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PACIS 2000 Proceedings

Pacific Asia Conference on Information Systems (PACIS)

December 2000

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Abstract
The popularity of the World Wide Web (WWW) has increased exponentially during the last few years. WWW techniques provide a simple and convenient interface, which is accessible almost everywhere, but which does not support tools for user interaction, due to the lack of mechanisms to support awareness. The aims of this paper are twofold. First, it presents the general concepts of situation awareness from the perspectives of user interaction on the WWW, and then a theoretical framework, which is used in examining existing awareness support systems. Second, our own system, People Awareness Engine, which supports situation awareness and enables user communication and collaboration on the WWW without any installations on the user's side, is presented and analysed.

Keywords: WWW, Awareness, CSCW, interaction, communication.

1. Introduction

What is a group? Or, by extension, what is group work, and what are its basic features? From the sociological point of view, Hughes et al. (1991) defined that all work, which is socially organised, is group work. According to this definition, every type of work, where several participants are involved, is group work, e.g. shopping (which includes electronic commerce (EC) in its' widest sense) is group work because there are at least two participants involved, a customer and a vendor. Schmidt and Bannon (1992) argued that co-operative work is a much more multifaceted issue, which can not be defined in one sentence. They claimed that co-operative work has several characteristics. For example, co-operative groups are large or part of a larger group; groups are transient, and their membership is unstable and often non-determinable; the pattern of interaction changes dynamically; and co-operative work is physically distributed. In addition, another set of elements can be drawn from face-to-face meetings and other traditional group work sessions. In those situations, the group members can see each other and the actions taken within a group, as well as actions performed around the group at all times, i.e. the participants are aware of several activities which may, or may not, be related to the group or its tasks. Also, the members of the group can easily share documents and other artifacts needed in a session.

Unfortunately, the situation is not the same for technical platforms such as on the World Wide Web. Since the WWW is rooted strongly in information sharing and not in group work or its' supporting functions, many problems are present. For example, an individual WWW surfer cannot participate in a session where people negotiate and share documents online, simply because users are not aware of other users or their actions. The question is not only that technically complex actions such as a person pointing or talking cannot be presented, but also

simple issues like representing other visitors within the same WWW page are impossible to accomplish. Protocols (e.g. HTTP (Berners-Lee et al., 1994)) used in the WWW are not designed for this kind of support, but to hide the complexity of distributed and heterogeneous environment. This encapsulation generates difficulties in representing people on the WWW.

Lately collaborative tools and services such as email, mailing lists, newsgroups, and electronic libraries have been either adopted from the Internet, or developed as a new medium. This has motivated many researchers to carry out some studies to find out the essential features for effective group work on the WWW (Brown and Benford, 1996; Chen and Gaines, 1996; Dix, 1996; Dix, 1997; Greenberg, 1997). In principle, these studies show that the WWW is lacking many basic features to support human communication and consequently group work. Reasons for this kind of failure are clear: the co-operating groups on the WWW are large, transient and unstable, their membership is non-determinable, and self-evidently participants are physically distributed. All are concepts noted by Schmidt and Bannon (1992) while writing about groups in other contexts. From the discussions above, we could highlight one very specific and important area for group systems on the WWW: Awareness — awareness of users, awareness of the group memberships and further members' identities, and the awareness of activities taking place inside and around the group.

In this paper, we will present a framework in which the awareness of others is studied from several viewpoints. Then we will present our own system, People Awareness Engine[1] (PAW), which allows users to be aware of other users in the same page or WWW site. Finally the framework is used to analyse PAW and related systems.

2. Related Studies

Suitable network infrastructure and document-intensive features of the WWW enable its' use as a base for co-operation. Basic support for co-operative work on the WWW, such as support for document handling and management, have already been implemented in several systems (e.g., Bentley et al., 1997; Horstmann, 1997) which provide rudimentary functions, e.g. brainstorming, and workflow and document management. These are all document-centric tasks and as such are ideal for the WWW platform. Another prominent feature of these applications is their support for asynchronous work rather than synchronous work.

Some systems have further extended asynchronous systems towards synchronicity by adapting tools for online communication on the WWW. For example, MetaWeb expands BSCW by running an awareness and communication application in parallel to it (Trevor et al., 1997). Also, CBE system (Lee et al., 1996) embeds an applet into a WWW page and provides a shared workspace, which is similar to Internet Relay Chat (IRC) systems where users must enter to a specific site to be able to communicate with others. In addition to these, some text-based systems as well as audio communication systems supporting human communication over ordinary WWW pages have been developed (e.g., Walther, 1996; Welie & Eliëns, 1996).

These different applications address the importance of "Web-based" communication by presenting different solutions. Therefore they are a step in the right direction, but they suffer from one or more of the following limitations:

[1] patent (Robinson and Pekkola 1999). Commercial development by At It Ltd.

- requirement to enter into a specified on-line "place" to be able to meet others and communicate with them
- lack of sufficient context to aid users in their communication attempts (i.e. the users are improperly presented, thus the awareness of others as well as the ability and accessibility to communicate with others are not made explicit)
- requirement of specific software to be installed on a client machine

These limitations are similarly noticed by Isaacs et al. (1996). They note that unintended interaction should also be supported among distributed communities, which, however, are not implemented in most of the systems. Very often naturally occurring informal contacts and communication attempts provide an opportunity for collaborators to learn about each other, and serve as a framework within collaborative tasks (Kraut et al. 1990).

3. Maintaining Awareness On The WWW

The importance of awareness of other people and their actions has been pointed out in many situations; e.g. in underground control room (Heath and Luff, 1991), in formulating planes (Goodwin and Goodwin, 1996), and in a stock exchange dealing room (Heath et al., 1993). However, those studies do not address the WWW and the situations which could occur there, thus they are slightly irrelevant in a technical, but not social sense.

The major issue of WWW-based co-operation is the maintenance of *situation awareness* between remote partners when changes taking place in one location affect the activities in another. This kind of situation awareness is illustrated in Figure 1. It shows a workspace, which is located in a server, and through which two message flows are passing by. Those flows are actually series of actions and state changes (human actions and data changes) which are considered to happen in the server side. Actually, there is a direct connotation with Robinson's "Double-level-language" (1991) which is about the presence of (these) two layers of actions in the group work; upon documents and simultaneously using spoken language to point out the issues in that document.

Figure 1. Maintaining flows of changes between two users in dispersed places.

In Figure 1, all other communication channels between location A and location B are deliberately ignored due to the structure of the WWW. Direct communication without passing the messages through the WWW server is possible to accomplish, but the difficulties of management and the impossibility to transmit the message to all other potential receivers in the same on-line community prevent its' usage. This premise of awareness study requires that changes in any of the states are perceptible to the system itself. Otherwise, they would be ignored and unreachable.

3.1 Situation Awareness

Situation awareness (SA) has long been recognised as a phenomenon that refers to the degree of accuracy by which observers' perceptions of their current environment mirror reality (Adams et al., 1995; Gilson, 1995). SA could be organised into two categories: *workspace awareness (WA)* and *user awareness (UA)*. Both of them can be seen as subsets of situation awareness and are used together to support co-operative work. In general, awareness information represents the maintenance of group consciousness by keeping everyone adequately informed.

Workspace awareness means the understanding of other person's interactions within a shared workspace (Gutwin and Greenberg, 1997). This involves knowledge about the tasks and activities of those persons. Referring to group work on the WWW, the WWW pages can be treated as a user interface. Here the user interface is not to be understood as a normal user-side surface interaction, but as a set of technical restrictions (or rules) which guide the users' actions in that space. Besides the user interface, typically there are work tasks to be performed, for example, writing electronic documents, ordering some goods, or communicating with others.

Users get feedback through the understanding of changes in artifacts (documents). This is an additional channel for communication through artifacts themselves (as stated in Robinson's (1991) "Double-Level Language"). In real life, when co-operating using physical objects, this communication through the artifacts is often as important as direct communication (Dix, 1996), or more important in a special situation in which opportunities for direct communication are not offered.

Awareness information provides knowledge not only about the changes on the artifacts, but also about the users' actions upon those artifacts. In the situation awareness context, user awareness represents direct actions occurring in the workspace (i.e. web page or site); that is, the information about who are around, whether they are available, and what they are doing. This includes conversational awareness (Clark and Brennan, 1991), by which we refer to questions like "did they hear, understand, and believe me?" In general, the maintenance of user awareness on the WWW provides functions like user action notifications and user conversations.

The user action notification includes the awareness information about each user's personal status (such as their WWW page entering and leaving times) as well as a contact indicator, which facilitates their ability and willingness to establish contacts with each other. For example, ICQ (ICQ 2000) provides some pre-formulated text-messages, e.g., "Available", "Away", "Extended Away", "Do not disturb", "Privacy" to indicate the users' awareness status and their eagerness to communicate with other users, and other systems support informal user conversations on the WWW by integrating text-chat programs with them.

3.2 Information Flows

Different implementations of situation awareness address different mechanisms to support co-operative work due to technical considerations and the nature of collaborative work. Based on the perspectives of different requirements, different modalities of awareness information are illustrated below:

- *User interaction*: The two basic modes are synchronous and asynchronous interactions. Synchronous interaction enables users to be aware of each other and other peoples' activities on a relatively high level. Meanwhile, real-time contact facilities can be adopted to enable them to establish communication channels with each other on the basis of mutual consciousness. Asynchronous interaction keeps awareness information on a lower level, which builds on a sequential information-exchanging mode.
- *User attention*: There are two general ways to identify user attentions: direct and indirect. Direct attention provides direct understanding of activities of other people, e.g. mainly as mediated by video conferencing or avatars in a 3D virtual reality environment. On the other hand, indirect attention means the attentions towards artifacts. Information required, or focused on, is about the activities, which change the state of that artefact, rather than about the person who performs the actions. Often this happens in asynchronous systems, e.g., workflow systems and ordinary WWW sites.
- *Information transmission*: There are two types of information transmission; active (push style) and passive delivery (pull style). In the active transmission, awareness information is explicitly generated and dispatched directly to participants (subscribers). The mechanism is restricted in synchronous systems, i.e. those in which all collaborators are virtually co-presented and working at the same time. On the other hand, passive mode is often used in asynchronous systems. Awareness information is perceived by an implicit pull or through artifacts. That is, the artefact is the information carrier. There are no immediate cues of awareness information for users.

3.3 Technical Issues

According to Norman (1991) and Chen (1996), a need for face-to-face communication in order to perform co-operative tasks becomes less necessary, if the mechanisms to support situational awareness have been well established among the group members whose roles are well defined. Although ordinary WWW users do not have explicit roles for collaboration, they have implicit roles set by the technology i.e. specific applications operating on the WWW:

- *Persistence*: The information is stored on the server side to ensure the consistency and persistence of data. If any changes in the data have been made, the users are notified in different ways depending on the situation, e.g. direct messaging is used while browsing on-line, or a reminder is sent when the user is off-line (by using email for example).
- *Authorisation:* In order to be able to identify the users (e.g. so that the email reminder can be sent), some user authorisation is needed. However, there are some cases in which the users are not willing to reveal their identity to every one (c.f. Kauppinen et al. 1998).
- *Operating platform*: Users may adopt the WWW browser as a tool for co-operation. However, even though the WWW browser provides a simple and uniform interface, a browser cannot be used in every situation due its' technical inadequacies to support complex co-operative tasks. This makes the use of standalone applications essential.

4. Framework for Analysing Awareness

The previous section presented several issues of maintaining the awareness of other people and their actions on the WWW. From the issues above, a framework for analysing awareness in several systems, including those on the WWW, can be summarised (see Table 1).

Table 1. Awareness Analysis Framework.

Situation awareness	Workspace awareness
	User awareness
User interaction	Synchronous
	Asynchronous
User attention	Direct
	Indirect
Information transmission	Active
	Passive
Persistence	
Authorisation	
Operating platform	WWW
	Standalone application

In the next chapter, we will present our own system, People Awareness Engine, which takes lessons learned to practice.

5. PeopleAwarenessEngine

PeopleAwarenessEngine (PAW) builds up a general infrastructure and a set of functions to support situation awareness and user communication on the WWW. The design purpose is to allow the users to be aware of each other when they are sharing the same page or pages located in the same site without using any external application, or without installing anything (software, cookies, plug-ins) on their machine.

When using PAW, users are considered to be located "nearby" in the sense that they are connected together when they are (1) looking at the same page (place), or (2) sharing the same site (space). PAW addresses the major concerns with works in the following way: because it is integrated into the WWW pages, users do not need to launch an external application (or, to go to a specific chat place; or, to install a plug-in or such) to be able to interact. The awareness of others is embedded into the WWW pages, or alternatively into an additional window, which are launched from these pages. The WWW page provides a shared context of interest, which provides reasons to interact with others. The design makes it easy for users to enter into interactions once they are aware of, or perhaps even "see" each other, and where they are located. For example, when using PAW with an electronic commerce (EC) site, the customers could ask questions in real time from the vendor while shopping there; or vice versa, the vendor might offer on-line help for the customers. Currently no such feature is supported in any EC applications. Asking questions or help through a help desk occur nowadays by sending email to the other end, but there is no way to know about other persons' presence, availability, or willingness to interact. PAW is simply used to create social proximity over the WWW pages. This kind of proximity supports the creation of a good customer relationship, thus increasing the potentiality for users' switching cost: you can find people here (See also Jackson, 2000).

PAW consists of four components, which are drawn from the theory of situation awareness. They are:

- *Counter* (workspace awareness), which enables users to be aware of others in the same page and in the same site, allowing the user to contact contact others who are virtually nearby[2].
- *User list* (user awareness) for users to get information about others, or contact anyone in the community.
- *Page list* (workspace awareness), which is similar to the user list, but which is generated according to the structure of the site (or, for example, according to the products in the EC market place).
- *Communication component (user awareness)* enables users to communicate by using text chat, or more advanced audio and video tools (which however, are not supported yet due to the technical inadequacies).

Figure 2 illustrates the structure of PAW architecture. The PAW server is operating in parallel, but independently, with the ordinary HTTP server. Once a browser downloads a page from the HTTP server, the applet is launched as usual, and the connection to the PAW server is established. The client communicates regularly with the server so network crashes etc. can be detected. On the client side, the main component is the Center, which contains the user and page lists as well as communication components.

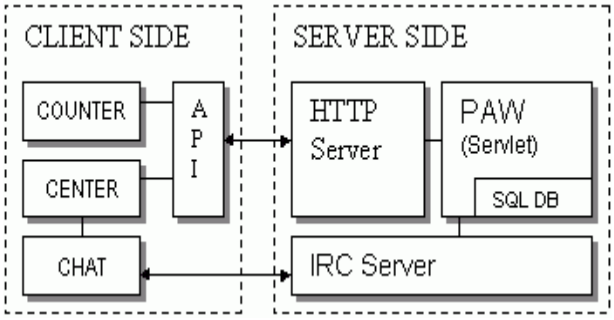

Figure 2. People Awareness Engine architecture.

PAW architecture is typical Client-Server architecture with some additional servers and services (see Figure 2). The advantage of PAW is the combination of means and reasons to co-operate (i.e. HTML pages) and awareness widgets (e.g. PAW counter) so that no installation on a client side is needed, but instead some modifications on server side need to be made. Embedding a Java applet pushes the need for support onto the webmasters who have to install the PAW link into each page. Another beneficial solution is to modify a proxy server, so that it inserts the code automatically into every page passing by.

a. PAW Functions

Counter (see Figure 3) is a Java applet, which is installed in every WWW page. It enables users in the WWW site to be aware of others who are nearby. For example, when the users enter any page, they see the number of people in the same page (i.e. the number of people who are interested in the same topic). As the users move from one page to another, the numbers in

[2] In this case, everything is linked and mapped onto a virtual place (server), where the users are also connected together.

the counter change with a sound effect. This sound effect provides peripheral awareness of actions (people entering and leaving) occurring in the same environment.

Figure 3. Counter showing the number of users on-line.

Although the counter is not shown very prominently, it provides basic awareness information and hides people's identity behind raw numbers[3]. It also prevents users from undesirable communication attempts, since it is possible to communicate with others or receive communication requests only when the Center is active. For example, let's consider a case where a customer is viewing a list of goods while another person arrives (by seeing the spinning counter or hearing the sound; i.e. getting peripheral awareness information). If the customer needs more information or just wants to chat with another, she opens the Center and accesses a communication tool. This case resembles situations in which people might be reluctant to turn around to see or communicate with others — however, they would be able to do so. The environment (i.e. the system) should not set such constraints, but to support alternative possibilities (Robinson, 1993).

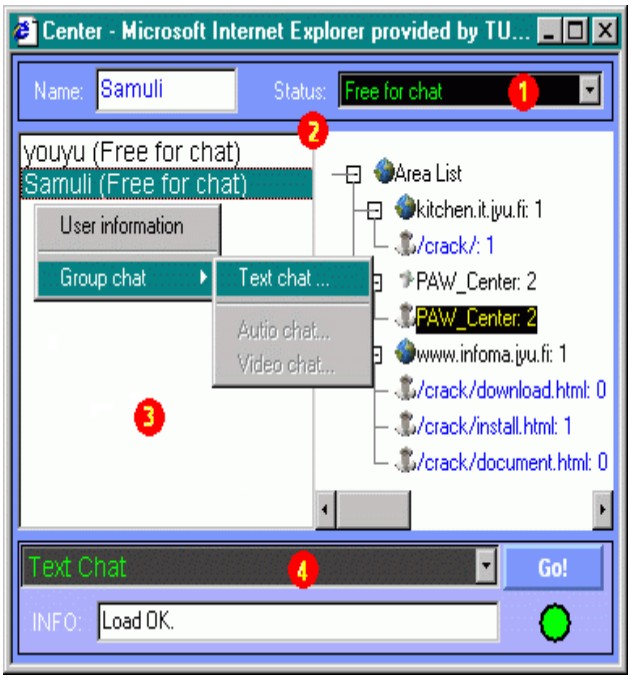

Figure 4. The PAW Center.

In addition to the counter, which allows low level awareness of others, PAW provides components for maintaining higher levels of awareness (user and page lists) and mechanisms for human communication. Much like other similar awareness systems, the Center (illustrated

[3] To address the user's privacy issues, PAW identifies users by using random numbers generated by the PAW system. If the users want to reveal their identity, they can change the number to more meaningful nickname. Privacy issues are off the scope of this paper, so they deliberately excluded.

in Figure 4) remains next to WWW pages providing constant awareness of others and the ability to communicate with them.

- Online status (❶ in Figure 4) shows person's visibility and willingness to interact with other people. The "Free for chat" mode allows all communication attempts to proceed unhindered. "No disturb" reveals that all incoming messages are ignored by the system, but the user is visible to others, while "Private" hides and denies everything (the user is not presented in the user list ❷).
- User and page lists (❷) represent higher level of awareness compared to the counter. The user list shows all people on-line while the page list shows their location.
- Detailed information about people is presented in the area ❸.
- Once the communication media is selected (❹, text chat, audio, and videoconferencing), an external tool is launched to allow people to e.g. compose and read text messages.

The list above includes a short description of implemented features. Using the earlier presented framework, it can be claimed that PAW supports workspace and user awareness, synchronous user interactions, both direct and indirect user attention, and active information transmission on the WWW (Table 2).

Table 2. PAW functions.

		People Awareness Engine
Situation Awaren.	Workplace	Yes
	User	Yes
User Interact.	Synchron.	Yes
	Asynchron.	-
User Attention	Direct	Yes
	Indirect	Yes
Info. Transm.	Active	Yes
	Passive	-
Persistency		Yes [4]
Authorization		
Platform	WWW	Yes
	Standalone	

It can be questioned whether the Counter is needed at all, because the Center provides more accurate information about users. However, the reason is obvious: the use of small counter reduces the intervention of users' normal page browsing or reading, while bigger Center window might disturb the user.

> *"If awareness is a passive and background notion, then the interfaces must be particularly lightweight. At the same time, if the awareness is a basis for more interactive exchanges, then the interface must provide those capabilities."*
>
> (Dourish and Bly, 1992)

The PAW Center appears *if and only if* the user makes a specific action to open it up to investigate further awareness information of others and/or communicate with them.

[4] PAW stores all events into a log-file, which can be analyzed and used later for any purpose.

6. Related Awareness Support Systems

Few systems provide awareness mechanisms to support user interaction. We will use the framework to analyse several off-the-shelf applications and well-known prototypes. This brief survey covers systems from desktop to WWW applications, and from educational experiments to commercial products in different operating platforms. Our sample is based on computer supported distributed group systems. It won't present every known application, but provide a set of applications, which support basic characteristics of group work and awareness.

- ICQ (ICQ 2000) is an Internet tool, which informs the user about other users who are on-line[5] at any time. The functions include public chat, private messages via ICQ, e-mail, and URL and file transfers. ICQ is a standalone application rather than a WWW-based user-tracking system. However, ICQ includes a tool, which adds a small status bar about user's presence in ICQ application (e.g. "Online" and "Offline" messages) into a WWW page, but in principle, ICQ can be regarded as an on-line reminder and communication tool.
- Elvin (Fitzpatric et al., 1999) is a synchronous notification application comprised by two stand-alone tools: Tickertape and CoffeeBiff. Tickertape displays text messages (events) scrolling across a single-line window. Text messages are sent by the system or by the other users. CoffeeBiff is an awareness tool, which shows users' interest to go to the kitchen for a cup of coffee. At the moment, there is no linkage to WWW, but the developers have intended to include support for situation awareness, e.g. different event sources like WWW news, emails delivery, and information stories.
- Cobrow (Cobrow, 2000) is similar to PAW in a sense that it shows the users on the same WWW site and provides a tool for text chat communication. However, major differences are the lack of counter-like-awareness tool and platform dependency on server side due used programming languages and implementation.
- Internet Foyer (Benford et al., 1996) constructs a virtual foyer, which is based on the WWW pages, for collaboration. The system links a physical foyer with virtual one in a way that people in virtual foyer are able to interact with those who are entering to a physical place and vice versa. However, it is not usual that ordinary WWW users get contacted with other users using the physical foyer, so the system employs a 3D image in representing the WWW users. For on-line communication and interaction, other applications need to be used.
- WAP system (Palfreyman and Rodden, 1996) provides an awareness prototype that gives the number of on-line users on the same site. The paper also touches other issues such as user profiles and connectivity with other applications, but those have not been implemented or tested.
- Nessie (Prinz, 1999) is an awareness environment, which supports event transmission. Situation awareness is oriented in two different ways: task or social relationship; and presented by sensors and indicators to symbolise particular awareness information. Nessie presents an open protocol and quite detailed descriptions on information presentation for event notifications, but it lacks studies on different awareness models, and consequently the adaptation of these models to different events. However, Nessie provides a set of tools so that some features can be integrated with WWW (via common gateway interfaces) while other more advanced features require users to install external applications on their machine.

[5] In this case, being on-line means that the user connects herself to the Internet by launching an external application, which exposes her presence to other people.

Several common shortfalls is distinguished:

- Software and platform-dependency: Most of mentioned systems require installation on the client side. It is unlikely that users will, or even are able to download and install programs on their computer, so WWW applications are ideal, and often the only choice for them. On the server side, platform dependency is not as crucial as on the client side, but, due to different programming languages and techniques, server side solutions are often platform and operating system dependent thus the issue of portability is valid. PAW is totally portable so it can be run on any browsers or server platform.
- Unclear awareness representation: Displaying awareness information should be considered with user interface design. For example, in Cobrow, it is difficult to find out from the user list who else is in the same page. This can be regarded as one of the key aspects for mutual awareness, since users need to know about the other people's interests before they may be willing to interact with others especially in the EC. For example, in an EC site where the cars are being sold, it is obviously essential to know about which car (or car brand) the person is interested in.

Table 3. Comparison of awareness support systems.

		ICQ	Elvin	Cbrow	IF	WAP	Nessie	PAW
Situation Awareness	Workplace						✓	✓
	User	✓	✓	✓	✓	✓	✓	✓
User Interaction	Synchron.	✓	✓	✓	✓			✓
	Asynchron.				✓	✓	✓	
User Attention	Direct				✓		✓	✓
	Indirect	✓	✓	✓	✓	✓		✓
Information Transmission	Active	✓	✓	✓			✓	✓
	Passive		✓		✓	✓	✓	
Persistency		✓	✓	✓			✓	✓
Authorization		✓	✓					
Platform	WWW			✓		✓		✓
	Standalone	✓	✓		✓		✓	

A summary of described systems is illustrated in the Table 3 by using the earlier presented framework. All these systems provide certain levels of awareness, since the user awareness is supported in each system. However, workspace awareness seldom is supported, even though it can be seen as an essential feature for group work, because the changes in the artifacts (or their states) need to be represented. Other dominant features are synchronous awareness updating, indirect user attention, and active information transmission. Also, it is remarkable that applications which are running only on the WWW have much less features for co-operation — simply because the common WWW technology (i.e. HTTP) does not support continuous communication.

7. Discussions and Future Work

Systems supporting situation awareness must satisfy general requirements for supporting awareness in different situations and provide mechanisms for easy and flexible awareness

information provision. Our awareness engine, PAW, however, is designed specifically for the WWW so that it can be used as a component which is integrated with other group work supporting systems (e.g. BSCW) through its' programming interface.

Currently most WWW-based systems do not support all aspects of awareness, since, for example, there are only a few theoretical studies about which they could relate to. One of them is Dix's (1997) work on defining general requirements for the WWW applications, where he lists essential features such as information structures, notification of actions (workspace awareness) and awareness of users in addition to more application dependent issues. However, in the future it is important that we set the awareness standards on the WWW, where applications differ significantly from traditional stand-alone ones.

In contrast to other systems (see Table 3), PAW can be seen as a kind of generic "meta-application" in which the theory about situation awareness is used. As mentioned before, PAW does not force users to enter into a specific place to be able to observe others, or even interact or communicate with them, since PAW is embedded into each page. Software and platform independence has formed a base, which we have used when designing the first versions of awareness protocol and further connectivity with other applications. Whenever the protocol is fixed, there is no need to modify anything except the awareness representation and the user interface, which are both task and domain specified settings. To present a general, complete awareness protocol is not the topic of this paper so it is excluded.

We believe that PAW will become widely used, since it has a theoretical background. In the future we have planned to integrate PAW with some EC sites with different contexts, users and tasks so that empirical evaluations of our system and its' usage can be achieved.

8. Summary

In this paper we have presented an awareness framework, which have been used when analysing some common applications. In particular, we examined the needs for awareness on the WWW, and the ways users are aware of each other. Finally we have presented our ongoing project, People Awareness Engine, through which situation awareness has been implemented into the WWW pages.

Studying situation awareness on the WWW, especially workspace awareness, has a particular set of requirements. The awareness information is domain-specified, and depending on the user's needs thus support for different kinds of awareness information are needed. The WWW is designed for global access, so potentially hundreds or thousands of users could be located on a same site at the same time (e.g., viewing at the statistics in an Olympic Games WWW site, or visiting Amazon.com just before Christmas). Therefore systems running on the WWW must be able to scale upwards by providing alternative possibilities for representing other people. Nowadays, however, most of the systems target small audiences (or groups) where intentions to use the system vary less depending on the time and task.

Furthermore, co-operative work on the WWW is normally seen as a universal access to information rather than a universal interface towards other users. If the WWW pages are treated as a user interface, there is no implicit connection between the workspace and artifacts inside that space. The awareness information is simply a set of changes, which have taken place there. The awareness is not about the changes of data itself, since the work is completed

in users' local physical places. Workspace awareness is needed when creating a seamless link between the physical work place and online environment. This issue needs to be studied and clarified in more detail once the systems are advanced enough.

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