Aura (right).

Light Patterns to Communicate Information

To improve workplace awareness and support opportunities for brief encounters between remote colleagues, we designed a specific "pattern language" to communicate the following information in an ambient and unobtrusive way:

- the general mood of the remote team,
- the number of people present in the remote work space,
- the presence and availability of certain team members, and
- the interest for communication with a remote team member.

We distinguish between two groups of patterns: *ambient patterns*, that represent general information like mood and presence, and *notifications patterns*, communicating individual or personalized messages. The Hello.Wall continuously displays dynamic ambient patterns interwoven with each other, representing the overall mood and general presence of the remote team members. To reduce complexity and support peripheral perception each parameter is divided into three levels (low, medium, high) with corresponding patterns.

Figure 2: Ambient Patterns on the Hello.Wall expressing 3 different levels of mood (left) and presence (right).

As an overlay to the ambient patterns, static personal signs will be displayed, as soon as a team member enters the remote lounge space (see Figure 3). To ensure better recognisability, the individual signs are displayed at fixed positions on the wall. Besides the static personal signs dynamic, attention-catching patterns are used to signal communication requests towards remote team members. All light-patterns are designed in an ambient and rather abstract way to achieve an aesthetically pleasing and non-monotonic appearance.

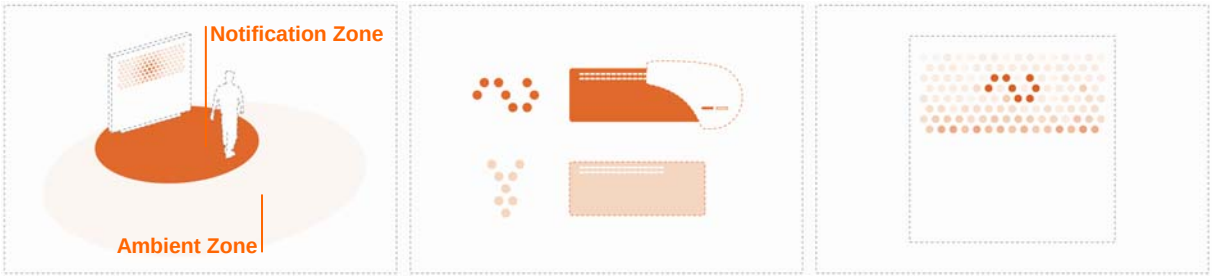

Figure 3: Identification via the Personal Aura artefact: People entering the notification zone (left) are identified according to their current professional role (middle) and their corresponding personal sign is displayed in the remote lounge (right).

EVALUATION

Both artefacts were tested in a living-lab evaluation over several weeks to investigate their potential for supporting awareness and facilitating community interaction in distributed teams. To support informal communication, we tried to establish awareness moments in order to create personal connections that lay the groundwork for community interactions. Our goal was to raise the awareness between remote colleagues and support community interaction between both sides. As shown earlier, there are many indications that future employees will not have their individual office desks but a network of workplaces. For the evaluation of the prototypes we set up a living-lab environment based on the business club concept with dedicated lounge areas for communication.

Test Environment

The test environment was set up at two remote work spaces of a distributed team: Fraunhofer IPSI (Darmstadt, Germany) and the Laboratory of Design for Cognition (LDC EDF R&D, Clamart, France). For the living-lab evaluation, a symmetrical configuration of two Hello.Wall artefacts with additional video-conference facilities was installed in the lounge spaces of both sites. This setup draws upon the observation that people in the lounge spaces were tentatively available for a conversation while having their coffee break.

The zones model introduced earlier is now mapped to the floor plans of both offices spaces (see Figure 4). While people in the ambient zone only contribute to the ambient presence patterns, people entering the notification zone are identified via their Personal Aura and their personal sign is displayed at the Hello.Wall at the remote lounge space. Thus the Hello.Wall continuously presents an intuitively perceivable picture about the remote site's state in an ambient way.

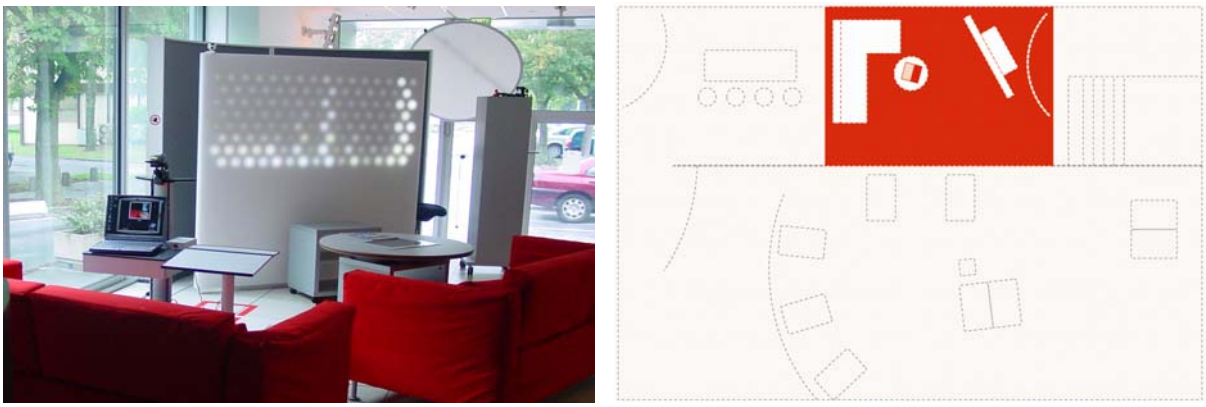

Figure 4: Lounge area at EDF with the Hello.Wall artefact and the video-conference station (left); and floor plan (right) showing ambient zone (light red) and notification zone (dark red).

To prepare the ground for informal face-to face communication, we aimed at supporting team members on both sides in approaching each other by successive signals of agreement before actually engaging in a conversation. Therefore we installed special "request buttons" were local team members could express their interest for video communication to the remote site. The overall mood of each team was captured with an easy but very effective three-button interface. After one of the "mood buttons" (low, average or good) was pressed, its respective value was added to overall mood of the local teams and the updated mood pattern appeared on the Hello.Wall in the remote lounge.

Evaluation Method

In each office space five members of a distributed team were equipped with prototypes of the Personal Aura artefact. Each participant had a personal symbols assigned to him, that was shown on the remote Hello.Wall each time he entered the local lounge area. The individual symbols were designed to overlay the ambient patterns continuously displaying the average mood and presence level of the team.

The members of the distributed team were engaged in a joint activity of preparing a final report for a multi-national project. Additionally to this task, all participants were also collaborating with local colleagues, who were not part of the distributed team. All employees were using the same local lounge space, but only the members of the distributed team were equipped with Personal Aura artefacts and were familiar with the meaning of the team patterns. The participants were asked to press one of the "mood buttons" every time they come into the lounge area and when entering or leaving the office building.

FIRST RESULTS & FUTURE WORK

First results of the observation already indicate the effectiveness of our approach and confirm its positive effects on workplace awareness and group communication. After the promising results of the prototype evaluation we started to improve the concept regarding different aspects. On the one hand, we are focusing on a better integration of the Hello.Wall with widespread office tools to get a broader and more detailed basis for awareness information. On the other hand, we are investigating new ways to communicate personal information between particular team members and explore the prospect of providing personalized in-depth information via mobile devices that directly communicate with the Hello.Wall.

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