User-Driven Design of a Tangible Awareness Landscape

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ABSTRACT

This paper describes the design and evolutionary development of a system for supporting informal interactions between geographically-remote members of a group. Based on simple internet technologies, the system described enables the use of novel, tangible devices for the purpose of discrete event notification. A simple system was initially developed for use in an office environment for providing awareness events via a single notification device. Over a four month period this simple system evolved into a suite of low-cost, low-tech notification devices for public and personal use. The numerous devices utilised by the final system constitute a physical landscape of awareness which have been demonstrated to support group and individual awareness of discrete events in both fixed locations and on the move.

Keywords

User-driven Design, Tangible Media, Awareness Landscapes.

1. INTRODUCTION

This paper describes our experiences of the evolutionary design of a simple groupware application. The description takes the form of a narrative concerning the user-driven evolutionary design and implementation of TANGERINE (TANGible Embodiment of Remotely Initiated Notification Events), a system for supporting lightweight social interaction between remotely-located members of a workgroup.

2. BACKGROUND

A major focus for CSCW research has been the study and support of work-related activities of remotely-located groups of individuals. Through such studies Bly [1] and others have identified the importance of informal social interactions in the collaborative process. They have concluded that there are many benefits to providing support within a technological groupware application for this type of interaction.

The work described here evolved from an initial requirement to provide a simple means for members of our research group, who were away from their workplace for extended periods of time, to maintain an informal sense of presence within our shared workspace. Individuals who were due to spend time away working in industry had expressed concerns that they would lose touch with events occurring in the research group. They spoke of a potential sense of isolation from the group with the associated fear of being sidelined from the activities of the group whilst they were away.

A physical space had been identified as a focal point for both formal and informal interactions between group members. The fact that this space was an office, and the fundamental workspace of a number of group members, immediately placed constraints on the choice of notification and communication technologies that could be used. It was felt, for example, that video conferencing would be an inappropriate technology to support informal interactions due to its potentially disruptive impact on the physical workspace. Beside, the aim was not to create such a heavyweight, potentially task-supportive media space. Rather the underlying notion was to create some physical sense of the remote user within the office.

Whatever technologies were brought into the workspace needed to be aesthetically appropriate and afford minimal interruptions for the regular occupants of the office. Furthermore, both the office occupants and the remote workers expressed the desire for a solution that was light-weight and fun to use. Our aim at this point was therefore to provide a light-hearted way for remotely located group members to experience a sense of their presence within the office, whilst limiting the level of disruption within the office to that of an informal, ‘head round the door’ visit.

3. DESIGNING INITIAL SYSTEM

The intention of people passing a door is often less the opportunity to enter into discourse with the occupants, as to say simply “I’m here”. The focus of our initial design therefore was to provide remote users with a mechanism for effectively saying a quick hello or simply affirming their presence within the space.

Through discussion it was identified that this action could be represented as any discrete event, which was available to the office as a whole. For example, a simple audio message or perhaps something more abstract such as a pager-like beeping, or flashing light bulb may have been appropriate. The general consensus however, was that these could simply become annoying to the occupants of the office. We needed therefore to

choose a communications media that would be acceptable to those people whose principal workspace the office was. It could be neither visually or operationally intrusive to the existing space and would ideally reflect the good-natured intent of a quick hello.

In the end we decided to create a device that would be similar in size and appearance to the toys and mascots the people in the office already had on their desks. This not only limited the impact of their introduction into the environment, but the light-hearted nature of their design also increased the affinity of the notification mechanism with both remote and local users alike.

The notification device constructed consisted of a wooden, motor-driven parrot operated via a serial connection to a web server in the office. A remote user could send an event to the web server by pressing a button on a web page and cause the parrot to spin for a short period of time. The overall architecture of the first, crude version of the TANGERINE system is illustrated in Figure 1.

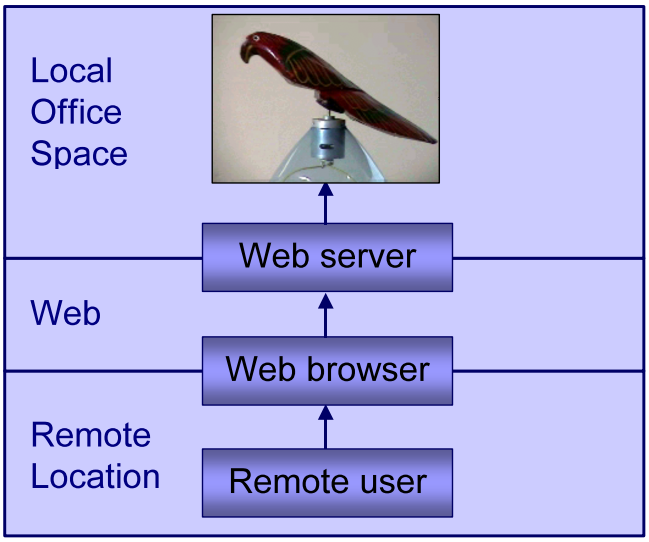

Figure 1. Initial system design

4. JUSTIFICATION

To justify our choice of notification device, we shall firstly compare and contrast the differing mechanisms available for achieving our stated system requirements. We shall attempt to rate each mechanism against a set of criteria in order to derive a quantitative estimate of their applicability for the purpose described above. The criteria used for this comparison include the following elements:

- *Content overhead* - The potential overhead of message size, small messages being preferable to large ones.
- *Requirement for response* - The likelihood that a reply to the message will be required, no reply needed being preferable to a forced response.
- *Level of interruption* - The degree to which peoples' work is interrupted by the arrival of the message or notification, minimal interruption being preferable.
- *Relative cost* - The expense of introducing the notification mechanism into the existing office environment, cheaper being better.
- *Integration into environment* - An evaluation of the way in which the mechanism becomes part of the office environment, more seamless integration being the preferred option.

Table 1 shows the quantitative comparison of each of these elements for a number of relevant notification mechanisms. It is important to note that the ratings each mechanism is given relate to it's applicability and utility for performing notification within the confines of our system requirements and design. They do not as such indicate the relative suitability of the approaches for all types of messaging and notification. When considering a particular criteria for a notification mechanism, it may become clear that a range of values may be valid. In such a situation, a typical or average rating has been allocated.

In Table 1, the more ticks that are present for a criterion, the better the mechanisms match the requirements for our particular application.

Table 1. Comparison of notification mechanisms

Notification mechanism	Content overhead	Requirement for response	Level of interruption	Relative cost	Integration into environment
Email	✓	✓ ✓	✓ ✓	✓ ✓ ✓	✓ ✓
SMS	✓ ✓	✓ ✓	✓ ✓	✓	✓
Telephone	✓	✓	✓	✓	✓ ✓
ICQ	✓	✓ ✓	✓ ✓	✓ ✓ ✓	✓ ✓
Net send	✓ ✓	✓ ✓	✓	✓ ✓ ✓	✓
Fax	✓	✓ ✓	✓ ✓	✓	✓ ✓
Pager	✓ ✓	✓ ✓ ✓	✓ ✓	✓	✓ ✓
Voice mail	✓	✓ ✓	✓ ✓ ✓	✓	✓ ✓
Bell/buzzer	✓ ✓ ✓	✓ ✓ ✓	✓ ✓	✓ ✓ ✓	✓
Parrot	✓ ✓ ✓	✓ ✓ ✓	✓ ✓ ✓	✓ ✓ ✓	✓ ✓ ✓

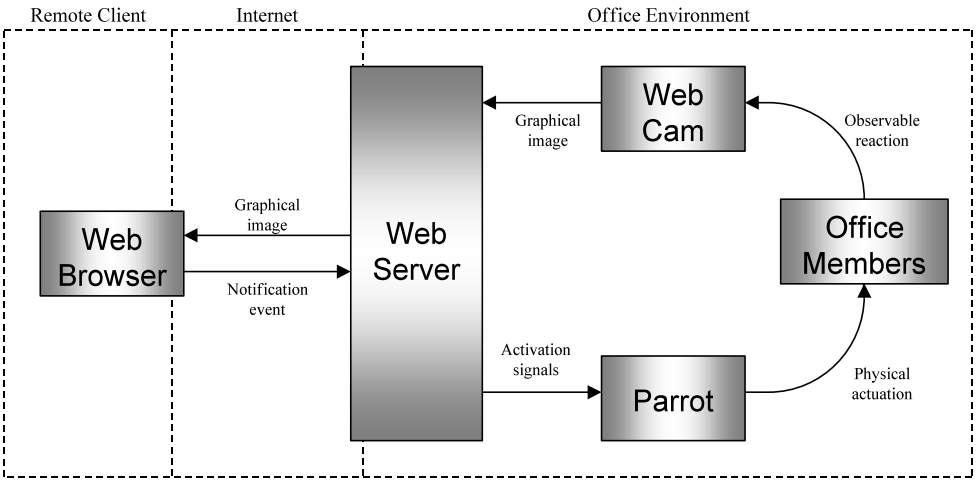

Figure 2. The webcam feedback loop

5. USER-DRIVEN DESIGN ADAPTATION: PHASE 1

Design challenge 1:
After only a short amount of time it became apparent that, unless people in the office happened to be facing the parrot at the time of an incoming event, the event would go unnoticed.

Design solution 1:
This was rectified by an addition of an auditory aspect to the notification event, which took the form of an appropriate bird noise[1].

Design challenge 2:
Incoming events (spinning and tweeting) were observed as having the desired effect, with both members of and visitors to the office responding positively to the sudden 'presence' of a virtual visitor. However, the invariable follow-up question "Who was that?" required consultation with the device's access log in order to discover the identity of the sender. This activity proved to be an interruption to work within the office to such an extent that the desired unobtrusive intent of the incoming event was threatened.

Design solution 2:
A solution to this problem was the introduction of a text to speech module on the web server. This was used to announce the initiator of the notification event, once that event had been processed. This involved the use of a simple lookup table of IP addresses to identify the name of the event sender.

Design challenge 3:
Although fulfilling the needs of many of the common types of event notification, the system was found to lack expressivisity for more advanced and involved notification.

Design solution 3:
The addition of the text to speech software provided the potential means for virtual visitors to have not only physical presence (the parrot) and a means of drawing attention to that presence (spinning and tweeting), but also a means of speaking to the occupants of the office. Encouraged by the acceptability of spoken messages in other notification systems [4, 7] the speech facility was made available on the parrot-event sending web page.

6. OBSERVATIONS FROM PHASE 1

During the first phase of evolution, we noticed that communications often took the form of composite notifications such as a parrot-spin to attract attention, followed by a spoken message or request. Communication also became coupled with access to a web cam which was already situated in the office. Incoming spoken events indicated that senders were occasionally seeking feedback in response to their initial event. This corresponded to either enquiries about the whereabouts of an office member, or some other question requiring a response. Requests such as "Is Simon there?" could be responded to by Simon's subsequent appearance (or not) in front of the camera. Requests for general information "Does anyone know…" would either cause someone in the office to email a response, or if it were a short answer, put a note in front of the camera. The webcam thus formed a feedback loop that was not designed into the system, but one which evolved as a result of user ingenuity. This feedback loop is illustrated in Figure 2.

We were happy at this point that TANGERINE fulfilled adequately its initial requirements in that it enabled remote visitors to send an informal greeting to colleagues in the office. In addition to this, remote users utilised the notification technologies in order to make simple enquiries and for them to receive quick responses to those enquiries. Remote users particularly liked the opportunity to send a parrot-mediated or verbal greeting and "be there when it arrived" by viewing the response in the office via the webcam. Remote users would, of course, also access the webcam just to see who was in the office[2]. Local users appreciated the humour of the parrot and readily associated it as being a tele-present colleague extending a greeting towards them.

[1] Over the period of reported use the humorous nature of the chosen sound effect (bird tweeting) minimised the annoyance factor of the audio notification.

[2] Unexpected, personally-directed spoken greetings, followed by the web server's announcement "Message sent by Zoe at BT" (or whoever) pleased many physical visitors to the office.

7. USER-DRIVEN DESIGN ADAPTATION: PHASE 2

Design challenge 4:
The informal and accessible nature of the communications technology meant that it was soon being used by individuals outside of the initial user-group. Family members and friends of the regular office workers were comfortable with the idea of pressing a button to send a parrot-spin event in lieu of greetings. But as the web server was unable to identify their machine's network address, it was impossible to tell who had sent the event. This problem was further compounded by the ambiguous nature of the generic parrot-spinning event, which effectively meant *hello* to everyone in the office at the time.

Design solution 4:
The chosen solution to this issue was the reconfiguration of the parrot so that its interface enabled a virtual visitor to choose who their event was aimed at. So, for example, spinning and tweeting could be an event to the entire office, whereas spinning accompanied by some other sound effect could signify that the greeting was for a particular office member – a bell for Jez, laughter for Peter, and so on.

Design challenge 5:
The problem still remained that the entire office would receive notification of an event meant only for one person.

Design solution 5:
Thanks to the simplicity of the architecture, individuals in the office began to elaborate on the theme of turning their "desk-clutter" into notification devices and the first configurable, personal notification device was created. One such device (shown in Figure 3) involved the incorporation of a counter-weighted motor into a pot-plant. On receiving an activation signal, the plant would vibrate, alerting its owner to the notification event.

Figure 3. A "Spider" Web Plant

This type of personal notification device was proximal to their owner, who limited the audible component of an incoming notification so as not to disturb others in the office. Where representation of events on the public parrot were constrained by the need for a shared understanding of the signals, a personal device had the potential to be customised by the owner, who could then use it to represent multiple events. Thus the configurable web plant previously mentioned had the choice of 4 motor speeds (from a short gentle shake all the way up to violent, leaf-shaking convulsions) and a range of sounds, combinations of which could be associated with each type of event.

Additional buttons on the original web page now allowed both local and remote users to send a range of discrete events to an individual (Hi, I've sent mail, I'm going for coffee, I'm back in the office, etc). Another user chose to augment their serial mouse by inserting a small motor, which provided only tactile event notifications, lessening the environmental distraction (but this suffered from the obvious drawback that they only received events if their hand was on the mouse at the time). This augmented, vibrating mouse is illustrated in Figure 4.

Figure 4. The vibrating mouse

Design challenge 6:
Devices created up until this point were geographically fixed event notifiers for either personal or group notification. A problem arose if, as often occurred, an office member left the office and thus was not able to receive notification events when they arrived.

Design solution 6:
When someone joked that it might be fun to carry the parrot on your shoulder we decided to create a portable device. This could effectively serve to notify someone moving around the department of predetermined events such as the arrival of a visitor or an awaited telephone call. In keeping with the light-hearted spirit of our prior developments, the mobile notification device selected was a purpose-built propeller hat (Figure 5), which maintains a radio link to a serial transmitter connected to a web server. Thus events sent via the web server cause the propeller on the hat to spin, the resulting vibration and downdraft indicating the arrival of the awaited event to the wearer (and anyone they happen to be with at the time!). Although this provides a useful

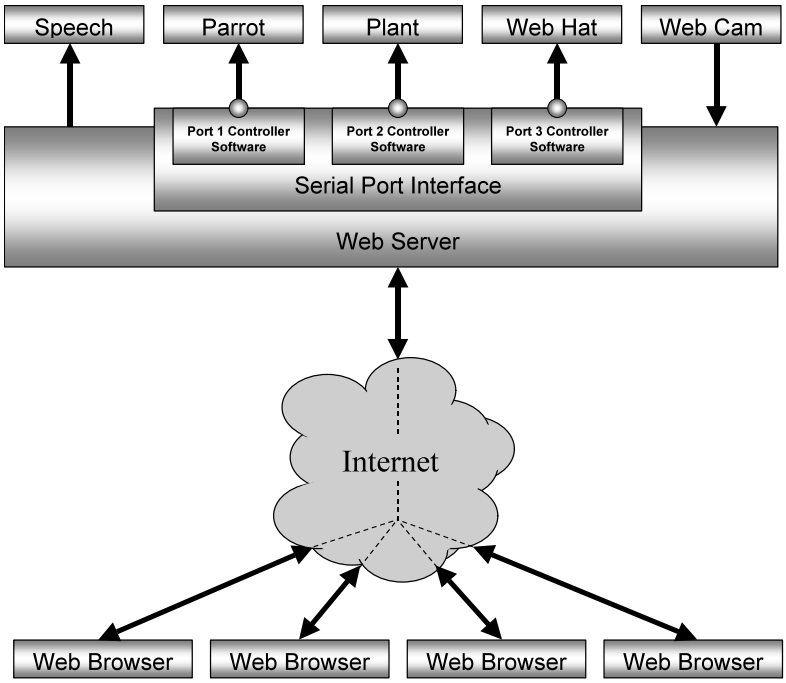

Figure 6. Current system architecture

mobile extension to TANGERINE, it should be borne in mind that such a device breaks the webcam-based feedback loop present in the system.

Figure 5. The Wireless WebHat

8. OBSERVATIONS FROM PHASE 2

A number of interesting observations can be made about the second phase of system evolution. Firstly, this phase saw the appearance of emergent requirements, such as the need for mobility and the desire for customisation and personalisation. This can only be expected as users became more familiar with TANGERINE and thought of a greater variety of tasks the system could support.

The evolution and refinement of the system during this phase resulted in a marked increase in the acceptance of the technology, signified by an expansion in usage scenarios as well as the number of remote participants.

9. THE CURRENT SYSTEM

The result of the user driven evolution of TANGERINE was the production of a rich 'landscape' of awareness information which was markedly different from the single device system which was first developed. Figure 6 shows the architecture of the current TANGERINE system. We shall now describe and investigate the nature of the system in more depth.

The fundamental architectural design is an asymmetrical one, where both the notification events and the feedback loop (use of the web cam to gather feedback on previous events) are driven by the remote users of the system. This is in contrast to systems where a remote user issues an event or message and the local user replies with an appropriate event or message. Symmetric and asymmetric architectures are illustrated in figure 7.

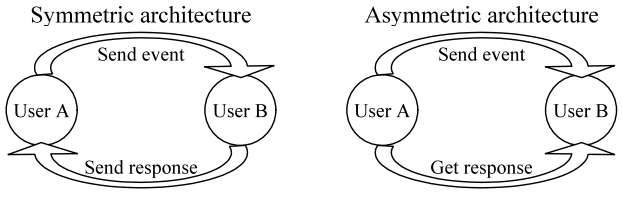

Figure 7. Symmetric and asymmetric architectures

Technologies such as video conferencing attempt to maintain a symmetrical awareness model, with both local and remote parties receiving similar information, in terms of video and audio. Most peripheral awareness technologies [6, 8, 9] differ in that they maintain a uni-directional awareness model, with *only* a local user

receiving a continuous stream of events about the state of some chosen event-generating phenomena.

The total number of serial ports on the main server determines the number of devices which may be attached to it. All simple serial devices have a consistent interface and thus may be replaced or 'hot swapped' while the system is live, without the need to restart or reconfigure the software. This allows local users to perform quick physical reconfiguration by plugging a new device into the appropriate notification port.

Unlike existing systems [5, 7] the implemented notification architecture has not been designed with the notion of users registering for particular events and not for others. This is due in part to the fact that the initial architecture was designed to support the issuing of notification events to the whole office and the ability to opt out of receiving events would violate this model.

The introduction of *configurable* devices, such as the web plant, does not effect the plug-ability of devices, since it only requires additional features to be added to the controlling software, rather than alterations to the hardware. Thus it is possible to have some plain notification ports and some configurable device ports, yet be able to freely swap devices between all ports.

A key feature of TANGERINE, which is supported by the current architecture, is ability for potentially anything that can be plugged into the serial port of a computer to be used as a notification device. This aspect of the system allows notification devices to become personal and personalisable. By being able to select a notification device which conforms to the interests, preferences and work behaviours of a user, the device may more easily represent, support, and complement the work of that user.

10. CONCLUSIONS

Essential to the design of TANGERINE was the need to support informal, lightweight communication. Rather than having to formally structure a message, remote users could quickly and effectively highlight their ‘presence’ by saying an abstract “hi”. By providing this type of communication it became possible for users to send messages without content but that still had meaning to the users of the office. The system also had the flexibility to allow more complex messages, requests and notification of significant events.

A benefit of this type of notification system identified by a number of the local users was that messages sent could be processed in a manner than ran parallel to any work in which they were engaged at the time. Whereas more formal messaging systems, such as e-mail, video-conferencing and lighter weight messaging services such as ICQ, require interruption of current task and serial processing of the content of a message in order to determine its significance and importance. The concise nature of the informal communication permitted fast evaluation of content and awareness of whether a response was required. This minimised interruption and permitted the filtering out of important messages from informal communication.

The potentially negative impact of the messaging and notification system in the office was minimised by the humorous nature of the notification mechanisms. Local users readily accepted the minor interruption caused by the parrot more readily than perhaps they would have done with more common notification mechanism such as pagers and ringing telephones.

By concentrating on creating devices from the normal 'desk clutter' found in most office environments TANGERINE achieved a high level of integration and acceptance in the workspace. In addition to this, by utilising existing entities from the workplace, rather than introducing additional devices, the impact upon the office members often scarce desk space has been minimised.

The system also proved popular from the remote user's point of view in that it offered them a lightweight, real-time messaging facility with the potential for receiving feedback on the events sent to the office. The kinetic, physical nature of the devices provided a compelling, tangible notification mechanism, which we feel would not have been achieved by 'solid state' devices. Local users responded with humour toward the physical, proactive entities.

One interesting phenomenon identified during the four-month period during which TANGERINE has been in place is that of office haunting. This occurs when a remote user sends events and often spoken messages even when they believe the room to be empty. The phenomenon came to light on a number of occasions when, often late at night, an occupant of the room could not been seen via the web cam and a haunting had taken place. The exact reasoning behind this mode of system usage has not been isolated as the users who performed such actions were unable to give a clear indication of their motivations. This phenomenon does however illustrate the compelling nature of the remote embodiment aspects of TANGERINE. It seems that a certain level of satisfaction can be attained by the remote user when using the system, irrespective of the existence of a recipient of the notification event.

The work described in this paper took place in a university research group where it was possible for a subset of the system users, the system designers and the system implementers to work in physical proximity for the duration of the project. Despite the limited scope of this project, there is little question that the end users played a very active role in the creation of a system to support informal remote social interactions. What the users ended up with is a system which not only suited their requirements, but one which they feel they designed themselves. Though simple, the system has been used extensively as described, not only by the initial group of remote workers, but also by the family and friends of the office occupants.

If the success of this project can be measured in terms of its utilisation, then that success is down to the participation of the end users in all stages of the system’s development. Having the system implementers at hand meant that a relationship could be established which allowed users to informally come to at any time with suggestions about how to extend or improve the system.

12. ACKNOWLEDGEMENTS

We would like to thank Ramesh Ramloll of Glasgow University for his input to this work, and for coining the term “Awareness Landscapes”. We would like to dedicate this paper to our colleague, the late Jeremy Boothroyd.

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