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The F@ Framework of Designing Awareness Mechanisms in Instant Messaging[1]

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ABSTRACT

This paper presents our research on awareness support in Instant Messaging (IM). The paper starts with a brief overview of empirical study of IM, using an online survey and face-to-face interviews to identify user needs for awareness support. The study identified a need for supporting four aspects of awareness—awareness of multiple concurrent conversations, conversational awareness, presence awareness of a group conversation, and visibility of moment-to-moment listeners and viewers. Based on the empirical study and existing research on awareness, we have developed the F@ (read as "fat") framework of awareness. F@ comprises of the abstract level and the concrete level. The former includes an in-depth description of various awareness aspects in IM, whilst the latter utilises temporal logic to formalise fundamental time-related awareness aspects. F@ helps developers gain a better understanding of awareness and thereby design usable mechanisms to support awareness. Applying F@, we have designed several mechanisms to support various aspect of awareness in IM.

INTRODUCTION

Instant Messaging (IM) is an application that supports nearly synchronous communication between people over networks. In recent years, IM has increasingly become a popular communication tool, used by millions of worldwide users at home and at work. IM was once mostly used by teenagers for chitchat over the Internet, but the service has quickly moved to the mainstream as many home users and business users find IM as an easy, fast and convenient way of communication with family members, friends and colleagues (Isaacs et al. 2002b; Nardi et al. 2000). The population of IM home users increased 28% from 42 million in September 2000 to 53.8 million in September 2001 (Perera 2001), and enterprise IM is

growing at approximately 20% annually (Shukla 2003). As reported in February 2003, MSN Messenger alone has more than 75 million registered users (Yudkowsky 2003). Research showed that 77% of IBM employees responded that IM had enhanced their communication by reducing the time they often spent on e-mail, telephone and face-to-face communications. And, more than 75% of IBM's clients, who have IM, acknowledged that IM enhanced their productivity (Shukla 2003).

Whilst email is more like exchanges of digital letters, IM closely resembles face-to-face spoken conversations in which exchanges are often short, quick and even incomplete sentences (Dix et al. 2004; Smith et al. 2000). Due to the conversational style of IM, there is a strong need for maintaining awareness between conversants. For example, awareness of the availability of other people assists users in deciding if they should move into conversations; and awareness of other people's activities helps to coordinate IM conversations naturally and effectively. Research on awareness in IM has gained much attention within the CSCW and HCI communities. Many studies, such as (Cech & Condon 2004; Isaacs et al. 2002a; Segerstad & Ljungstrand 2002; Tang et al. 2001; Viegas & Donath 1999) have researched various techniques to support different aspects of awareness including users' presence awareness, awareness visualisation, turn-taking convention, and so on. Although different awareness features have been included in IM systems, there are still many aspects of awareness need to be supported, as discussed in the next section.

This paper summarises our empirical study of awareness in current IM. The study helps us gain real-world users' experience with current awareness support. The study has identified four issues of awareness support that are currently lacking in IM—awareness of multiple conversation awareness, conversational awareness, presence awareness in a group chat, and in-progress viewing and listing awareness. Based on the study and existing research on awareness, we have developed the F@ (read as "fat") framework of awareness. F@ helps to

extend developers' understanding of awareness and thereby design relevant awareness mechanisms. Applying F@, we have designed several mechanisms to enhance awareness support in IM.

The remainder of the paper is organised as follows. The next section reviews related research on awareness in IM, followed by the summarised results of our empirical study. Then, the paper presents the F@ framework and describes our innovative awareness mechanisms by applying F@. Finally, we conclude the paper by recapitulating the findings of our work and presenting a view of future research.

IMPORTANCE OF AWARENESS IN INSTANT MESSAGING

This section reviews different techniques developed by previous research to maintain awareness in IM.

Presence Awareness

Providing presence awareness information about the availability of other users is one of the primary and most important features of IM. Presence awareness helps users decide if and when to move into conversations (Nardi et al. 2000). At a rudimentary level, presence awareness informs users if their buddies are online or offline. This feature has been implemented in all popular IM clients such as messengers of AOL, ICQ, MSN, Yahoo and Jabber (e.g., Yahoo Messenger shows yellow icons to indicate online users and grey for offline users). At a higher level, IM systems incorporate many other features such as sound alerts and live video to inform when buddies come online and go offline. Hubbub (Isaacs et al. 2002a) uses auditory cues to support presence awareness—whenever users' buddies go online, their 'sound IDs' are played at the user's site.

Furthermore, IM users can even set presence messages (e.g., 'On the Phone' and 'Stepped Out') so that other users trying to contact them know that they are on the phone or not in the

office. Some IM systems not only show if users are available, but also provide the level of their activities. For example, Activity Meter (Isaacs et al. 2002a) shows users' level of activities within the last 15 seconds. Chat Circles (Viegas & Donath 1999) changes colours of users' circles to indicate how active they are.

When IM becomes part of an integrated communication platform, more sophisticated support for presence awareness is required. For example, as the mobility factor is added to IM, a new degree of presence awareness is introduced. Hubbub shows if users are online, and also indicates whether they logged into IM networks from their PCs or their PDAs. WebWho (Ljungstrand & Segerstad 2000) provides awareness of both virtual and physical presence. It displays a notification if users are present in an IM network (i.e., virtual presence), and their geographical location (i.e., physical presence). A study of WebWho shows that both virtual and physical presence awareness affect content of IM messages.

IMVis (Neustaedter et al. 2002) and Chat Circles explore alternative metaphors to represent presence awareness. IMVis develops a 3D tunnel to show available buddies around the outside edge of the tunnel, and less available buddies closer to the vanishing point of the tunnel. Chat Circles represents users as coloured circles. The circles expand as a new message arrives, and become blurry after a period of idleness.

Turn-taking Awareness

Turn-taking has been well-known as a fundamental process in human conversations (Dix et al. 2004). In face-to-face communication, turn-taking is supported by a suite of fine-grained back channels such as body language, eye-contact, voice intonation, facial expression, and so on. But those fine-grained back channels are almost missing in IM. Moreover, IM inherits many generic problems of text-based communication tools with respect to turn-taking such as visibility of listening-in-progress, control over turn positioning and visibility of turns-in-progress as discussed comprehensively in (Herring 1999; Smith et al. 2000).

Several solutions for maintaining turn-taking in IM have been developed. Yet, effective support for organising turn-taking rules and resolving floor control conflicts is still very limited (Cech & Condon 2004; Voida et al. 2002; Woodruff & Aoki 2003). The simplest solution for turn-taking is that a conversant explicitly offers the floor to other conversants by asking direct questions such as "What do you think, Bob?". However, this solution is limited as it does not suit the conversational style of IM in which exchanged messages are short and instant (Dix et al. 2004). Other alternative solutions for turn-taking have been studied. For example, IM systems provide awareness cues such as the textual 'Who is typing' indicator in MSN Messenger and Yahoo Messenger, the visual 'focusing' and 'not-focusing' cues used in Hubbub, and the auditory typing cues used in Babble. Threaded Chat (Smith et al. 2000) adopts the threaded conversational style, which has been widely implemented in discussion boards to support turns and replies in IM conversations.

When voice chat is added to IM, supporting turn-taking in auditory conversations is even more challenging compared to text-based conversations. IM systems have introduced a visual indicator that signals when a person is talking in IM conversations. For example, Woodruff and Aoki (2003) examine an effect of the push-to-talk mechanism on turn-taking convention.

Contextual Awareness

Contextual awareness refers to information that provides users with context of IM conversations. Commonly, IM applications support contextual awareness by displaying a *quasi-shared window*—a window containing messages sent by all participants in a conversation. We define the term, 'quasi-shared', to refer to that window because currently local messages appear on that window instantly, but remote messages are displayed in the order of their arrivals at a central server. Consequently, the order of messages shown on conversants' screens can be different from one to another. Despite being un-identical, the

quasi-shared window still provides IM users with some degree of a common understanding of the flow of messages.

Providing information about other conversants' activities, such as if they are typing, talking, focusing or not focusing on a chat window (discussed in the previous section), also helps to maintain contextual awareness in IM. Chat Circles uses the cadence of size of coloured circles on a user's screen to show the flow of conversations. Babble uses a graphical representation called 'social proxies' to show the activity that people carry out with the application. This also helps to provide users with an intuitive sense of context in conversations. Some other IM clients such as Gaim (http://gaim.sourceforge.net) and Trillian (http://ceruleanstudios.com) even notify users when their buddies close chat windows, and display a timeout flag if a conversation is inactive for too long.

One aspect of maintaining contextual awareness in IM is to support identity awareness. Awareness of people's identities is crucial for managing oneself in a public space. In the case of IM, although each user is not publicly seen by everyone in the networks, they are a part of a big group in which each individual presents their own sense of identity. Providing identity awareness enhances context of conversations as it shows people with whom they are communicating. Commonly, IM systems support identity awareness by associating IM users with different nicknames, colours, avatars, coloured circles (Viegas & Donath 1999) and even 'sound IDs' (Isaacs et al. 2002a). These attributes are indicators of identity in the IM virtual community. Our study reported in (Tran et al. 2004) shows that IM users even reach out for multiple identities that allow them to project themselves differently to different users.

Emotional Awareness

Emotions are a social need and play an important role in human communication. Both our own affective state and our perception of that of others influence the process and outcome of our conversations (Damasio 1994). There has been a growing interest in providing expressive

representation of emotions in IM (Garcia et al. 1999). At the most basic (but very popular and effective) level, IM users convey their emotional state like happiness, anger or sadness by using punctuations and acronyms e.g., :-) stands for a smiling face, and ;-) is for a winking face (Dix et al. 2004). Advancing from that, IM systems have integrated those punctuations with animated graphical emoticons (Rivera et al. 1996). Recently, Yahoo Messenger has developed animated utterance called 'Audibles'. Audibles include animated images and auditory track, used to deliver messages (e.g., hello, goodbye and flirt) and also to reflect the affective state of a sender and the illocutionary force of the messages.

In addition to emoticons, the avatar is another graphical representation that is also commonly used by users to portray their emotional state (e.g., "*I use a funny avatar when I am happy*"). Furthermore, IM users express their emotions through their online status[2]. As reported "*I often use status to tell my friends if I am sad or happy and also edit my status to tell them what I am doing like studying, cooking, and stuff*" (Tran et al. 2004). Conductive Chat (DiMicco et al. 2002) explores a new metaphor to convey IM users' emotion by incorporating users' skin conductivity levels into IM.

THE STUDY AND RESULTS

This section reviews our empirical study of IM that was used to gain users' feedback on their real-world experience with awareness support in IM, and summarises the results of the study. The study was composed of an online survey and face-to-face interviews. The reader is referred to (Tran et al. 2004; 2005) for the detailed description of the empirical study.

In brief, the online survey consisted of demographic multiple choice questions, 7-point Likert scale questions and open-ended questions. 173 participants (56 females and 117 males) took part in the survey. The participants were students from several universities in Australia. Most

[2] An online status is a text-based description composed by a user and can be seen by the user's buddies.

of them were in their early twenties and had used IM for more than 3 months. After the survey was completed, we conducted further informal face-to-face interviews with 6 participants (2 females and 4 males), who were selected from the 173 participants of the online survey. Open-ended and follow-up questions were used in the interviews. The follow-up questions were used to probe participants so that they talked more about their use of IM. Listening to participants' stories of how they had used IM helped to gain valuable insights we would not have gained otherwise.

The study overall yielded much data, and some results of the study have been published in (Tran et al. 2004; 2005; 2006a). This section briefly summarises four findings related to awareness support in IM.

Awareness of Multiple Concurrent Conversations

The online survey showed that it is common behaviour for IM users to interact with many people simultaneously: 92% of the respondents had used IM to chat with two people or more at the same time. Five out of the six interviewed participants responded that at one time or another they had typed into a window that was not the one intended, especially when they had multiple conversations with many buddies at the same time. Such a mistake may happen because support for managing multiple conversations in current IM is weak.

Conversational Awareness

More than 60% of the survey participants responded that they often want to show other people which earlier messages of the same conversation that they want to refer to. But current IM applications provide very limited support for this, thus users have to copy the messages to which they want to refer and paste them to a new message. In addition, more than half of the respondents said that they want to link emoticons with exact messages posted by other people.

Presence Awareness in a Group Chat

There is a lack of awareness support in a conversation that involves a group of more than two people. Many awareness cues, which are provided in a one-to-one conversation, are either missing or become significantly less effective in a group conversation. For example, a visual 'Who is typing' cue is missing in a group chat especially when more than one person is typing at the same time. This leads to many problems in maintaining turn-taking and resolving floor control conflicts in a group chat. Furthermore, IM applications do not provide any presence awareness of those who were in the group chat and had already left, or those who are going to join the group chat.

Visibility of Moment-to-moment Listeners and Viewers

The study showed that IM systems should provide some level of visualisation to support awareness about the visibility of listening- and viewing-in-progress. Current IM does not provide moment-by-moment information about people who are listening to auditory messages and/or viewing webcam. In addition, our respondents suggested that IM systems should provide information about if other users are able to participate in an audio or video chat.

FRAMEWORK OF AWARENESS IN INSTANT MESSAGING

Based on the results of several empirical studies of synchronous groupware, including the empirical study of IM presented in previous section, we have developed the F@ framework of awareness. F@ was developed with a twofold objective: provide a better *understanding* of awareness and facilitate the *design* of awareness mechanisms. F@ addresses many aspects of awareness in synchronous distributed collaboration, as presented in (Tran et al. 2006b). This paper merely focuses on aspects that are relevant to awareness in IM.

F@ consists of two parts: an *abstract* level and a *concrete* level. The abstract level presents in-depth descriptions of awareness. The concrete level exploits temporal logic to formalise *some* fundamental time-related aspects of awareness. It is not a goal of the concrete level to

formalise all elements of group awareness which are addressed at the abstract level. Instead, the formulas presented at the concrete level aim to demonstrate the feasibility of formalising the concept of awareness as an approach of defining precise requirements of designing supporting mechanisms.

Abstract Level of F@

Awareness in IM involves users' knowledge of a conversation. This type of knowledge includes answers to questions like, "Who is talking?", "Who is listening?", "Can they hear me?", "Do they pay attention?" and "Who is talking next?". By answering such mechanical questions, awareness helps users maintain a sense of awareness of what is happening in a conversation (Gutwin & Greenberg 2002).

When a group is no longer co-located in the same room, a rich set of verbal and non-verbal cues (e.g., intonation, eye contact, facial expressions, etc.) which is often naturally available in a face-to-face conversation, becomes difficult to find over distance. To address this issue, there has been a large body of research committed to investigating the benefits of *media spaces* technologies for facilitating distributed conversations. For example, significant effort has been devoted to studying how synthetic audio and video links can help to support awareness (Bly et al. 1993; Dourish & Bly 1992; Finn et al. 1997; Tang & Minneman 1991). Although computer-integrated audio-video media are useful in providing rich context of a conversation, these technologies are faced with many problems such as turn-taking control, eye contact, gesture, privacy, and so on (Fussell et al. 2004; Gaver 1992; Kraut et al. 2003). In addition, a physical setting largely reliant on video is often not flexible enough to deliver appropriate images for the context of a conversation (Hudson & Smith 1996).

In many cases, text-based links are preferred over rich medias like audio and video for several reasons, such as their low-bandwidth requirement and relaxed styles (Erickson et al. 1999). Text-based communication tools are able to support conversational awareness in their own

way such as allowing copying-and-pasting contents of previous messages, colouring and highlighting emphasised words, providing textual cues of who is typing, and so on. Commonly, text-based communication tools such as chat and IM often organise messages in chronological sequence. This sequential method of presenting conversation has been found inefficient in supporting conversational awareness in group discussion for several reasons, such as lack of mapping between people and their messages, no listening-in-progress, poor turn-taking support, etc. (Smith et al. 2000; Vronay et al. 1999).

In order to understand and support conversational awareness, it is useful to determine a set of components that are involved in the conduct of a conversation. According to coordination theory (Malone & Crowston 1994), awareness needs to be supported in the *communication* process, which involves senders, receivers, messages and languages. In this research, it is assumed that senders and receivers use the same language. Thus awareness depends on the relationships between the three components of *senders*, *receivers* and *messages*[3].

Our empirical study of IM shows a need for improving four major aspects of awareness, including *multiple concurrent conversations*, *conversational context*, *presence* in a group chat and *listening- and viewing-in-progress*. These four aspects of awareness can be interpreted from the perspective of the three group components—senders, receivers and messages. For example, awareness of presence involves a sender's knowledge of the availability of a receiver, and vice-versa. Awareness of listening- and viewing-in-progress involves a receiver's perception of a sender who sent a message as well as a sender's perception of a receiver who would receive a message.

In addition to the three group components, it is valuable to consider a specific set of information that needs to be provided to support awareness in IM. Adopting the approach

[3] A message can be conveyed in various forms including, but not limited to, text, graphic, audio and video.

used in Gutwin and Greenberg's framework of workspace awareness (2002), we present elements of knowledge that relate to awareness as a set of the *5W1H* (i.e., "Who", "What", "Where", "When", "Why", and "How") dimensions, as shown in Table 1. These six dimensions articulate and categorise information that should be provided to help people stay aware of a conversation.

The specific elements and questions listed in Table 1 are fundamental and common sense, and cover typical conversational interaction and behaviour. Therefore, they are not an exhaustive list of possible questions. Besides, in different situations, the specific information required to make up a person's awareness varies depending on the nature of a conversation and the surrounding environment.

Dimensions	Awareness elements	Specific questions
Who	Presence (current)	Who participates in a conversation?
	Presence (past)	Who was in a conversation?
	Presence (future)	Who is going to join a conversation?
	Identity (current)	Who is this person?
		Who is talking?
		Who is listening?
	Identity (past)	Who was this person?
What	Context (current)	What does this message respond to?
		What are responses to this message?
		What is a question of this response?
		What does a person refer to?
	Context (future)	Who is talking next?
Where	Location (current)	Where is the latest message?
When	Event (past)	When did a person join a conversation?
		When was this message sent?
	Event (future)	When will a person leave a conversation?
Why	Motivation (current)	Why is a person saying that?
	Motivation (past)	Why was this message sent?
	Behaviour (current)	Why does a person stop talking?
How	Reaction (current)	How do other people react?
	Reaction (past)	How have others changed their behaviour?
	Reaction (future)	How will others react after I send this message?

Table 1: Dimensions of awareness in IM

Concrete Level of F@

Drawing on the importance of the "When" dimension, the concrete level aims to model some essential time-related properties of awareness, using *temporal logic* as a vehicle. Temporal logic (TL) is an extended version of first-order logic (Davis 1990) by adding temporal aspects to it. Let $\mathfrak{T}$ be a linear-tree of time and s be a node in $\mathfrak{T}$. Let φ be a proposition which can hold at some nodes in $\mathfrak{T}$. A notion of proposition φ being satisfied (i.e., $\models$) at node s in $\mathfrak{T}$ is defined as: $\boldsymbol{M\ (s,\ \mathfrak{T})\ \models\ \varphi}$.

As mentioned earlier, it is not the intention of the concrete level to formalise every aspect of awareness that is addressed at the abstract level. The concrete level models two aspects—*presence awareness* and *awareness of turn-taking*. This is to illustrate the viability of formalising awareness, whilst the formalisation of other aspects is left as future work.

The abstract level shows that awareness of a conversation involves three components of *senders*, *receivers*, and *messages*. Therefore, a conversation can be considered as a set:

$Conversation = \{P_p, M_g\}$, where P_p denotes people and M_g denotes messages.

A person is said to be part of a conversation iff (if and only if) the person is in *Conversation* at node *s*. This relation can be expressed as follows:

$$M\ (s,\ \mathfrak{T})\ \models part\_of(p,\ Conversation) \Leftrightarrow M\ (s,\ \mathfrak{T})\ \models (\exists x \in P_p)\ (p = x)$$

The predicate *part_of*(*p*, *Conversation*) is useful to indicate whether or not a person is in a conversation, but is unable to specify the temporal points at which a person joins or leaves a conversation. Thus, two additional relations between a person and a conversation are defined: *join*(*p*, *Conversation*) and *leave*(*p*, *Conversation*).

$$M\ (s_i,\ \mathfrak{T})\ \models join(p,\ Conversation) \Leftrightarrow$$
$$M\ (s_{i-1},\ \mathfrak{T})\ \models \neg\ part\_of(p,\ Conversation) \wedge M\ (s_i,\ \mathfrak{T})\ \models part\_of(p,\ Conversation)$$

$$M\ (s_i,\ \mathfrak{T})\ \models leave(p,\ Conversation) \Leftrightarrow$$
$$M\ (s_{i-1},\ \mathfrak{T})\ \models part\_of(p,\ Conversation) \wedge M\ (s_i,\ \mathfrak{T})\ \models \neg\ part\_of(p,\ Conversation)$$

Presence awareness of past/ current/ future conversants

In addition to showing "current conversants" who are currently participating in a conversation, it is useful to provide information about the presence of "past conversants" who were in the conversation and had already left, and "future conversants" who might join the conversation. IM systems often use a history of events to track the presence of past conversants and current conversants. Regarding future conversants, systems can use an invite-and-accept protocol to identify who are going to join a conversation.

(a) Past conversants

Past conversants are those who were *once* in a conversation. Operator once is denoted as '♦'. Person *p* is considered once in *Conversation*, iff at state s_j in the past, *p* joined a conversation, and at another state s_k after s_j also in the past *p* left the conversation.

$M\ (s_i,\ \mathfrak{I}) \models \blacklozenge\ part\_of(p, Conversation) \Leftrightarrow$
$M\ (s_j,\ \mathfrak{I}) \models join(p, Conversation) \wedge M\ (s_k,\ \mathfrak{I}) \models leave(p, Conversation)$, where $j < k < i$

(b) Current conversants

Current conversants are those who joined *Conversation* at a state in the past and have not left the conversation.

$M\ (s_i,\ \mathfrak{I}) \models\ part\_of(p, Conversation) \Leftrightarrow$
$M\ (s_j,\ \mathfrak{I}) \models join(p, Conversation) \wedge M\ (s_k,\ \mathfrak{I}) \models (\forall k: j \leq k \leq i)\ \neg leave(p, Conversation)$

(c) Future conversants

Future conversants are those who will *eventually* join a conversation and are not currently in the conversation. Operator eventually is denoted as '◊'. Person *p* is considered eventually in *Conversation*, iff *p* is not currently in the conversation now (s_i), and will join the conversation later (s_j: $j > i$).

$M\ (s_i,\ \mathfrak{I}) \models \Diamond\ part\_of(p, Conversation) \Leftrightarrow$
$M\ (s_i,\ \mathfrak{I}) \models \neg\ part\_of(p, Conversation) \wedge M\ (s_j,\ \mathfrak{I}) \models join(p, Conversation)$, where $j > i$

Based on the formulas of past/ current/ future conversants above, the phenomenon by which a user is aware of the presence of conversants is defined as:

$M\ (s,\ \mathfrak{I}) \models aware(user,\ presence\text{-}conversants) \Leftarrow$
$(M\ (s,\ \mathfrak{I}) \models (\forall p_i{:}\ p \neq user)\ \blacklozenge part\_of(p_i,\ Conversation) \wedge know(user,\ p_i)) \wedge$
$(M\ (s,\ \mathfrak{I}) \models (\forall p_j{:}\ p \neq user)\ part\_of(p_j,\ Conversation) \wedge know(user,\ p_j)) \wedge$
$(M\ (s,\ \mathfrak{I}) \models (\forall p_k{:}\ p \neq user)\ \Diamond\ part\_of(p_k,\ Conversation) \wedge know(user,\ p_k))$,

where $p_i,\ p_j,\ p_k,\ user \in Conversation$.

Awareness of turn-taking

Awareness of turn-taking involves people's fundamental knowledge of who is sending a message and who is receiving a message. At node s_n during a conversation, an action of sending a message from a sender to a receiver can be modelled as:

$$M\ (s_n,\ \mathfrak{I}) \models send(sender,\ receiver,\ message),$$

Similarly, at node s_m during a conversation, an action of confirming that a receiver receives a message can be modelled as:

$$M\ (s_m,\ \mathfrak{I}) \models receive(receiver,\ message)$$

To support a person's awareness, the following conditions need to hold when a sender sends a message to a receiver. First, a sender needs to be aware of the fact that the sender sends a message to a receiver:

$M\ (s,\ \mathfrak{I}) \models aware(sender,\ send(sender,\ receiver,\ message) \Leftrightarrow$
$M\ (s,\ \mathfrak{I}) \models send(sender,\ receiver,\ message)$

Second, a sender needs to know that the receiver actually receives a message. In the following formula, it is assumed that a transmission is real-time:

$M\ (s_j,\ \mathfrak{I}) \models aware(sender,\ receive(receiver,\ message)) \Leftrightarrow$
$M\ (s_i,\ \mathfrak{I}) \models send(sender,\ receiver,\ message) \wedge$
$M\ (s_j,\ \mathfrak{I}) \models receive(receiver,\ message)$, where $j > i$

Third, a receiver needs to know that a sender sent the receiver a message:

$M\ (s_j,\ \mathfrak{I}) \models aware(receiver,\ send(sender,\ receiver,\ message)) \Leftrightarrow$
$M\ (s_i,\ \mathfrak{I}) \models send(sender,\ receiver,\ message) \wedge$
$M\ (s_j,\ \mathfrak{I}) \models receive(receiver,\ message)$, where $j > i$

DESIGNING AWARENESS SUPPORT FOR INSTANT MESSAGING

This section summarises our four mechanisms (Tran et al. 2005) that have been designed to enhance awareness support in IM. The design of these mechanisms is evolved in part from our empirical study of IM, in part from the knowledge presented in F@, and in part from the design of existing awareness mechanisms.

- **Conversation Dock (ConDoc)**: ConDoc utilises a focus+context visualisation technique (Greenberg et al. 1996) to help users manage multiple concurrent conversations. ConDoc shows all active conversations in a miniature window and magnifies a particular conversation as a user moves a mouse over the conversation.
- **Relaxed Instant Messenger (RIM)**: RIM combines the threaded styles and linear styles to organise IM messages, and thereby accommodates more flexible turn-taking, and provides richer contextual awareness. Displaying messages in threads allows a structural and coherent conversation, whilst a linear format is useful in providing a point of focus in a conversation and keeping users updated with the latest messages.
- **Group List**: Group List supports presence awareness of people who are no longer in a group chat and who are going to join the group chat. Group List also conveys awareness of *multiple* users' activities (e.g., who are typing and who are talking) by providing visual 'someone is typing', 'someone is talking' indicators. For example, whenever a user is typing, an animated keyboard icon appears next to the user's name on the contact list.
- **Track View**: Track View informs users of who are currently listening to their auditory conversation and who are currently viewing their webcam. Track View also allows the local user to stop any current viewer from listening to their voice or seeing their video.

Out of these four mechanisms, we have implemented and evaluated ConDoc and RIM. The evaluations show positive results and feedback on the design (Tran et al. 2006a).

REFLECTIONS ON THE USE OF F@

Up to this point, the paper has presented user needs and the design of four awareness mechanisms. This section steps back from the detailed descriptions, and presents higher-level reflection that can be drawn from the design and development of these mechanisms. In particular, the reflection focuses on a comparative analysis of relations between the principles of F@ and the designs of mechanisms.

Reflections on the abstract level

Table 2 presents a list of awareness elements that are addressed in F@ and supported by our new awareness mechanisms. As seen in Table 2, many, though not all, awareness elements raised by F@ are supported by our new awareness mechanisms. The evaluations of ConDoc and RIM confirm that awareness elements provided by the mechanisms help to enhance awareness. This confirmation indicates that awareness elements presented at the abstract level are useful and can be applied to designing other mechanisms to support awareness of a conversation.

Awareness elements	Design of RIM, ConDoc and proposed mechanisms
Presence (past/ current /future)	- RIM shows active users who are currently participating in a conversation - Buddy List shows if users are able to join audio and video conversations - Buddy List shows past and future conversants
Identity (current)	- RIM and ConDoc display username, colour, avatar - RIM shows multiple "who is typing" cues - The thesis proposes a design to support multiple concurrent identities

The "Who" dimension

Awareness elements	Design of RIM, ConDoc and proposed mechanisms
Context (current)	- RIM uses a tree to create a structural layout of messages - RIM allows posting explicitly questions or answers to a particular message - RIM uses the same colour for messages of the same topic - Track View supports listening- and viewing-in-progress - ConDoc displays multiple conversations in a miniature view, and magnifies a particular conversation when the mouse moves the conversation

The "What" dimension

Awareness elements	Design of RIM, ConDoc and proposed mechanisms
Location (current)	- RIM shows the latest message at the bottom of the linear window, while the message can be allocated at any node in the threaded window - ConDoc indicates when new messages arrived at a particular conversation

The "Where" dimension

Awareness elements	Design of RIM, ConDoc and proposed mechanisms
Event (past/ current)	- RIM shows elapsed time since users joined or left a conversation - RIM indicates if anyone is typing a message - RIM indicates if anyone join or leave a conversation

The "When" dimension

Awareness elements	Design of RIM, ConDoc and proposed mechanisms
Motivation (past/ current)	- Users send messages to ask explicitly - RIM supports a logical and structural layout of message that allows users to reason the purpose of sending a particular message (e.g., to answer or to question, etc.)
Behaviour (past/ current)	- Users send messages to ask explicitly

The "Why" dimension

Awareness elements	Design of RIM, ConDoc and proposed mechanisms
Reaction (past/ current/ future)	- Expressed via emoticons - Users send messages to ask explicitly

The "How" dimension

Table 2: F@ and mechanisms for conversational awareness

Reflections on the concrete level

The concrete level primarily formalises two aspects of awareness—presence awareness of conversants and awareness of turn-taking. This section considers how those temporal logic formulas are interpreted and applied to the design of the mechanisms introduced in this paper.

Presence awareness

As presented at the concrete level, the presence aspect of awareness is formulated as follows:

$$M\,(s, \mathfrak{I}) \models \mathit{aware}(\mathit{user}, \mathit{presence\text{-}conversants}) \Leftarrow$$
$$(M\,(s, \mathfrak{I}) \models (\forall p_i: p \neq \mathit{user})\ \blacklozenge \mathit{part\_of}(p_i, \mathit{Conversation}) \wedge \mathit{know}(\mathit{user}, p_i)) \wedge$$
$$(M\,(s, \mathfrak{I}) \models (\forall p_j: p \neq \mathit{user})\ \mathit{part\_of}(p_j, \mathit{Conversation}) \wedge \mathit{know}(\mathit{user}, p_j)) \wedge$$
$$(M\,(s, \mathfrak{I}) \models (\forall p_k: p \neq \mathit{user})\ \Diamond\ \mathit{part\_of}(p_k, \mathit{Conversation}) \wedge \mathit{know}(\mathit{user}, p_k)),$$

where $p_i, p_j, p_k, \mathit{user} \in \mathit{Conversation}$.

Buddy List enhances support for presence awareness of conversants by showing both past and current conversants.

Awareness of turn-taking

The concrete level presents three conditions that need to hold when a sender sends a message to a receiver in a conversation.

$$M\,(s, \mathfrak{I}) \models aware(sender, send(sender, receiver, message)) \Leftrightarrow$$
$$M\,(s, \mathfrak{I}) \models send(sender, receiver, message) \qquad (CA1)$$

$$M\,(s_j, \mathfrak{I}) \models aware(sender, receive(receiver, message)) \Leftrightarrow$$
$$M\,(s_i, \mathfrak{I}) \models send(sender, receiver, message) \wedge$$
$$M\,(s_j, \mathfrak{I}) \models receive(receiver, message), \text{ where } j > i \qquad (CA2)$$

$$M\,(s_j, \mathfrak{I}) \models aware(receiver, send(sender, receiver, message)) \Leftrightarrow$$
$$M\,(s_i, \mathfrak{I}) \models send(sender, receiver, message) \wedge$$
$$M\,(s_j, \mathfrak{I}) \models receive(receiver, message), \text{ where } j > i \qquad (CA3)$$

In face-to-face conversations, people are naturally aware of to whom they are talking and whether the listeners can hear them through verbal and non-verbal cues. However, these three conditions often do not hold in computer mediated communication tools such as IM applications.

In general, IM meets (CA1) and (CA3) by providing visual cues such as "Who is typing" in the case of text-based conversation, and a coloured bar that raises in the case of audio conversation to inform a sender and a receiver that the sender is sending a message. But, that is often only supported for the case of one-to-one conversations. When a conversation involves a group of more than two people, these two conditions often do not hold. For example, when two people are typing at the same time, IM does not indicate who they are; or when two people are talking at the same time, there is no visual indicator showing who is talking. Group List was designed to support CA1 and CA3 by showing people who are concurrently typing in a conversation.

Current IM applications fail to meet (CA2). That is, a sender does not know whether a receiver actually receives the message. Hence, in many cases, a sender needs to ask the receiver explicitly for confirmation (i.e., if the receiver actually receives the message). To address this issue, IM applications can distinguish the cases when a message is delivered to a receiver successfully and when a message does not reach an intended receiver. IM

applications can provide awareness mechanisms such as a message pool that keeps all failed-to-deliver messages, and allows a sender to choose if the sender wants to re-send or simply ignore those messages.

The issue of providing support for (CA2) is even more problematic in the case of audio and video communication. IM users are provided with no awareness cues informing them if receivers attend to their broadcasted audio and video contents. IM applications can include awareness mechanisms such as Track View that are used to inform a local user of who else is currently listening to the user's auditory track and who else is currently viewing the user's webcam.

CONCLUSIONS AND FUTURE WORK

This paper reviews our empirical study of awareness support in Instant Messaging (IM). The study involved an online survey and face-to-face interviews that aimed to understand user needs for supporting awareness in IM. Based on the results of the study, we have developed the F@ (read as "fat") framework of awareness. F@ includes an abstract level and a concrete level. The abstract level presents an in-depth description of various aspects of awareness that IM users need to be supported, whilst the concrete level presents the formalisation of awareness, particularly focusing on time-related aspects. F@ is used to gain a better understand of awareness and help developers design usable awareness mechanisms.

We have applied F@ to designing four mechanisms that can be used to enhance awareness support in IM, such as *Conversation Dock* supports awareness of multiple concurrent conversations, *Relaxed Instant Messenger* assists turn-taking convention and provides richer conversational awareness, *Group List* enhances presence awareness in a group chat, and *Track View* supports awareness of in-progress listeners and viewers.

As future work, we will continue working on the development of the framework and the implementation of other awareness mechanisms, and once the awareness features are implemented we will conduct user studies to evaluate the usefulness of those features.

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