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Requirements and Guidelines for the Design of Team Awareness Systems

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***Abstract*—**This paper presents a set of guidelines for the design of multi-user awareness systems. In a first step, general requirements for team awareness systems are analyzed. In the second part of the paper, the identified requirements are aggregated and transformed into concrete design guidelines for the development of team awareness systems.

***Keywords*—**User Interface Design, Awareness Systems, User-Centered Design, Human Factors.

I. Introduction

WITHIN the last decade, a multitude of applications for supporting awareness and informal information exchange within distributed work teams emerged. Quite a number of these so-called 'awareness systems' have been tested in real world situations (see, e.g., [9]). Although it was shown, that the installations were successful in getting people to communicate more easily, the majority of systems was abandoned after the demonstration period [53]. The rejection of the systems was mostly due to serious usability problems, caused through recurring interruptions and privacy violations. Most of these problems could have been avoided, if the user requirements were thoroughly analyzed prior to the design process. Instead, existing systems were usually developed from available communication technologies, enriched with additional functionality, or by combining different media into one application. Following this approach, it was ignored, that the employed communication technologies were originally developed based on the requirements for explicit peer-to-peer communication. Trying to adapt these technologies, and especially their interaction paradigms, to support informal information exchange among multiple users, will never be successful. The problems encountered in existing research prototypes are not inherent in the information itself or its processing, but are caused by the way, the data are collected and represented. Considering a proper set of design guidelines when developing new awareness applications can help to overcome these problems. By providing interface developers with concrete guidelines for the design of multi-user awareness systems, this papers aims to expand the current comprehension of how team awareness systems have to be designed.

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II. User Requirements

In order to constitute the basis for the definition of design guidelines, the paper starts by identifying general user requirements for multi-user awareness systems. As mentioned above, the majority of problems encountered with current awareness systems are caused by poor or inappropriate user interfaces. The following sections provide an overview over the requirements system designers have to consider when developing user interface for team awareness systems.

A. Low Cost of Interaction

In local work environments, the behavioral cost of maintaining awareness, in terms of the amount of effort needed to provide and perceive information, is very low. The required information is usually picked up passively while passing by each other or during informal communications in the hallway. Consequently, there is no additional effort necessary to maintain awareness. In contrast, existing awareness systems require considerable input on the sender side, and permanent attention on the receiver side, causing continuous interruptions of the work process. Recent evaluations showed, that the acceptance of awareness systems is strongly determined by the effort users have to undertake, to provide relevant information to their team members. According to Huang et al. [30], the required effort for the input action has to be comparable to the amount of effort the user is already exerting, to share information in real life. As the behavioral costs of accessing a communications system seem to be an important determinant of the system's usefulness, the interaction between the user and the application should be simple and lightweight, without requiring much effort from the user to minimize the costs associated with each instance of use [72]. According to Kraut et al. [38, 39] such a low-cost communication medium should be so ubiquitous, that potential users need make no planned effort to use it.

B. Continuous Information Flow

Awareness systems are defined as systems, that help people to effortlessly maintain awareness of each other's whereabouts and activities. Many authors, e.g., Markopoulos et al. [46], note, that the emphasis has to be put upon 'effortless' and 'maintain', in order to differentiate those systems from goal-directed communications media, like for example the telephone or e-mail. Continuous information

perception is an important feature of co-located work, as the information requirements for future activities are usually not predictable. Hence, most authors (e.g., [31]) stress the importance, that awareness systems operate in a continuous fashion, rather than strictly on the basis of explicit connections between individuals. This is also supported by evaluations of Rettie [58], who compared different communication media regarding the degree of connectedness and found, that duration of communication is positively related to the experience of connectedness. The benefit of providing awareness on a permanent basis was also shown in early experiments with media rooms [3]. In addition, if communication systems work asynchronously, like telephones or e-mail systems, distributed teams do not only have to deal with a spatial distribution, but also with the possibility of temporal decoupling. Hence, user interfaces should support a continuous and long-term 'flow' of information, in order to provide geographically distributed teams with real-time awareness information and to increase the 'naturalness' of the collaboration.

C. Ubiquitous System Availability

Within a local work environment, awareness information is usually continuously available and passively perceived by those present. Contrary to this natural behavior, existing awareness systems require users to employ dedicated devices or applications to provide and perceive awareness information from remote peers. As most existing systems were designed to run on standard desktop computers, people, who are peripheral computer users, cannot attend to awareness information in-between uses [41]. When designing new awareness systems it is of particular importance to address the fact that people get more and more mobile within the workspace. The permanent increase in personal mobility has to be supported by a fundamental change in the design rationale of information and communication technology, away from desktop-based solutions towards smart environments [64]. Several authors (e.g., [19] or [47]) addressed the trend of higher local mobility by developing awareness applications, that run on networked mobile devices. But as empirical evidence showed, users often do not take mobile devices with them, while working outside of their personal workspace [29]. Hence, it is essential to make awareness information continuously available, independent from a specific location or device.

D. Minimization of Disruptive Effects

As there is a significant increase in work involving high levels of concentration [65], a key issue in workplace productivity is to ensure the need for quiet and uninterrupted work [43]. But modern communication technologies, have dramatically increased the sources of interruption in work environments [5]. In a study about e-mail usage, Jackson [35] found that, on average, users took 64 seconds to "recover the mental thread" of what they were doing before in order to be able to resume previous tasks. Those interruptions do not only cause users to complete their tasks slower (see, e.g., [2]), many interruptions (41%) do also result in the discontinuing of the interrupted task beyond the duration of the interruption itself [52]. Studying interruptions in work environments, Hudson et al. [32] observed, that some participants considered interruptions caused by electronic media so distracting, that they physically moved either within the work space or to some place outside the office. Especially for continuously operating systems, were everyone is always 'connected' to everyone else, resource demands are usually high, and the opportunities for unwanted interruptions of the primary activity go up dramatically [31]. When designing awareness systems, it is important to balance the requirements for continuous awareness information with the users' need to perform their foreground task without frequent disruptions [20]. Therefore, a key challenge is to design interfaces that help people to stay aware of remote users without being overwhelmed or distracted by the presented information.

E. Multi-Party Communication

Today, most awareness systems, and especially ambient and public systems, are only developed to connect two remote locations. But when supporting awareness in distributed groups, dyadic communication is usually not sufficient [37]. Instead, continuous multi-party communication is required to support awareness [48]. The number of people who should be linked has a large impact on the design of a communication system, and especially on its interfaces [40]. While working teams are usually formed of 3 to 5 members [62], this group size might also be useful, when designing awareness systems for non-working environments. In a focus group study on instant messaging, Washington [68] found, that panelists wish to represent between 5 and 7 buddies. To meet this requirement, the user interface must be designed to support communication between multiple users distributed over several locations.

F. Personalization and User Control

People usually participate in more than one team at a time [57]. As people need to be aware only of particular persons at a remote location, the awareness systems must enable the concentration on a group of suitable partners [39]. Results from a focus group study by Hindus et al. [27] showed, that, while being interested in receiving presence information about others, users were reluctant to send information about themselves continuously. Instead, they wanted to control the timing and type of interaction they provide more closely. Therefore, it is especially important to let control remain in the hands of users [34]. This implies, that the interface allows users to decide, what kind of information they want to share, and with whom [49]. The same should be possible for the depth of the information [30] and the general availability for communication [40].

G. Privacy Protection

The collection and processing of personal data is inevitably connected to the core functions of most awareness systems

[18], making privacy and awareness seem to be a contradiction in itself. As the required data are usually highly dynamic, most applications use automated capturing mechanisms, giving users no control over the data that are generated. This problem is especially important, as awareness systems are designed to be 'always on' and hence highly sensitive to privacy issues [12]. In addition, offices are generally considered to be a private domain [71]. Kraut et al. [39] report major concerns from users, who fear privacy violations, as others will have access to personal information without their ability to control it or without their knowledge. Privacy problems are a widely discussed topic since the early days of ubiquitous computing (see, e.g., [70]) and are addressed in several guidelines, focusing on the design of privacy-enhancing technologies (e.g., [42]). Nevertheless, current awareness systems offer very little privacy protection (e.g., [66] or [29]) or do not address privacy topics at all (e.g., [47]). Therefore, is it of particular importance, to deliberately design new interfaces that address these new challenges and enable users to provide personal awareness information, without causing privacy violations. Like privacy regulation in real life, the implemented strategies should be lightweight and transparent [51], requiring minimal additional effort from the user. In the following sub-sections the relevant information types are briefly discussed.

H. Relevant Information for Supporting Team Awareness

Awareness is often defined 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 [17]. Hence, maintaining awareness requires different types of information to be continuously available for all team members.

1) Presence and Availability

Awareness of the presence and availability of remote colleagues are key issues of improving distributed teamwork [24]. The information proved to be of direct importance for both formal and informal collaboration [61]. Most brief office conversations are unplanned, and hence are potentially interruptive [59]. Sharing an indication about the current state of a person also helps to avoid interruptions through poorly-timed communication attempts [14]. Co-located users can typically assess someone's interruptibility very quickly and with a minimum of effort, allowing them to balance the benefits of an interruption with its cost [33]. In addition, especially information about the availability of a remote colleague is a prerequisite for informal communication and information exchange, as informal communication will only take place if both parties have the time. Today, informal communication is mostly restricted to team members, who share the same work place. Providing information about presence and availability of remote team members can serve as the pathway for spontaneous informal communications over distance [57]. Besides this, continuous information about the presence of remote colleagues is likely to establish an increased feeling of connectedness. Nardi et al. [50] evaluated the use of a buddy lists in IM applications and observed, that people found value in simply knowing who else was 'around' as they checked the buddy list, without necessarily wanting to interact with anyone. According to the authors, these 'awareness moments' produce a certain feeling in the people, and, by creating personal connections, lay the groundwork for closer interactions.

2) Tasks and Activities

Information about current activities and tasks of colleagues are further important aspects for successful multi-site work [19, 57, 24]. As explained above, this information can also help team members to find a less disturbing moment for an interruption. It also makes the communication more efficient, as there are less misunderstandings and necessities to request additional contextual information [16].

3) Mood and Atmosphere

An important feature, that is missing in remote teamwork, is awareness of the mental states of the remote team members, which is again an important part of common ground [53]. Milewski and Smith [48] found, that participants in face-to-face conversations modified their behavior, besides other things, depending on the people present and their current social mood. Information about the mood of remote team members and the current atmosphere at the remote side will help to choose an appropriate timing and communication style.

III. Design Guidelines for Team Awareness Systems

Based on the identified requirements, a set of 11 specific design guidelines for team awareness systems was elaborated. The following four sections provide a thematically clustered overview over the guidelines.

A. Selective Awareness Information

Awareness information in work environments originates in many different forms, such as the sight and sound of co-workers, the opening angle of office doors, and the location of people and objects [72]. When this information is directly displayed in the remote space, users are required to mentally aggregate the data, in order to get an impression of the current situation. But, as the information processing capacity of humans is limited [67], this usually leads to interruptions of the primary task, which was shown in several evaluations. Dabbish and Kraut [6], for example, 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. Also Gutwin and Greenberg [22] observed, that too much awareness information can result in an 'awareness overload'. As a consequence, users often have trouble discerning between useful and unimportant information, when large amounts of information are presented [72]. Hence, Pedersen

and Sokoler [56] concluded, that awareness information should be aggregated or abstracted to a smaller number of simpler forms, in order reduce information overload, ease intelligibility, and to preserve privacy. To do so, three complementary strategies should be employed: information filtering, progressive information depth, and context-dependent information representation.

1) Information Filtering

> ***Design Guideline 1:*** *Awareness information should be filtered to preserve user privacy and to reduce information overload.*

Not all information, that is available in a local work environment, is equally helpful to mediate awareness. Some information, like, for example, data about people that are in the same office, but who do not belong to the distributed team, might even cause unnecessary disturbance. As it is obviously not necessary to capture, distribute and present all information that is available in the local environment, the transmitted information should be filtered. Filtering can be done either automatically by the system, this means that only specific environmental information is captured by the system, or individually, by personalizing the information according to the user's preferences. Individual filtering can be applied on both sides: while capturing information to preserve privacy on the sender side, and when representing information, to reduce information overload through personalized awareness data, at the receiver side.

2) Progressive Information Depth

> ***Design Guideline 2:*** *Awareness information should be variable in its level of detail, ranging from continuously presented high-level information to individually accessible in-depth information.*

In the real world, awareness information usually varies in its 'degree of accessibility'. While some information is permanently available and is passively perceived by all people present, other information requires additional effort to be received, either in form of longer observations or explicit actions. For example, presence information is continuously available to those, working in the same physical space, while gaining information about the current activity of a co-worker usually requires some additional effort (e.g., to walk over or talk to the colleague). Existing awareness systems do not integrate this natural behavior into the system design and present a fixed amount of data to all users. Therefore, only a reduced set of awareness information, which is of general importance for all remote team members, should be continuously presented in the remote space. More detailed (and personalized) information should be made available to users upon request.

3) Context-Dependent Information Representation

> ***Design Guideline 3:*** *Personalized awareness information should be adapted to the current context of each user.*

Throughout the day, users work on different tasks and interact with different groups of people. Hence, Gross [19] argues, that users do not only need awareness information independently of their current location, but also adapted to their current context. This requires the interfaces to be designed for easy and unobtrusive context capturing, as well as for personalized and situation-adapted information representation.

B. Ambient Information Representation

Awareness information is usually delivered as a continuous secondary task, requiring users to rapidly and frequently switch between a primary activity and the awareness task [4]. This simple act of explicitly changing focus and the time it requires can be a significant disruption to a user's primary task or train of thought [63]. As receiving awareness information is not a primary activity, that a user frequently engages in [72], awareness applications should not distract users from their focus. Therefore, user interfaces should deliver awareness information in a way that it can be perceived as a secondary task, and support smooth transitions between both activities. The majority of awareness systems tries to create artificial proximity by imitating face-to-face interactions and increasing the degree of perceived realism [28, 12]. In contrast to this approach, a number of authors, e.g., Washington [68] or Karahalios and Donath [36], argue, that attempting to replicate face-to-face communication by means of emulating its processes and interaction techniques is incorrect and narrow in scope. Hollan and Stornetta [28] conclude, that designing awareness systems, that emulate physical proximity, will never be as good as the real thing, as only second-best substitutes could then be created. This hypothesis is supported by an evaluation of Fish at al. [13], who evaluated a system, that attempts to imitate opportunistically encounters in hallways by arbitrarily connecting two users. With 97 % of such connections being terminated immediately, this approach proved to be highly unsuccessful. In most cases, the attempt to duplicate real-world situations resulted in an increased use of high-fidelity media. But more fidelity and more bandwidth do not necessarily produce better results [31]. Instead of designing systems that address a maximum of senses, it is more important to consciously transmit meaningful information, and at the same time respect social norms [8]. To represent awareness information effectively, peripheral information perception seems to be favorable over solutions that appeal to main human perception [40]. Hence, awareness information should be subtly delivered via peripheral representation devices, using abstract forms of information visualization.

1) Peripheral Information Representation

> ***Design Guideline 4:*** *Awareness information should be presented in way, which enables users to perceive the information in the periphery of their attention.*

Most awareness systems use graphical user interfaces (GUI) to represent awareness information to remote users. GUIs usually require the user's full attention, otherwise they are completely out of focus [69]. Due to this binary nature of a GUI, users have to sit down in front of the screen to use the system [68]. But as mentioned above, awareness systems should enable recipients to attend to foreground tasks while maintaining peripheral knowledge of continuous awareness cues [60]. Hence, awareness applications need to stay in the users' periphery of attention, when they are not directly interacting with them [72]. In contrast to GUIs, peripheral displays enable users to monitor an information source, while focusing on a separate primary task [7]. Therefore, peripheral displays should be used as a lightweight method of obtaining and presenting awareness information, while allowing users to continue their work on a primary task.

2) Abstract Visual Representation

> ***Design Guideline 5:*** *Awareness information should be visualized using abstract representation techniques.*

In contrast to traditional content-oriented communication, connectedness-oriented communication does not focus on the reproduction of message contents, but on the social relationships, expected to be formed as a result of communication activities [40]. As mentioned above, there is no need to transmit high-fidelity data to mediate awareness. Kuwabara et al. [40] argue, that a small amount of data is sufficient, if it induces a sense of connectedness in the mind of the receiver. Therefore, a variety of authors, e.g., [60], suggest abstracting the awareness information and to display it at the receiver's side, in a symbolic and meaningful way. IJsselsteijn et al. [34] even argue, that it is better, to let the receiver imagine the status of the other person, rather than interpret high-fidelity audio or visual information, which will place heavier demands on attention and cognition. And, as the persons receiving the data are usually not strangers, interpreting properly abstracted awareness information is easy [47]. Several evaluations support this theoretical argumentation. Dabbish and Kraut [5] compared different awareness displays in order to find out, how the informational intensity of a display relates to the visual attention and cognitive demand required from users. They found, that information-rich displays impose substantial attentional costs on the user, and that an abstract display provides similar benefits with less distraction. Based on these results they conclude, that abstract displays provide the best trade-off between useful information and distraction.

3) Calmness and Design

> ***Design Guideline 6:*** *Awareness information should be visualized in an aesthetically pleasing and unobtrusive way.*

A permanent confrontation with audiovisual impressions is often considered to be disturbing and distracting, and might also lead to stress and stress-dependent psychosomatic problems [45]. Cadiz et al. [4] found, that although additional information is valuable, users typically wish to avoid needless distraction by dynamic information displays, favoring calm and elegant peripheral awareness interfaces. Designing calm and unobtrusive interfaces is especially important in office environments, where much work involves speaking, reading, or writing. Some authors, e.g., Fogarty et al. [15], go even further and demand, that ambient displays that are primarily chosen and installed because of their aesthetic properties.

C. Active Privacy Support

For the system to be successful, it is important that users provide information voluntarily and on a continuous basis. Even if there is theoretical and empirical evidence, that distributed teams benefit from the awareness information mentioned above, it is important that users feel comfortable providing that information to distributed team members. In multi-party awareness systems, the benefits an individual user gains, depend on the degree of adoption by the group as a whole. If a part of the team is not willing to use the system due to privacy concerns, the benefits for the rest of the team are reduced. This is related to the 'Threshold Effect', if usage drops below a certain level, people will stop using such a system [60]. To overcome this critical mass problem, it is important to address potential privacy concerns in the design process. Research shows, that there is a common fear among users, that they do not have sufficient control over who knows what about them. The willingness to provide personal information usually varies depending on the type of information, the information recipient, and reason the information is used for (see, e.g., [1]). Historically, there has been poor support for preserving privacy and for protecting solitude in distributed collaboration support tools. While many raise it as a concern, most media space installations simply ignore privacy issues [51]. Especially, when it comes to large displays in public spaces, existing applications offer only crude privacy support. For example, Vogel and Balakrishnan [66] and Huang et al. [29] both address privacy issues in public spaces. But instead of implementing appropriate measure, to help users protect their privacy, they simply rely on users to occlude the view of their personal information from others with their body. To guarantee adequate privacy protection, three approaches should be combined.

1) Individual User Control

> ***Design Guideline 7:*** *Users should be in control of the information which is captured and broadcasted.*

Most current systems attempt to support awareness by automatically capturing and presenting information about the location, presence or activity of remote colleagues. In contrast to this approach, Sawhney and Schmandt [60] define transparency, trust and control over activity information made available to others, as essential characteristics of awareness system. In addition, they underline the importance, that senders have to recognize easily, which aspects of their activity are being made perceptible to others. Those requirements are supported by a number of user evaluations. For example, Washington [68] reports, that the majority of panelists, participating in a focus group study on instant messaging, felt it was important to have control over information captured and broadcasted to others. Similar results are reported by Olsen et al. [54]. In line with these findings, Heath et al. [25] argue, that it is important to provide participants themselves with tools, which enable them to selectively render actions and activities to others.

2) Personalized Awareness Information

> ***Design Guideline 8:*** *Users should be able to provide personalized awareness information, communicating different information to different persons.*

Awareness information is not generally public or private. Rather it depends on the user, how confidential he regards certain types of information. In a discussion of group calendar privacy, Palen [55] found, that information regarded totally innocuous by some participant, were considered personally private to others. In the same way, Zhao and Stasko [71] argue, that individuals usually have different comfort zones in the level of personal awareness information being broadcast, and that this comfort zones change over time. They conclude, that individuals should be able to determine the level of personal information being transmitted. But privacy settings are not only dependent on the sender's preferences, they are also determined by the information receiver. Godefroid et al. [18] argue, that each user has control over his own data, and the ability to determine, what is available to other individuals or groups. Handel and Herbsleb [24] receive similar responses in a user study, as that many potential users are uneasy providing presence information, which is available to everyone. Kuwabara et al. [40] extend these requirements by arguing, that also the level of detail should depend on whom the information is sent to.

3) Context-Dependent Privacy Profiles

> ***Design Guideline 9:*** *Users should be able to dynamically adapt their personal privacy settings to the current context.*

From the users' perspective, there is not only the need for privacy, but also the need for lightweight mechanisms to control privacy [44]. The willingness of users, to provide and receive awareness information is a highly situated issue, depending upon the current activity, on other users as well as on the social environment [46]. As those parameters constantly and dynamically change during the day, users should be able to easily adapt their personal privacy settings to their current context.

D. Easy and Intuitive Interaction

Easy and implicit mechanisms to capture information are essential characteristics of awareness systems [60]. IJsselsteijn et al. [34] suggest, that systems should either automatically capture awareness information, or support lightweight manual input. But a variety of authors, e.g., Milewski and Smith [48], argue, that there is always a trade-off between low communication cost and user control. Awareness systems, that expect users to explicitly provide information, mostly ensure good privacy protection [60]. But as the 'status' of a user usually changes throughout the day, the required overhead to update the information is a major drawback of those systems [21]. Despite the necessity for colleagues to remain informed, people may have neither the time nor the inclination to provide the necessary data to inform others what he or she is doing [25]. IJsselsteijn et al. [34] observed, that, if many deliberate actions are required to provide awareness information, chances that people will use the system, will decrease. In order to eliminate the required user input, an assortment of techniques have been tried to provide automatic status information [48]. These include video (e.g., [72]), audio analyzes [15], infrared and ultrasonic sensors (e.g., [40]), and active mobile devices (e.g., [47]). However, when the data are largely generated automatically and potentially quite frequently, users have very few control over the information provided to other users, making it nearly impossible to ensure appropriate levels of privacy [18]. Most existing applications provide input and output via one device, with typically static interaction paradigms. Awareness information is either captured automatically via sensors and continuously transmitted to the remote side, or users are required to provide manual input, whenever they want to transmit information. When designing the interfaces, most developers do not take into account, that the requirements for capturing information and perceiving awareness are fundamentally different. In the real world, awareness information is picked up continuously at the periphery of attention. In contrast, awareness information is either provided continuously without special input (e.g., presence), or explicitly through certain actions (e.g., indication of availability for certain persons). Hence, the

trade-off, between low communication cost and user control, can be solved by separating input and output modalities, and combining automatic capturing techniques via sensing technology, with explicit and implicit user input.

1) Separation of Input and Output

> ***Design Guideline 10:*** *Input and output interactions should be realized using separate interfaces, each adapted to the inherent characteristics of the specific interaction form.*

Using different devices for input and output interactions makes it possible to adapt the interfaces to the specific requirements of each form of interaction. As mentioned above, awareness is perceived passively through continuously available cues within the physical environment. To support natural forms of information perception, it seems appropriate to integrate the information within the very spaces the users occupy [10]. Therefore, the representation devices should be seamlessly integrated into the physical environment in order to unobtrusively present awareness information to users. Perceiving awareness information does not require users to directly interact with the presentation devices. In contrast, having control over the awareness information that is provided, the user must somehow interact with the system. To explicitly communicate status changes, some sort of physical input interface is required. To meet the requirements of privacy, high flexibility and low communication cost, a hybrid approach should be chosen, which combines implicit and explicit interaction mechanisms.

2) Combination of Different Interaction Modalities

> ***Design Guideline 11:*** *The interaction modalities should be adapted to the different information characteristics.*

Maintaining awareness requires users to aggregate different forms of information [23]. While some data can be gathered automatically, others can not, or sometimes should not be captured automatically. Therefore, explicit and implicit forms of user input should be combined with automatically captured sensor data. Mixing these automatic detection mechanisms with manual updating capabilities seems to be a useful overhead-reduction strategy [48].

IV. Conclusion

By defining detailed user requirements for team awareness systems, this paper extends the current understanding of important aspects for interface design in multi-user systems. While requirement analyses done so far explored only singular aspects of interface design, this paper followed a structured analytic process to address the various facets of distributed teamwork. Based on the identified requirements, a set of design guidelines for team awareness systems was developed. The guidelines expand the current comprehension of how team awareness systems have to be designed and thereby provide interface developers with concrete guidelines when designing multi-user awareness systems.

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