address: social awareness and task-oriented awareness.

We consider *task-oriented awareness* as the awareness that is focussed on activities performed to achieve a specific shared task. This kind of awareness can be promoted by change notifications or information about the state of a certain document or a shared workspace. It allows users to coordinate their activities on the shared object. This might happen either in a synchronous or asynchronous way. Notifications that contribute to the task-oriented awareness, embody information on who does or did which actions on which shared task or task-related object.

Social awareness includes information about the presence and activities of people in a shared environment. Systems focussing on social awareness provide notifications similar to the information received when walking along an office floor. Notifications that contribute to the social awareness embodies information on who is present and in which state in a shared environment.

The difference between task-oriented and social awareness is primarily determined by the shared context. For task-oriented awareness the shared context is established by an object that is part of a cooperative process, for social awareness it is the environment that is inhabited by the users. We believe that it is essential for a cooperation support environment to support both types of awareness. However, looking at the different systems it appears that most are concentrating on the support of either of these types. Gutwin et al. (Gutwin, et al., 1996) distinguish additional forms of awareness, but for the following considerations a concentration on these two forms is more appropriate.

GroupDesk (Fuchs, et al., 1995) or Interlocus (Nomura, et al., 1998) are examples for systems that provide task-oriented awareness. They supply a shared workspace for the support of asynchronous cooperative work. Changes to shared objects are indicated to users by visual notifications. All notifications are closely associated to the shared objects.

Video based systems such as Portholes (Dourish, Bly, 1992, Lee, et al., 1997) increase the social awareness of people in a shared environment, e.g. an office building. Systems like Social Awareness@work (Tollmar, et al., 1996) provide social awareness by an indication of the presence and state of people

For the Internet and the World-wide web many systems are being developed that supply information on the presence of other users in the Internet or on a currently visited web-page. Probably the most successful application is ICQ, a tool that informs users about the Internet-presence of other people. More sophisticated applications such as CoBrow (Siedler, et al., 1997) present the list of users who are currently visiting a web pages and offer additional communication channels. All these systems belong to the group of social awareness systems. They display information on the presence of others in a shared environment.

Room based systems represent an approach to integrate social and task-

oriented awareness. Examples are: Diva (Sohlenkamp, Chwelos, 1994) or TeamRooms (Roseman, Greenberg, 1996). In these systems virtual rooms provide a shared location for the organisation and collection of task-oriented objects. For users who cooperate on a task and thus share a room, the information that somebody is working on a document, contributes to the task-oriented awareness Social awareness is increased by supplying general information about the presence of people in virtual rooms or buildings. Another approach for the integration of social awareness into a task-oriented system, i.e. the BSCW (Bentley, et al., 1995), is the MetaWeb (Trevor, et al., 1997) application.

Most of these applications either augment a single application, such as a shared application tool (Dourish, Bellotti, 1992), with additional awareness features, or they provide a new cooperation environment that embeds other applications and incorporates notification mechanisms to inform users about relevant cooperative activities. Common to the second group of applications is, that they provide a new desktop interface and that users who want to benefit from the awareness functionality need to perform all their cooperative work using these desktops, e.g. as in DIVA, GroupDesk or TeamRooms. Since most users are very reluctant to change from one working environment to another, just for the benefit of a single new feature, such awareness augmented platforms are very valuable for the evaluation of specific awareness features, but they seldom have the potential to become a general purpose working environment.

Further characteristic of these systems is that they primarily focus on the support of a specific application and that they do not interweave mechanisms for the support of social and task-oriented awareness. Moreover, most are designed as closed solutions which can not be extended in a simple way

We believe that a more promising approach is the provision of a generic extendable awareness infrastructure including simple and lightweight mechanisms for the generation and user configurable presentation of notifications at the standard desktop interface. This is the motivation for the NESSIE awareness environment that is described this paper. First we give an overview of the conceptual model and the architecture, followed by a description of different sensors for the reception and generation of events. Then we describe different methods for the presentation of awareness information. Two scenarios illustrate the applicability of the environment. The paper concludes with a discussion of related work.

Conceptual Model

It is essential for a general purpose awareness environment to provide its services application independent. Experiences with PoliAwaC (Sohlenkamp, 1998), show that a presentation of awareness information just within an application is not sufficient. It is necessary that relevant events about user activities can be

externalised from one application and promoted to other applications. Thus users can stay aware about important events and activities even if they are not actually using or running a particular groupware system. Principle for NESSIE is therefore that it supplies its services application independent as an awareness bridge for different applications and settings. This should also allow for a mixture of events from real world and electronic settings.

The conceptual model of NESSIE is based on the approach that information about cooperative actions that are relevant for the awareness of the state of a co-operative setting can be captured through the generation of events. Events are generated by sensors that are associated with actors, shared material, or any other objects that constitute or influence a cooperative environment. They contain identifiers of the originator, the action, the time, and the context in which the action took place (e.g. shared workspaces, cooperative process, workflow).

The reception and generation of activity events is enabled through the realisation of lightweight *sensors*. Different sensors should be provided by the infrastructure for the integration into other applications, such as document change notifications, presence sensors, or information monitoring agents. Additional sensors should be realisable without a large effort, i.e. the environment should supply simple protocols for the interaction with sensors. Sensors are not restricted to the reception and generation of events in electronic environments. In the near future, sensory environments will emerge and will become integral part of our working and living environments (Saffo, 1998). Thus the infrastructure should integrate real world sensors to recognise activities and states of places in the "real world" and to promote this information to other real or virtual places.

After creation, an event is transmitted to an awareness server. An important task of this server is the propagation, transformation, and notification of events. Several models exist for the computation of that task. In (Mariani, Prinz, 1993) a model based on the water-ripple metaphor is presented, that interprets the relationships between shared objects as a transport media for events Following that approach in (Fuchs, Pankoke-Babatz, et al., 1995) and later in (Fuchs, 1998), the notion of interest profiles is introduced as a method to specify the awareness information someone is interested in. Empircial studies of that concept in the PoliAwaC groupware client show, that this is a suitable specification method (Sohlenkamp, et al., 1999). Thus we have adopted that notion and concept for the event distribution and notification method of the NESSIE environment.

Alternative approaches are suggested by the spatial model presented in (Benford, Fahlén, 1993) and its generalisations and extensions in (Rodden, 1996) and (Sandor, et al., 1997). We believe, that CSCW research is still lacking enough experiences to decide which model is the most appropriate for a specific setting. Therefore we propose implementations of these models as plug-ins to the awareness server. This will allow a setting based selection of the appropriate model.

The presentation of awareness information is performed by configurable

indicators. Tools are offered that allow an easy mapping of activity events to suitable indicators. Analogue to real world sensors it is also possible to integrate real world indicators such as the artefacts proposed in (Wisneski, et al., 1998) with the NESSIE environment to foster awareness of virtual presence and remote activities beyond the limitations of a computer monitor.

The NESSIE environment is not intended to support highly synchronous applications such as application sharing systems that rely on a high frequency of technical synchronisation events, e.g. mouse-clicks or scroll events. The NSTP (Patterson, et al., 1996) platform provides a suitable support for such applications. We aim at the support for action relevant events that increase the social and task-oriented awareness of the cooperation status, not of the technical application status. Such kinds of events occur in a lower frequency, allow for other architectures and demand new ways of information presentation.

Architectural Overview

An awareness environment should be integrated with and based upon current Internet technologies. Beyond the advantage of an easy distribution of the environment, the interoperability of the environment with other applications can be more easily achieved. Many applications offer communication interfaces to Internet services In addition to that baseline, the following requirements, derived from the considerations of the conceptual model, guided the design of the NESSIE awareness environment:

- application independent infrastructure;
- open, extensible protocols for the interaction with the environment;
- lightweight sensors and means for an easy realisation of new sensors;
- configurable set of indicators and means for integrating new indicators;
- integration with web-technology to provide a high level of interoperability.

The following sections first give an overview of the systems architecture, then specific aspects such as access control and reciprocity are discussed in more detail.

Architecture

Figure 1 illustrates the architecture of the NESSIE awareness environment. Central components are the NESSIE server in combination with the event database and the NESSIE client. The server supports two methods for the production and provision of events: asynchronous (pull) server interaction by a cgi-interface or synchronous (push) notifications based on registered interest profiles by the NESSIE client. Both methods are described in the following two subsections.

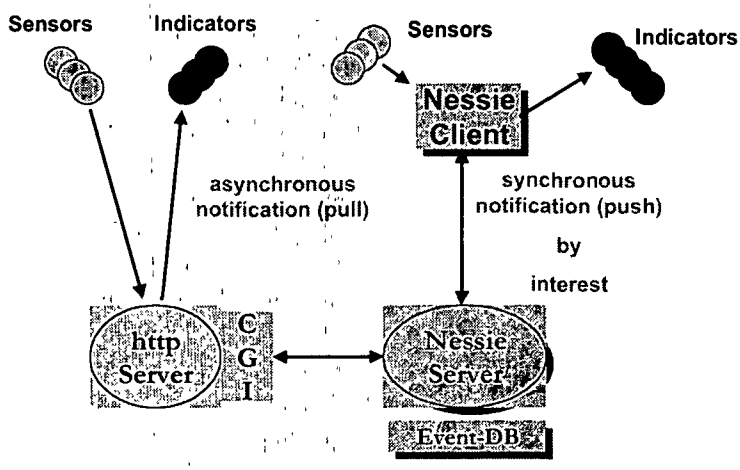

Figure 1 The NESSIE Architecture

Server Interaction via http

A very simple technique is provided for the interacting with the server using cgi scripts (left hand side of Fig.1). This interface allows the submission of events via http-calls of a cgi script. The script interprets the call parameters that consists of attribute-name/value pairs, as a event descriptions.

The event protocol is open and can be easily extended. The server requires only the provision of the two parameters: sensor-type and event-type. All other parameters can be dynamically defined. The creation of a new, or the extension and modification of an existing event-type requires no server-side modifications. Optionally, for common reference, event-type specifications can by documented in the event-type registry (an HTML-document). This registry provides a set of well-defined core-events and is furthermore used by the NESSIE client to create user interface templates for the specification of event-queries in interest profiles. The expiration date of an event can be specified by a special attribute. After the expiration date this event is no longer returned to any event-query and will be transferred with next event garbage collection into a history database

The cgi interface offers a showevent-operation for event-queries. Regular expressions can be used as parameter values to describe generic event-patterns. The format (lists, HTML-documents) and content (number and types of returned attributes) of the return-result can be controlled using additional control attributes.

By the provision of this cgi-interface it is possible for a wide range of applications to report events to the NESSIE server. Through this externalisation, information becomes available for users outside of a specific application domain. For example, the integration with the MS-Office suite was easily realised by the implementation of simple macros. These macros signalise document

modifications to the NESSIE environment and they indicate the document history or other relevant events, e.g. modifications on related documents or the presence of co-authors of that documents, by retrieving event information from the server.

With the cgi-interface for event generation and retrieval the NESSIE environment can be easily integrated as an application independent awareness bridge into legacy infrastructures. Dynamic event types are a key factor for scalability and enable the application of NESSIE in different organisational boundaries. However, the http solution embodies the disadvantage that applications must explicitly pull the NESSIE server for new events. Accordingly, this mode of operation can not be used for settings where events must be immediately processed or indicated, but provides appropriate means when loosely coupled interactions are sufficient. The following subsection describes an alternative mode.

The NESSIE Client – Support for Interest Profiles

The right hand side of Figure 1 illustrates the interaction of the NESSIE client with the NESSIE server. The client is user specific and represents a user within the environment. It realises the following functions:

- indication of the currently online NESSIE users and provision of ad hoc communication tools;
- a user interface for the specification of interest profiles;
- a communication interface to the server for the registration of interest profiles and receipt of events that have been submitted by sensors;
- interfaces to configure and communicate with awareness indicators.

When users log into the NESSIE client their presence is indicated to other users. On demand they will receive events that have been submitted since their last presence, that match their interest profiles and that have not yet expired.

In this section, we concentrate on the concept and support for the specification of interest profiles. Users describe their interest in events by the specification of interest profiles. An interest profiles contains the specification of:

- an event-query describing the events that are relevant for that profile,
- the indicator that is used to present that event,
- and a specification of the actual event information that shall be presented by the indicator.

Figure 2 shows the user interface of the client for a profile description. First, the user has to specify the indicator and indicator-type that shall be used to present the event For that purpose the NESSIE client provides a number of pre-registered indicators (see section below). It is possible to indicate different events by a single indicator. In this case a single indicator can by used as unique place for the presentation of events that originate in the same context. For example, all events produced by the modifications of a certain document set or by the presence of people that belong to the same organisational context, e.g. a project can be presented by a single indicator.

In the second step, an event-pattern is specified applying the same language that is used for the cgi-interface. An event-pattern is registered at the NESSIE server by the client. Whenever the server receives an event that matches the registered event-pattern, it immediately forwards all event attributes to the client. Users can select the event-pattern either from existing profiles or they can create new patterns. If the event-type specification is documented in the event-type registry, then the NESSIE client dynamically creates user interface templates that support the specification of event-patterns.

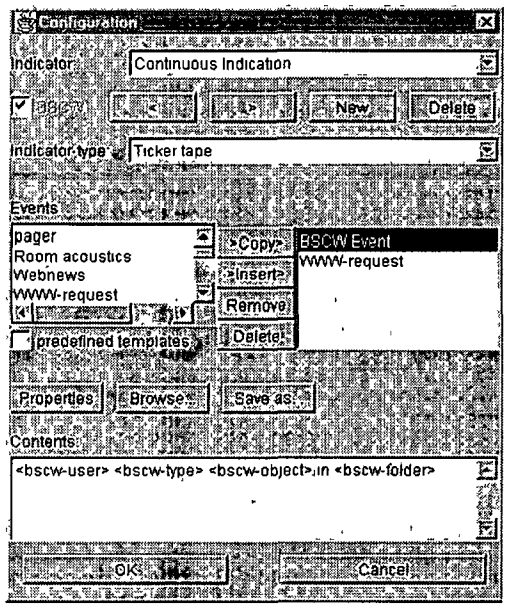

Figure 2: The configuration window of the NESSIE client user interface

In the third step, users specify the event attributes that shall be presented by the selected indicator. Explanatory text can be added to the selected attributes if the indicator supports a textual presentation. In addition to the list of pre-registered indicators, it is also possible to launch external applications such as media players and to forward event attributes as parameters to these applications. This allows for an easy integration of new indicators into the awareness environment.

Initially the NESSIE client stored the whole user configuration at the users computer. The application of the client quickly indicated that users wanted to exchange their interest profiles. This led to a redesign that allows the storage of single interest profiles as single objects in a BSCW shared workspace. The sharing of profiles between different users offers new opportunities for the configuration of awareness information within a group. It is for example possible to use a shared workspace for the administration of group-wide interest profiles,

i.e. profiles that each member of the group should use. Individual profiles can be added by retrieving profiles from additional workspaces. When a user launches the client, the user profiles are read from the workspaces and registered at the NESSIE server.

The provision of two interfaces (cgi and NESSIE client) by the NESSIE server enables different modes of interaction between client applications and the server. Ramduny et al. propose a taxonomy for the classification of notification servers (Ramduny, et al., 1998). The sensor-server interaction fits into the category A2 ("client tells server"). Category A4 ("server bound to data") is supported too, because of the close association of the event database with the server. This enables the server to provide notifications of past events which is important for the support of asynchronous working modes. The indicator-server interaction covers B2 ("server tells client") and B3 ("client polls server").

Access Control and Reciprocity

An often discussed awareness issue is the danger of misusing awareness information for control purposes. We address that problem by the introduction of event access rights and the disclosure of interest that others have registered in events that a user generates by interacting with shared objects.

An event that is submitted to the NESSIE server can be protected against unauthorised access by the inclusion of an access control attribute. This attribute lists the ids of users or a group of users who are allowed to receive that event. For simplicity the usage of the cgi-interface to the NESSIE server requires no authentication. Therefore access protected events can not be retrieved through that interface. However, the client requires a login on start-up for user identification and for the retrieval of the users interest profiles from the BSCW workspaces. The user identification is presented to the server together with the registration of the interest profiles This enables the server to perform an access validation on protected events. If the identified user is member of the access control list, a protected event is forwarded to the respective NESSIE client. With the introduction of access control for events the awareness environment ensures that activity information can be made visible to a restricted group only.

Although access rights are a suitable method to restrict access to awareness information, it can not guarantee to exclude misuse. An approach towards that problem is the provision of reciprocity. This is achieved by disclosing those users who have registered interest in event to those users who produce the event – "when you see me I see you". Whenever an event is submitted to the NESSIE server this information can be requested by inclusion of a special "observer" attribute into the parameter list. The return information lists those users who will receive that event instantly and those who are potential recipients. Potential users are those who have registered interest in that kind of event, but who are not

currently running a NESSIE client. If the event is not already expired, they will be informed the next time they start NESSIE client.

This information is useful not only for the support of reciprocity. It further informs a user about the list of people who will become aware of the activity that is indicated by the event. This is important when a certain reaction is expected on the activity that raised the event. Users who participated in the field study of the PoliAwaC client considered that functionality as very important. Borning and Travers (Borning, Travers, 1991) experienced a different user behaviour in their evaluation of Polyscope. The symmetry functionality offered by Polyscope was not considered as useful. We assume that the reason for the different receptions of this functionality is grounded in the fact that Polyscope provides synchronous awareness, while both PoliAwaC and NESSIE aim at the provision of asynchronous awareness. In the asynchronous case events are not that volatile, i.e. it is more important to know who is able to receive events later in time. Another fact is that in video-based systems reciprocity can easily cause disruptions (Hudson, Smith, 1996), while NESSIE allows for the configuration of less intrusive indicators. Borning, et al. report that users actually preferred less intrusive bitmap images over full video and NYNEX portholes users required the indication of the audience in the main display (Lee, Girgensohn, et al., 1997, pg. 391).

Event transformation

An event transformation module of the NESSIE server allows the transformation of submitted events. This functionality is useful for two purposes. First, it allows the mapping of events into other event-types to transform the event semantic. It is used for example to map noise and move events that are submitted from room sensors into more general events that indicate activity in a room. Second, it enables forwarding events from one NESSIE server to another one at another location. This contributes to the scalability of the environment and provides in addition a bridging function for the exchange of selected events between two settings that both use a local NESSIE server.

Sensoring Activities

This section gives a brief overview of the sensors that have been developed for the NESSIE environment. Sensors are used to create and submit events to the NESSIE server. Sensors are not necessarily software based. We have also integrated real-world sensors as we will see in the following.

Presence sensors are used to detect the presence of people in a certain place or at a certain location. We understand places or locations as real places or as locations in an information space. Therefore we have developed software sensors,

that can be integrated into web-pages, BSCW workspaces, or a computer desktop to sensor the presence of a person at a certain location. In addition, sensors based on video image motion recognition, infrared-motion detection, and photoelectric barriers have been realised to sensor the physical presence of people in a room. The event information and precision differs between these sensors. Some are able to identify the event originator because they are located at a location where users need to identify themselves, others forward anonymous events only. The utilisation of that information differs, too. Presence sensors in information spaces are primarily used to indicate the presence to people at the same location in the information space. This promotes the social awareness of others and turns information objects into places and encounters where others can be met. The application domain for real world sensors are public rooms, e.g. coffee rooms. Presence information about these places is primarily used by people at other locations who want to stay aware of the social activities in order to decide if they want to join in.

The cgi interface enables the introduction of presence sensors into closed environments, such as Active Worlds, a multi-user virtual world that allows users the creation of their own places and buildings. People spend an enormous effort into the design of their houses, but it happens rarely that someone meets somebody else at the own house (Fuchs, et al., 1998). It would be a helpful feature being able to detect if somebody is approaching a place, even if one is not currently running the Active Worlds client. An externalisation of presence information can solve that problem. The Active Worlds system provides a function to combine a collision event with a call of a web page. This is often used to pop up web pages when users enter certain places. We are using that function to create a presence event through the cgi interface By registering an interest profile for that event it is possible to become aware of the presence of others at a particular place in Active Worlds and to join in immediately.

Task and activity sensors are used in combination with shared material to indicate modifications to shared documents. Simple macros have been developed as sensors for MS-Office documents. Embodied in a document they create events whenever a document is modified. These macros are also used as indicators. They report about past actions on that or related documents and the current presence of co-authors. The integration of sensors with the BSCW systems allows the externalisation of user activities in shared workspaces.

Real world activity sensors include acoustic sensors that measure the noise level and map that onto a discrete set of activity levels, i.e. silence, smalltalk, discussion, or even party using the servers event transformation module. The installation of such a sensor in a coffee room allows the perception of the activities without being able to observe and control in detail what's going in. This distinguishes these kind of low-fidelity sensors from a web-cam which obviously provides a clearer view of the activities in a room but also more sophisticated means for control which may violate privacy.

Content watcher sensors are realised to observe the content of web pages for the occurrence of special keywords. These sensors are used to observe web pages that report traffic news, weather reports and news. For example, users can configure a sensor that creates events about traffic jams on the way home observing of a traffic report web page. Other content watcher sensors are used to create events based on an extraction of news from newspaper pages. By configuring an appropriate indicator for such events, e.g. a tickertape, users can create private push channels with the NESSIE environment.

The sensors introduced so far are sensors that automatically create events based on the occurrence of a specific situation. Additionally, NESSIE provides web pages for the manual creation of events. This is used to announce meetings, internal news, or visitors to our research group.

Early experiences show that these sensors provide a good starting point for the generation of events that foster awareness about the task-oriented and social activities in a cooperative environment. We believe that the ubiquity of internet tools and the extensibility of event-types makes it easy to develop and integrate new sensors into the NESSIE environment.

Presentation of Information

Gutwin et al discuss a number of awareness widgets in (Gutwin, et al., 1996) Their work is focussing primarily on presentation methods for awareness information in synchronous work on shared material. The various awareness widgets are tightly bound to the shared objects and workspaces. Furthermore the presentations are internal to the shared application, i.e. the awareness information is available only for users who are currently using the application. PoliAwaC is an example for a user interface supporting asynchronous work that also uses awareness widgets (coloured icon overlays, icon enlargements, etc). These are closely bound to the shared objects, too. The association of an awareness widget with the shared object has the advantage that the awareness information is presented in the context of its origin, i.e. the associated object.

NESSIE aims at the presentation of awareness information for more loosely coupled modes of cooperation that are not restricted to the simultaneous use of shared material Additionally NESSIE aims at the externalisation of awareness information from applications to promote this information also to users who are not currently working with the system. Therefore we need to consider presentation methods that are not tightly coupled with the objects of origin.

This section presents examples of presentation tools for discrete event notification, for the indication of virtual presence through real world indicators, and for the presentation of awareness information in a cooperative context.

Discrete Event Information

The NESSIE client provides a number of indicators for the discrete presentation of events. These include simple windows for the listing of event information, different background images, or sounds. Applet indicators have been developed to show the presence of others on a currently browsed or on related web-pages.

For the presentation of news, activities in shared workspaces, and visitors to web pages of our research group, the tickertape has proven useful (Fitzpatrick, et al., 1998). The actual appearance of an event in the tickertape can be specified individually using the NESSIE client.

Event indicators such as the tickertape are suitable for the presentation of single events that require a textual representation for being understood. In the following sections we discuss the transfer of events to a presentation by real world indicators and in a contextual presentation of a cooperative setting.

Virtual Presence Through Real World Indicators

The limited screen real estate raises a problem for all monitor based indicators. Users prefer a full screen mode of their applications. Consequently, awareness indicators are always in danger of being quickly overlaid by other windows. One solution to that problem is the use of additional screens in the periphery of the main monitor or projections onto the background of the users computing screen (see Fig. 3). Another solution is the utilisation of tangible interfaces (Ishii, Ullmer, 1997) to foster awareness through ambient indicators.

We are particularly interested in the design of real world indicators that promote a sense of virtual presence. An example for such an indicator is the activity balloon. This indicator consists of a tube that contains a fan. Within the tube resides a balloon that is blown out and that circulates above the tube when the fan is activated. The fan itself is connected to a computer by an interface card that can be controlled by the NESSIE client. Thus it is possible to use the activity balloon as an indictor for any incoming event. We found the activity balloon in particular useful for the indication of visitors to a web-cam. The faint noise of the fan and the dancing balloon produce an ambient feeling for the presence of a virtual visitor who is accessing the web-cam. It supports peripheral awareness and reciprocity of seeing and being seen. Because it is an indicator that is rather overheard it avoids disturbance of the actual work.

The activity balloon operates also as an actuator. If a user removes the balloon from the tube the web-cam is switched of by a switch that is integrated into the tube. This combination of an indictor with an actuator turns the activity balloon to a tangible interface for virtual presence.

An extension of this indicator is the balloon theatre that combines several tubes into a single indicator. Each balloon can be controlled individually, i.e. different balloons can be bound to different incoming events Examples are the presence of

visitors at a set of web pages, in different virtual rooms of a VR environment, or in rooms of a real building. Mixing the indication of presence events with activity events, this indicator can be used to indicate bustle activity of an environment.

Information in Context

The indicators presented so far are suitable for the discrete presentation of events. For other settings, awareness of the activities in a cooperative environment can be better achieved when awareness information is presented either in the context of work or in a social context. This section presents approaches for each of these alternatives.

A BSCW shared workspaces represents a context for a group of people who manage and share their working documents by that workspace. The BSCW user interface uses a number of different awareness icons to indicate actions on shared documents. This presentation is helpful to find out about the activities on a single object in detail, but it is difficult to become aware of the current and past activities within the group or on the particular activities of a group member. The new monitor tool (Trevor, Koch, et al., 1997) provides a better synchronous awareness of the current activities, but it still concentrates on the actions at a single object level. Especially after a temporal absence, it is difficult to find out what has happened. In such situations it is more likely to ask "What did people do?" than "Which operations have been performed on which objects?".

NESSIE provides that awareness information by the presentation of pictorial activity indicators for the members of a group as part of the shared workspace user interface. User activities in a shared workspace are received by the BSCW sensors and submitted to the NESSIE server. These object specific events are collected, interpreted and transferred by the event transfer module into an activity description for the members of a workspace. We distinguish between the activities: reading, contributing, absence. A mixture of activities is possible. Special indicators are included into the workspace user interface that retrieve this information from the NESSIE server and map it onto a comic-like, animated pictorial presentations (using "animated GIFs"), that display the activities of the group member since the last visit. This gives a user a first overview on the past activities in this specific work context.

Additionally, we investigate the presentation of awareness information using the 3D multi-user environment SmallView (Broll, 1998). The 3D environment is used to build different rooms, each room representing a different context (Figure 3). A context can be either an organisational context, e.g. a project, or a spatial context, e.g. a coffee room. A project context for example, combines different visualisation methods for the display of presence or activity events. These events originate from presence and activity sensors that are located in shared documents, workspaces, and other project related material. Events produced by real world

sensors that are located for example in a coffee room are used to drive the presentations of the virtual rooms.

The 3D indicators are not intended for navigational purposes, i.e we do not intend that users navigate between rooms using the 3D interface. Instead they perform their work using their normal office- and groupware-applications. Sensors recognise when a users work affects the state of the cooperative environment or when a user changes the working context, e.g. by switching between different shared workspaces or folders, or by processing documents that belong to different contexts. The events that result from these actions are interpreted and the avatar that represents the user is moved to the appropriate room in the 3D environment. McGraths pertinent phrase for that technique is "let the system do the walking" (McGrath, 1998, p 22). In addition to moving a users avatar around, the state of a user is also mapped onto the animation of the avatar. At the moment we distinguish between the states: idle, reading, and writing.

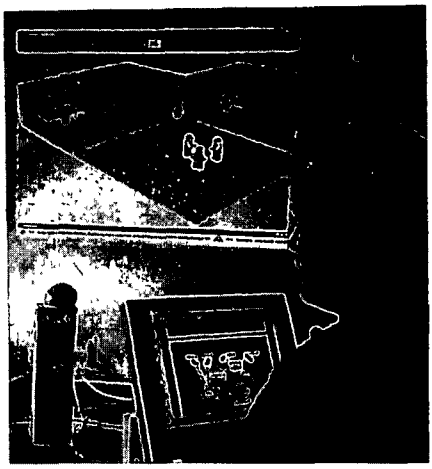

Figure 3: Ambient display of a 3D world that indicates the activities of users in several BSCW workspaces as well as in a public coffee room.

Using the 3D indicators, users are able to the get an immediate overview of the task-oriented, but also of the social activities in their environment. With the integration of instant communication media new social encounters emerge through the 3D indicators. Users can see who else is currently working in the same context, they can immediately communicate with these people, or they may decide to stroll to the coffee room because the corresponding 3D indicator shows activity.

One might ask why we do not use video based media spaces. The difference is that video based systems do not allow the creation of artificial rooms as we do with the organisational context based rooms. From a video image it also difficult to guess what type of operations a user is currently performing on shared material. By the visualisation of a users action through symbolic animations of the users

avatar this kind information is much easier to present. For the perception of real rooms video is a very useful approach. However, the advantage of symbolic representations based on acoustic sensors and motion sensors is the provision of a higher grade of inaccuracy, thus protecting more privacy. Observers can see a level of activity, but they can't see who is actually acting. Video images can be blurred to reduce the accuracy of the original, but we believe that a sharp 3D visualisation is more attractive than a blurred video image.

The problem with 3D indicators is that the amount of required monitor space is higher than the space that is normally left when users run their everyday applications. For the use of these indicators we therefore envisage an office scenario with peripheral monitor screens or projections onto the background of the users monitor.

Related Work

A protocol for presence awareness for web users is presented in (Palfreyman, Rodden, 1996). The proposed architecture includes also an awareness server and client. However, both the architecture and the protocol are intended for the provision of presence awareness on web pages. The authors do not consider the provision of a generic awareness infrastructure.

The Notification Service Transfer Protocol (NSTP) (Patterson, Day, et al., 1996) presents a more comprehensive approach. In contrast to NESSIE the NSTP infrastructure is developed for the support of synchronous groupware applications. NSTP supports event exchange for the synchronisation of shared applications, while NESSIE supports the exchange and externalisation of activity relevant awareness information.

"Buddy Lists" application such as ICQ or AOL messenger are widespread presence information tools. Since recently an IETF working group is developing an instant messaging and presence activity proposal (Saraswat, 1998) which results in PIP, a "Presence Information Protocol" (Mohr, et al., 1999). These proposals are focussing on presence awareness only, other forms of awareness are not investigated. The scope of NESSIE goes beyond presence awareness, but we observe the standardisation initiatives and plan to incorporate the PIP protocol in future versions of the NESSIE server.

In summary, non of these approaches considers the provision of a generic awareness infrastructure including a set of application independent sensors and indicators. They are either infrastructures for the support of mainly synchronous applications, e.g. NSTP, or they require the use of new applications. A configurable mapping of awareness information on configurable indicators is also out of their scope.

More related to NESSIE are the internet notification service Elvin (Segall, Arnold, 1997) and Khronika (Lövstrand, 1991). Elvin is a publish-subscribe noti-

fication service where consumers use content-based addressing to select notifications of interest. The developers consider the application domain for Elvin in area of network management, legacy application integration and as an infrastructure for computer-supported cooperative work. Khronika is an event browsing and notification system that addresses the problems of information overload and information distribution. Key elements are events, daemons, and notifications. Initial motivation for Khronika was the information overload caused by the massive distribution of undirected event-information, e.g. through email list. The system provides a central service for the management of such events. Users can express their interest in events by constraints that are observed by daemons. Instead of being swamped with email announcement users can select the information they want to be aware of.

The NESSIE infrastructure provides a generic and open platform for the submission, transformation, and notification of events that are relevant for the promotion of task-oriented and social awareness in a cooperative setting. The provision of event access control, the support for reciprocity, the event transformation functionality, the sharing of interest profiles among groups, and integration of real-world sensors and indicators as well as the transformation of discrete events into a contextual presentation are unique characteristics of the NESSIE environment.

Conclusion

In this paper we have introduced the awareness environment NESSIE. Key elements of NESSIE are an application independent generic infrastructure, an open and extendable protocol including dynamic event types, and a set of sensors and configurable indicators, both for discrete and contextual event notifications. The NESSIE server supports access control, reciprocity, different interaction methods, and implements a subscription method that is based on interest profiles. With the integration of real-world sensors and tangible interfaces for the presentation of awareness information, NESSIE enables new ways for the provision of task-oriented and social awareness.

NESSIE supports distributed team members in providing and receiving awareness information on the task-oriented progress, but also on the social activities at the local and remote sites. The various discrete event notification mechanisms are suitable for the indication of task-oriented activities, in particular on time critical work items. For example users can register interest on documents or shared workspaces so that they are immediately notified about all activities on these document spaces. In addition, the 3D indicators can be used to become aware of the activities of remote team members. The real world indicators can be applied to create a cooperative ambience by indicators for virtual presence between remote sites. Another aspect of the NESSIE environment for virtual

teams is the support of the team building process: By the provision of mutual awareness on the actual and past presence of others within an Intranet information space it is possible to create chance encounters. These encounters support people in finding coworkers with similar interests and thus can facilitate a team building process.

Future development work concentrates in the realisation and integration of alternative awareness models such as the spatial model into the NESSIE server. The current NESSIE environment is in use by our research group. Initial experiences indicate that the approach of an application independent awareness service is promising. The open protocol and the flexible configuration of the NESSIE client and indicators supported the ad-hoc integration of new sensors and the rapid realisation of new ideas for the presentation of awareness information.

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