

SUPPORTING EMOTIONAL COMMUNICATION BETWEEN MULTIPLE USERS IN INTELLIGENT HOME ENVIRONMENTS

Richard Etter (1), Carsten Röcker (1), Daniel Gilgen (2)

(1) Fraunhofer IPSI, Germany

(2) Büro 48, Frankfurt Germany

Abstract: In this paper a concept is presented, that supports awareness and emotional communication between family members, distributed over multiple intelligent home environments. A technical communication infrastructure is presented, which allows connecting different types of input and output devices. This platform is extended by several examples of emotional user interfaces, which address the individual needs of different user groups.

Keywords: Emotional Communication, Awareness, Intelligent Home Environment, Personalized User Interfaces, Smart Artefacts, Ambient Displays, Communication Infrastructure

INTRODUCTION

Interpersonal communication is a fundamental element of all human relations and serves various social purposes. Through the exchange of messages, thoughts and feelings, social communication leads to greater familiarity and contributes to the development of social relationships (1, 2). Besides explicit verbal communication, especially implicit communication and awareness are important to foster a feeling of togetherness and thereby contribute to personal well-being.

Technology-Mediated Communication

With people becoming more and more mobile, it is not unusual to rely on e-mail, instant messaging and phone calls, to communicate with family and friends across the street or across the world. As a result, technology-mediated communication has become an essential part of many relationships.

But as existing communication devices were mostly designed for information exchange, they only afford explicit communication rather than the kinds of implicit communication available through co-presence and mutual awareness (3, 4). Due to the explicitness of the interaction, the devices are not appropriate to mediate awareness and support informal interactions between distributed users.

According to Markopoulos et al (5), the main drawbacks of existing communications technologies are their synchronous nature and explicit interaction paradigm, requiring people to have a reason for contacting someone.

Awareness Systems

Due to the shortcomings of traditional communication devices, a multitude of applications for supporting awareness and informal information exchange between different groups and places emerged within the last decade. These applications are usually denoted ‘awareness systems’ and defined as a “class of computer-mediated communication systems that support individuals or groups to maintain a peripheral awareness of the activities and the situation of each other, e.g., their well-being, their availability for interactions, or an overview of their activities” (5, 6). The main difference to content-oriented communication tools is the lightweight nature of these systems, allowing users continuously and effortlessly maintaining a feeling of connectedness with each other (7). Since the goal of awareness systems is different from traditional goal-directed communication devices, they are not to be seen as replacing existing communication means, such as telephone or e-mail, but rather as enriching

them by strengthening existing social bonds and enabling new kinds of interaction (8, 9).

Existing Multi-User Awareness Systems

There is a variety of different applications that try to mediate awareness and support informal collaboration, and the approaches taken to support the illusion of non-mediation are radically different. The systems range from text-based applications (e.g. 10) over audio (e.g., 11) and video-based systems (e.g., 12) to virtual reality systems (e.g., 13). In addition to these single-media applications, several cross-media approaches exist. The group of integrated awareness systems includes desktop media spaces (e.g., 14), shared community board (e.g., 15) as well as several mobile systems (e.g., 16).

Problems of Existing Systems

Most existing multi-user awareness systems are designed for office environments. Although it could be shown, that some of the installations were rather a success in supporting awareness and informal communication in office settings, none of the approaches presented above seem suitable to mediate emotional awareness information in home environments. The reason for this has to be seen in the fundamentally different information and interface requirements of home awareness systems. The requirements for awareness systems used in home environments differ from those of office spaces in two aspects.

Awareness Information. First, the type of awareness information used in workplace awareness systems is different from the information necessary to mediate awareness in home environments. In the office context, awareness is usually defined as a general sense of the presence, availability, and activities of others in a shared environment (17). Hence, most awareness systems provide presence and location information in order to provide remote user with a sense of the activities in the local workspace. This information is sometimes supplemented with data extracted from online calendars or address books. In contrast the activity in home environments is very complicated to detect and the availability might not be the same for all connected persons at a specific time.

User Interfaces. Second, the interface concepts of current office awareness systems are not transferable to home environments. Most awareness systems use graphical user interfaces (GUI) to represent awareness information to remote users. Even if graphical information representations might fulfil functional requirements, they are inappropriate regarding the usability needs of home users. GUIs usually require the user's full attention, otherwise they are completely out of focus (18). Due to this binary nature of a GUI, users have to remain in front of the screen to use the system (19). In addition, empirical evidence (20) shows, that users wish to avoid needless distraction by dynamic information

displays, favoring calm and elegant peripheral awareness interfaces.

AWARENESS IN SMART HOME ENVIRONMENTS

The concept of intelligent home environments propagates a vision of future living spaces where people are supported and assisted in their everyday activities by information and communication technology that is very different from the computer as we know it today (21). The envisioned technologies "will weave themselves into the fabric of everyday life until they are indistinguishable from it" (22).

Following this concept, several projects (23, 24) aim to support awareness and informal interactions between people that have close emotional ties. In contrast to office awareness systems, these projects focus on connectedness-oriented communication and aim to support and augment social relationships among people, by fostering a sense of connectedness among them (8).

Awareness Systems for Home Environments

Most of these awareness systems make use of ambient display technologies to facilitate lightweight, informal and emotional forms of communication. While ambient displays, by their nature, are not limited to certain kinds of information, most systems map presence information associated with other people to artefacts, situated or integrated in the environment. The systems are designed, to support users in effortless maintaining awareness of the whereabouts and activities of others, and do so, by representing this information through changes in light, sound, movement, or temperature, in the user's environment (19).

Looking at the design of the output interfaces for ambient awareness systems, two fundamentally different approaches are visible. One group of application uses physical artefacts to visualize information, the other relies on large graphical displays, showing abstract pictures compositions.

The usage of physical artefacts to represent awareness information is especially common in applications, that focus on providing intimate affective communication between pairs of people. Strong and Gaver (25) developed several artefacts that allow pairs of people staying in contact. In their scenario, the mobile partner carries a small picture frame, and picking up the frame, transmits information to a stationary device at the other partner's home. Depending on the device, a feather inside an acryl cone is whirled around (Feather artefact), or a heating element warms a container with essential oil (Scent artefact). Another tool for supporting intimate communication is the Kiss Communicator (26). Blowing on the devices creates ripples of light, that can be sent to a remote partner's device, once a desirable pattern has been achieved.



Figure 1 Kiss Communicator

Another group of ambient awareness systems focuses on providing awareness in small, closely-related groups in the home environment. The FamilyPlanter (8), for example, was developed to be used by family members living apart. The system uses infrared and ultrasonic sensors, to monitor the presence of a user, and transmits the status to a selected family member via a server. At the receiver's side the FamilyPlanter presents the received information by rotating and illuminating optical fibers. Besides this automatically generated presence information, the system also offers a possibility to explicitly send 'messages' by touching a sensor at the FamilyPlanter, which causes the artefact at receiver side to emit a sound.

A similar approach is taken by Hindus et al (27) with the Lampshade Intentional Presence Lamp, a decorative artefact that serves both, as a lamp and a communication device. In contrast to the FamilyPlanter, the presence of people is not automatically captured. Instead, presence information is only communicated, if the user explicitly activates the Lampshade device. Other systems supporting awareness in small intimate groups include Digital Family Portraits (28) and Curtain IPL (27).

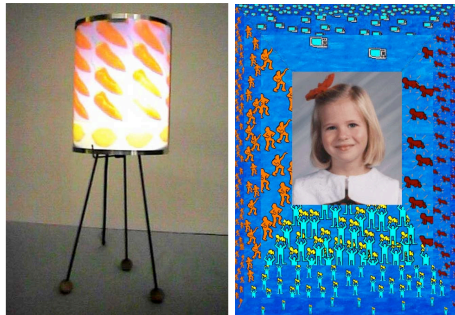


Figure 2 Lampshade Intentional Presence Lamp (left) and Family Portrait (right)

Focusing on larger communities, several authors explored the use of Informative Art, to provide presence awareness, using large peripheral displays. The Motion Painting, developed by Holmquist and Skog (29), uses a web camera to determine the activity level in a specific location. Depending on the level of activity, a dynamic visualization is created by painting thin, vertical lines from left to right on the screen. With a raising activity level, the color of the lines differs more and more from the background color of display. Other examples by Skog (30) are the Activity Wallpaper, an ambient visualization of activity information, based on an analysis of audio data, or the Exhibition Activity Monitor, measuring the amount of people passing through a door.

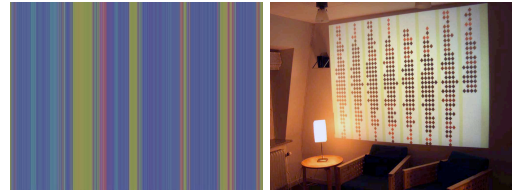


Figure 3 Motion Painting (left) and Activity Wallpaper (right)

While most ambient awareness systems use dedicated input devices to capture information, De Guzman et al (31) use available status information from instant messaging applications and visualize this information in the real environment using physical artefacts. The prototypes include The Expanding Ball, which displays the status of remote buddies by changing the size of a geodesic expanding plastic ball, or The Chime, a physical client, conveying IM status through movements of a lantern wind chime and colors of LEDs within the lantern. Other examples are the IMFrame and Spinner (31) or IM Ambient Media (19).



Figure 4 Spinner and Chime: Physical artefacts used to display the status information of instant messenger programs

Problems of Existing Home Awareness Systems

Although these systems proved to be successful in mediating presence in peer-to-peer situations, they are not adequate to support awareness in intelligent home environments, where multi-user communication is required. Restricted through the design of their interfaces, most systems only allow transmitting one parameter to a single remote device. But in order to stay aware of family and friends it is necessary, that home awareness do not only support peer-to-peer communication, but allow users to exchange personalized awareness information with several remote peers using one device.

In addition, most approaches neglect the heterogeneity of the targeted user group. While potential users are likely to have the same needs regarding the types of awareness information, their ability and needs regarding specific interface properties varies widely. The fact that users from different age classes have different abilities, should also be reflected in the design of the user interfaces. To obtain a seamless integration into the home interior common non electric objects like coffee cups, lamps picture frames are use to implement awareness technology. This approach can cause irritation because the distinction to ordinary, non smart objects is missing (32).

GOAL

This paper aims to develop a concept for a system that supports awareness and emotional communication between multiple family members, distributed over several locations.

Personalized Interfaces

Since potential users have different abilities and needs regarding interfaces, a series of interfaces is presented that mediate awareness. The focus is on different concepts for artefacts that enable multiple persons using their own personalized devices to stay in touch.

Multi-User Communication Infrastructure

In order to enable devices to communicate with each other a common infrastructure is required. A conceptual system architecture is presented that allows connecting heterogeneous types of devices that address the individual needs of different user groups.

THE COMMUNICATION INFRASTRUCTURE

For users who want to stay connected to others, two issues are important. First users want to communicate. Second, users want to have social awareness of each other.

In order to enable multiple users to communicate with each other, a common communication infrastructure is required. In the following a conceptual design is described that allows connecting multiple heterogeneous devices and supports the integration of existing services (see Figure 5).

Architectural Design of the Communication Infrastructure

The design of the platform is based on the principles of a service oriented architecture and follows a strictly component based approach. For applications and devices the communication platform offers two services, a notification service and an awareness service.

The Notification service enables users to send and receive notifications with their devices. Once a device of a user is registered, the user is able to send notifications to other users. On the other hand the device receives notifications for the current user.

The Awareness Manager provides awareness related information to applications and devices. This service allows devices to subscribe to available context data. The context data is provided by the Context Service Adapter. Via the Context Service Adapter existing context management services can be plugged in the platform. In the following the main components of the platform are highlighted.

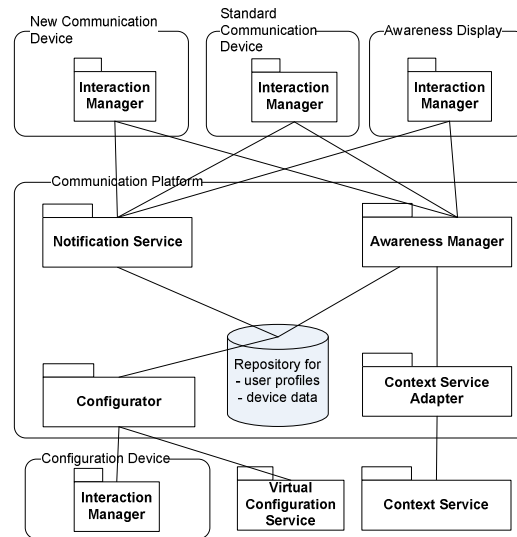


Figure 5 Design of the Communication Infrastructure

Awareness Manager. This service provides applications with awareness information. Awareness related information can be any type of context-information, e.g., the activities or location of remote persons. In pervasive computing environments a variety of sensor data is available and many of this data can be used to provide social awareness to people. The Awareness Manager enables applications to easily access context data without having to deal with the management of the data.

Context Service Adapter. This component enables to connect existing context management frameworks to the communication platform. In recent years a number of toolkits and frameworks have been developed that manage context data (33, 34, 35, 36). The Context Service Adapter unifies the format of context data provided by different frameworks and context sources and makes the data accessible for the Awareness Manager, respectively the devices that are connected to the communication platform.

Notification Service. This notification service enables users to explicitly send notifications to each other in order to stay in touch. Devices register by providing the ID of the user that is currently using it. From then on a user is able to send notifications to other users. At the same time the devices receives notifications that are addressed to the current user.

Configurator. This component allows managing the communication platform. This includes e.g. the management of users. Since the configuration of a multi-user platform is a complex issue, the Configurator allows connecting tangible configuration devices to the communication platform. These physical devices seek to reduce complexity via tangible interaction.

Interaction Manager. The InteractionManager is a client that connects via Internet to the services of the communication infrastructure. It enables devices to use the services offered by the platform.

PERSONALIZED INTERFACES

Existing approaches to foster awareness between users usually use the same interfaces for all users. As a result of our scenarios investigation, it became clear that different users have different needs and preferences in the usage of communication interfaces. This means a person might want to use more than one type of device in order to display awareness information in the course of a day. A further aspect is that in the field of emotional communication, the look and feel of devices is essential.

In order to reflect the need for heterogeneous devices, a series of devices is presented in the following. The devices are categorized in the four categories Awareness Displays, New Communication Devices, Standard Communication Devices, and Configuration Devices.

Awareness Displays

Most awareness displays use ambient display technologies to represent awareness information. Ambient displays combine the paradigms of ubiquitous computing and calm technology in an aesthetically pleasing way. Displaying mostly non-critical information, they reside on the periphery of a user's attention and are designed to convey background or context information, that the user may or may not wish to attend to, at any given time (37). 'Display' in this context means any construction, which makes information perceivable. So an ambient display must not necessarily be a traditional display like a computer monitor, but it may also be a dynamic light installation, a water fountain or any other artifact, which is able to display information (38). In most cases, information is not visualized directly. On the contrary, different degrees of abstraction are used to display information, making it easier to be interpreted and requiring less attention (37).

Awareness Displays register to the communication infrastructure and subscribe to context data they are interested in. Ideally the communication infrastructure provides a unified and easy access to all type of context-data. This enables to easily exchange the type of the displayed data.

Intelligent Environments. Experiences with existing systems showed, that it is not useful to imitate face-to-face communication through high-fidelity media. 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 (39). As awareness information is usually perceived passively through continuously available cues with the physical environment, ambient representation

devices are favorable over solutions that appeal to main human perception (8).

In addition, the perception of awareness information does not require users to directly interact with the presentation devices. Hence, it seems appropriate to integrate the information within the very spaces the users occupy (40). Figure 6 shows an example of an ambient representation device designed like an abstract painting, embedded in an intelligent environment. Different patterns and their transitions can unobtrusively present awareness information (41).

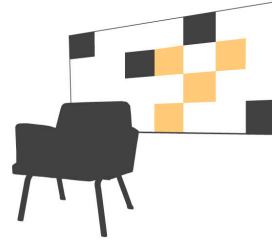


Figure 6 Ambient information representation via an Intelligent Environment

Auditory Displays. Auditory displays can be used to represent a broad variety of awareness information. They are capable of presenting information with different intensity levels, ranging from alerts to ambient notifications. An advantage is that the auditory scenery can sound complete and coherent, although the sound contents are independent of the information that is represents. An example is an auditory nature scenario, which represents the location of remote persons. However, the nature scenario could equally represent the number of personal notifications a user has received during the day. Connecting auditory displays to a common platform allows using the same auditory scenery to display different types of information, depending on the user's preferences and current context.

Wearable Artefacts. The awareness devices presented so far were mostly stationary and restricted to indoor use. But especially kids are always on the move and require mobile devices with easy to use interfaces. An example for such a device is shown in Figure 7. A traditional wrist watch is augmented with communication technology and a visual display to communicate constantly changing information.

In addition, short notifications can be send to other communication device connected to the platform. For example, by pressing a button on the watch, a 1-bit message (e.g., "Everything is fine") is send to a pre-selected user or group. In return a notification can then be represented via electrocutan mechanisms integrated in the wristband.

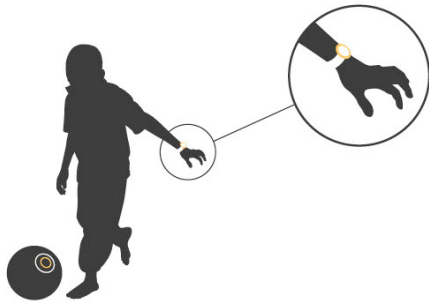


Figure 7 Smart Watch with an integrated awareness display and a Smart Ball to capture activity information

A further example of a mobile awareness device is Smart Jewellery. A user group for Smart Jewellery are elderly people. Modern communication devices often discourage them from staying in contact with their loved-ones because of the complexity of the devices. Integrating communication functionality in 'everyday' objects, like for example jewellery, can help to overcome the aversion against novel forms of communication (42).

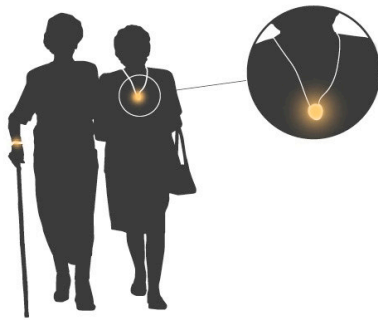


Figure 8 Smart Jewellery: The mood of a remote person is visualized via the light intensity of an intelligent pendant

New Communication Devices

New types of communication devices enable novel forms of emotional communication. An example for such devices, are one-bit communication artefacts, which transmits only a single bit at a time. The interpretation of the transmitted data is left to the users and depends on the current context. One bit might mean 'I'm home' or 'I think of you' (43). Similar to other awareness displays, those devices can register to the communication infrastructure and provide the ID of the current user. From then on, the device receives notifications intended for the registered user. Depending on the type of the device, it is also possible to receive notifications and messages provided by the communications platform. As all human senses can be addressed, there are almost endless possibilities for combining different input and output modalities. In search of new interaction devices, existing products are often enriched by adding new communication functions.

Smart Clothing. A further application domain for new communication devices is smart clothing. Smart clothing aims at augmenting fashion with communication and information technology. The clothing becomes smart and assists people in their everyday activities. It adopts a new role by turning into an interface for information and communication. The clothing enables to display information in more convenient and unobtrusive ways, without interrupting users in their current activities. Of particular interest is clothing that connects wirelessly to a mobile device a user is carrying. Via smart clothing, mobile devices can display information by using a wide range of modalities, e.g., light patterns (44) on the cloth or unobtrusive vibrotactile feedback. With the previously described communication infrastructure a mobile device can register to the NotificationService and from then on receives notifications for the current user. Notifications, which can be sent by any device registered to the infrastructure, are then displayed on the clothing. Figure 9 illustrates smart fashion mapping information unobtrusively to the clothing.



Figure 9 Smart Clothing: Communicating emotional information via heat

Augmented Everyday Artefacts. There are several objects, which most people constantly carry with them. A pen, for example, is a truly mobile artefact and traditionally used as a 'communication device'. By augmenting a pen with gesture recognition functionality, handwriting is transformed automatically into machine text and can be transmitted to other devices by using the communication platform. By twisting the rubbery ball at the end of such a smart pen, a pre-installed receiver is selected. Non-verbal communication can be supported by pressing the soft rubbery ball. The longer the ball is pressed, the more important the notification is rated. Beside these input options, the pen can also provide several output options. Awareness information can be displayed by illuminating the ball using different colors. Notifications can be indicated through vibrations or additional sound. With an integrated display text messages can be displayed.

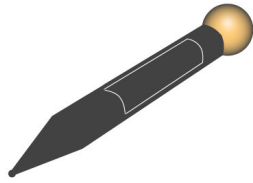


Figure 10 Smart Pen supporting multi-user communication

Standard Communication Devices

This category comprises devices, that display information using traditional output channels. Standard communication devices usually use auditory or visual displays. A typical example is a smart phone. Smart phones are widely popular and accepted in manifold environments. Some users might prefer traditional devices in certain situations, e.g., during work, in order to be connected to their remote loved-ones. Therefore, it is important to support these devices even though they might not be the most suitable devices to communicate emotional awareness. A smart phone might allow a user to receive notifications and at the same time provide awareness information by displaying the activity of remote persons on the screen.

Configuration Devices

Since the platform enables multiple users to communicate and stay in touch, configuration can be a complex issue. In addition to standard configuration via graphical interfaces, the platform is designed to support tangible configuration devices. These devices attempt to reduce complexity for the user by making the configuration tangible.

The configuration device enables users to configure with whom they want to share which awareness data. To simplify the design of the configuration device and to provide a better overview, it was decided to implement three groups of users: intimate, close and distant persons. These groups have a pre-defined selection of values which will be associated to their members. Besides having defined groups of persons, it is possible to configure the relation to each member individually. Furthermore there is an option to stop the transmission of personal data without losing the configured personal settings.

Design of the Configuration Device. If a user wants to be connected to a number of friends there are manifold possible configuration combinations. Thus, the main focus regarding the form factor of the device is to reduce complexity of the configuration process.

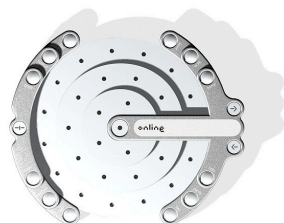


Figure 12 Top view of the configuration device

The configuration device consists of rings surrounded by four groups of three buttons (Figure 12). Each group of buttons represents a parameter for shared awareness data, e.g. location. In the current design there are three values for each parameter. Each of the three rings is a metaphor for a 'circle of friends', ranging from intimate to distant. The inner ring at the top level provides 4 sockets, the middle ring 9 and the outer ring 14. They stand for the increasing amount of persons which can be assigned to the defined groups.



Figure 13 Example for different figurines representing real world users

Persons are represented by small figurines defined by an iconic representation of a female, a male and a child (Figure 13). Beside their form the avatars can be distinguished from each other by their illuminating color. In standby mode they are clear. Since the design of the avatars is arbitrary, a range of different forms is possible to satisfy the needs of individualization. The only requirement is that a figurine must have a cylindrical base with an electric connector which can be plugged in a socket of a ring on the configuration device.

Configuration of User Profiles. If the user wants to define the type of awareness information that is sent to a certain person, she touches the figure. When a figurine has been touched, the current configuration is displayed through the illuminated buttons (Figure 15). Each group of buttons represents one awareness parameter, e.g., location. By pushing the buttons of one group, the user configures one type of awareness data that is sent to this person. A group of persons can be configured by touching one of the rings. All persons plugged in on this ring are then affected by the changes the user makes.



Figure 14 Configuration device configured to share awareness information with 5 persons.

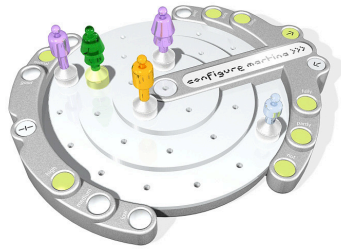


Figure 15 Configuration of the relation to an individual person

Tangible Notification Device. The main purpose of the device is to configure which personal data are transmitted to whom. Besides this, the device is able to display notifications. If a notification for a user arrives, the figurine blinks and the avatar base lights up. If a blinking figurine is touched the message is displayed on the device (Figure 16).



Figure 16 Blinking figurines indicating new messages

CONCLUSION

This paper presented a holistic concept for supporting awareness and emotional communication between multiple family members, distributed over several intelligent home environments. It was shown, that current home awareness systems fail to meet basic user needs as they only support peer-to-peer communication.

It is further argued, that awareness systems for the home domain must not only support multiple users to simultaneously stay aware of with each other, but that they also have to provide diverse interface concepts, tailored to the specific abilities of the different types of users.

To demonstrate the validity of this argumentation, a technical concept for a communication infrastructure was presented, which allows connecting different types of input and output devices. This conceptual model was extended by several examples of emotional user interfaces, which addressed the individual needs of different age groups. It was shown how these different types of interfaces interact with each other and thus enable multiple persons to stay in touch with each other, using their own personalized devices.

The different interface concepts presented in this paper successfully demonstrated, that dedicated devices for capturing and representing awareness information in smart home environments have great

potential to enhance usability in multi-user awareness systems. The artefacts have to be seen as a foray into a new age of user interface design, with a variety of novel interaction techniques and artefacts still to come.

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