Human-Computer Interaction in Online Communities

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One major impact of the Internet (net) has been its support for computer-mediated online communities. Communication through email and list servers and shared information archives through web browsers and servers support the discourse and knowledge processes of on-line communities in such a novel and effective way as to be revolutionary. Human-computer interaction (HCI) issues arise in the support of individual users of the Internet because the rapid growth of the technology has been achieved by repurposing existing tools without necessarily taking into account novel requirements. There are also new HCI issues emerging at the community level, and tools are being built that add to the effectiveness of such communities by organizing their knowledge products, supporting awareness of new material, attracting relevant members, and so on. This article addresses issues of HCI in online communities, the underlying cognitive, cultural, social and media theories, empirical modeling of community processes, and the use of the results to improve the supporting technology.

Keywords: human-computer interaction, online communities, utility, usability, likeability.

1. INTRODUCTION

Our research focus has long been the study and support of human-computer interaction, but it has gradually shifted from a focus on individuals and their cognitive processes to groups and their cognitive processes. Some groups that we have been supporting and studying have been professional communities defined only by their common interests for whom we, or others, provide services. Other have been major international projects with better defined membership related to an agenda of specific tasks. What we have come to realize is that the effective support of such communities depends on modeling not only the cognitive processes of individuals, but also those of the community as a whole. Many of the tools we have developed support community processes, and the most significant and challenging of these are those that model these processes dynamically so that the community can reflect upon its own operations.

One may see some of the issues by contrasting two recent books: Nielsen's (2000) *Designing Web Usability* is a valuable application of classical HCI principles to the design of web sites; Kim's (2000) *Community Building on the Web* is also valuable in proposing well-grounded good practice for managing the human side of a web community. What is needed now is a wider concept of HCI

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that bridges between these works and provides a principled framework that encompasses both the individual and the socio-cultural HCI issues. Ishida's (1998) initiative in organizing a conference on *community computing and support systems* in Kyoto in 1998 was the first major attempt to develop such a bridge. For example, the TRURL agent-based simulation environment (Terano, Kurahashi and Minami, 1998) has been used to determine what agent behaviors lead to effective community development and to provide foundations for the kinds of recommendation made by Kim.

The following sections outline the development of the net and web, the human factors issues that arise, a layered protocol model of human-computer interaction, its application to the likeability and usability of the major Internet services, and modeling and supporting online communities in terms of awareness.

2. DEVELOPMENT OF THE INTERNET AND WEB

The Internet came into being through serendipity rather than design in that the intentions and aspirations of its originators had little relation to what it has become. The Eisenhower administration reacted to the USSR launch of Sputnik in 1957 with the formation of the Advanced Research Projects Agency (ARPA) to regain a lead in advanced technology. In 1969 ARPANET (Salus, 1995) was commissioned for research into networking. Use by the scientific and engineering communities grew through the 1970s, and in 1984 the National Science Foundation funded a program to create a national academic infrastructure connecting university computers in a network, NSFNET. In 1987 the net had grown to such an extent that NSF subcontracted its operation to commercial providers, and in 1993/1994 the network was privatized.

The World Wide Web came into being through a similar series of serendipitous processes commencing in 1989 when Tim Berners-Lee (1989) presented CERN with a proposal for managing its documents effectively: *"We should work toward a universal linked information system, in which generality and portability are more important than fancy graphics techniques and complex extra facilities."* The major impetus behind the web implementation came in 1992 when Marc Andreessen joined the *www-talk* list server and started the development of what became the *Mosaic* browser and eventually *Netscape* and *Internet Explorer.* Marc took the full affordances of printed documents as his target model, and added the fancy graphics techniques and complex extra facilities that Tim had disclaimed. He and Eric Bina radically changed the nature of the web when they enabled web documents to become interactive through the embedding of HCI widgets such as text edit boxes, check boxes, radio buttons, selection lists and menus. This allowed web documents to be used as graphic user interfaces, web browsers as universal interfaces, and HTML as a generic interface programming language.

In conjunction with these developments, the advent of the personal computer in the mid-1970s, of direct manipulation graphic interfaces in the mid-1980s, and the continuing decline in costs of computers and Internet access to consumer product levels, led to the growth of the *information highway* (Baran, 1995) in the mid-1990s. The interplay of the technical, knowledge and human resources on the Internet are apparent in Krol's (1992) *Request for Comments* (RFC) that answers the question "What is the Internet?", offering three different definitions:

- a *network of networks* based on the TCP/IP protocols;
- a *collection of resources* that can be reached from those networks;
- a *community of people* who use and develop those networks.

The human-computer interaction issues associated with that community include all those of individuals interacting with personal computers, and add to these new issues of supporting those to

access effectively the massive collection of resources now available to them, and to operate effectively in a community in which they participate primarily through the Internet.

3. HUMAN FACTORS OF THE NET AND WEB

A good starting point for a comprehensive analysis of the human factors of the net and web (Gaines, Chen and Shaw, 1997) is Shackel's (1991) basic factoring of human factors issues into:

- *utility:* will it do what is needed functionally?
- *usability:* will the users actually work it successfully?
- *likeability:* will the users feel it is suitable?

Shackel measures usability on four dimensions:

- *effectiveness:* performance in accomplishment of tasks, the access to potential utility
- *learnability:* degree of learning to accomplish tasks, the effort required to access utility
- *flexibility:* adaptation to variation in tasks, the range of tasks for which there is utility
- *attitude:* user satisfaction with system, the manifestation of potential likeability.

One has to take into account that *utility* in a collaborative environment is not just for individual users but for communities. For example, the *accessibility* of a system to all members of the relevant reference community is a utility consideration. One has to take into account that *usability* is not intensionally defined in terms of compliance with human factors guidelines, but rather extensionally defined in terms of evidence of a high proportion of effective users. The literature on usability emphasizes user studies (Wiklund, 1994) and evaluation methodologies (Ravden and Johnson, 1989).

It is important to have developed a full analysis of the utility of a technology before one considers its usability. The analysis of what is "needed functionally" is fundamental to understanding the problems users have in fulfilling that need. The utility of email, for example, often appears so obvious that human factors analysis focuses only on the user interface. However, a deeper analysis of needed functionality will reveal that the support of discourse through a textual medium with no voice intonation, body language, and so on, involves complex interpersonal factors (Walther, 1992; Spears and Lea, 1994). Most computer interfaces do not specifically support the 'netiquette' (Shea, 1994) of electronic discourse, but consideration of the HCI issues draws attention to the need for user guidance or training, and suggests that tools that evaluate email in terms of the emotional loading of the words involved might be useful to users.

Human factors studies of the net and web have to analyze the social expectations of the community within which the communication takes place, and the users' objectives in communicating. The computer system has no technical 'understanding' of these issues, but they determine the utility of a computer-mediated system, and failure by users to conform with the cultural norms or express their intentions effectively is failure of usability as much as is pressing the wrong icon to send the mail.

4. A LAYERED PROTOCOL MODEL OF HUMAN-COMPUTER INTERACTION

The human factors issues discussed above can be analyzed in terms of the layered protocol models which have been developed to provide a conceptual framework for complex systems of people and computing services (Gaines, 1988). Figure 1 shows a six layer model that partitions each subsystem, person or computing service, into:

- *cultural* layer which encompasses the milieu of the community within which the system operates and influences user intentions;

- *intentionality* layer which encompasses the objectives of the agents operating within the system;
- *knowledge* layer which encompasses the overt background knowledge necessary to translate agent intentions into actions;
- *action* layer which encompasses the skills or services of the agents as they translate intentions into actions and communications;
- *expression* layer which encompasses the encoding of actions or communications into a specific sequence of discrete acts – the *neurobehavioral expression of action;*
- *physical* layer which encompasses the encoding of actions into physical effects.

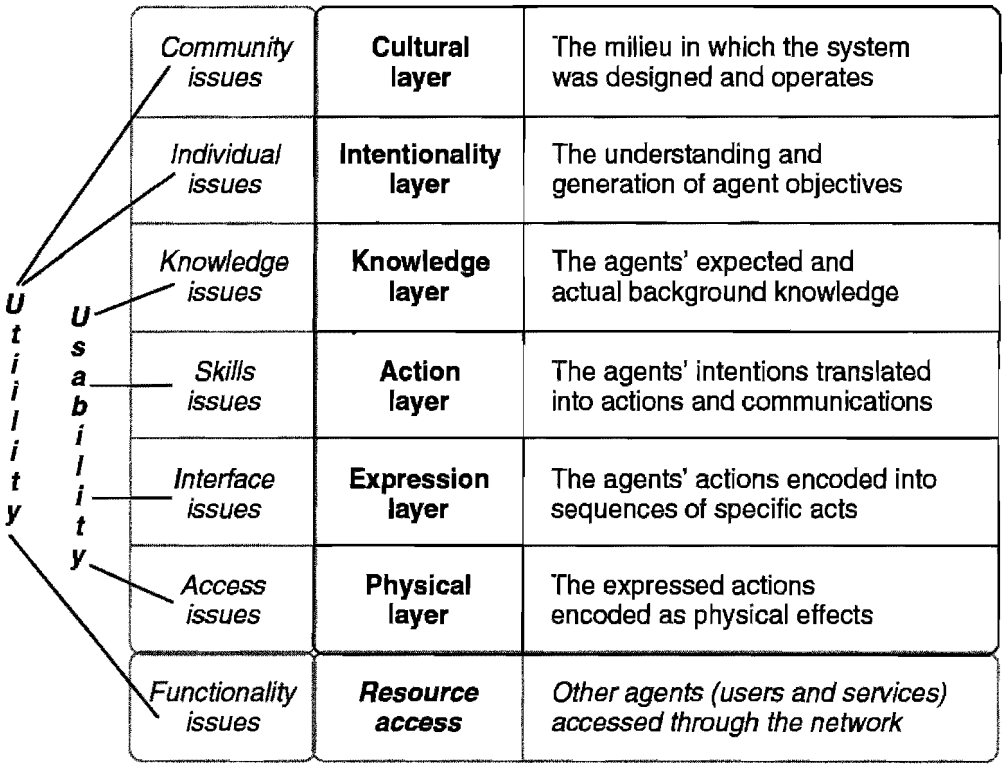

Figure 1: Layered protocol model for human-computer interaction

The action and expression layers are separated to allow actions to be conceptualized both as unitary abstractions and as the particular expression of those abstractions as a sequence of acts. For example auto-dialing may be conceived as a single cognitive entity even though it may be expressed by a menu selection, dialog box click or command line text entry.

The term 'agent' is used to cover both human users and computer services. At the current state of the art, the top three layers are design time considerations in developing computer services and only the three low levels are operational at run time, although the development of 'knowledgeable agents' as a computer technology is a major research area.

Multiple six layer models of users and three layer models of services may be combined to provide a model of a complex system in which users communicate with other users and services through a network at the physical layer, establishing 'virtual circuits' at the upper layers (Gaines, 1988). This is shown as "resource access" at the bottom of Figure 1 which subsumes the functionality that the agent can access through the network.

Shackel's *utility* can now be seen as an evaluation of the extent to which a user's intentions can be realized through processes accessing functionality available. For the net and web it is also appropriate to assess functionality in relation to a community's needs.

Shackel's *usability* can be seen as an evaluation of the extent to which users can translate their intentions into effective actions to access the functionality. It factors through four layers into:

- *knowledge* issues concerned with the background knowledge that the user has available through experience or training;
- *skills* issues concerned with the user's capability to translate intentions into actions using the background knowledge as appropriate;
- *interface* issues concerned with the facilities provided for the user to translate abstract actions into a sequence of acts;
- *access* issues concerned with the provisions for the user to access the functionality specified through the sequence of acts.

Shackel's *learnability, flexibility and likeability* are non-functional aspects of usability that are manifest in each layer. Likeability is the least studied of the three because it has seemed a subjective matter with no behavioral model that can only be tested through questionnaire techniques. However, in recent years Csikszentmihalyi's (1990) concept of *flow* as the phenomenon underlying the psychology of optimal experience has been applied to modeling user satisfaction with computer-mediated communication (Trevino and Webster, 1992). In their application of the model to flow phenomena in interaction with the web, Hoffman and Novak (1995) summarize the concept as: *"Flow has been described as 'the process of optimal experience' achieved when a sufficiently motivated user perceives a balance between his or her skills and the challenges of the interaction, together with focused attention. Flow activities in the Web, specifically network navigation, facilitate concentration and involvement because they are distinct from the so-called 'paramount reality' of everyday existence."*

It is reasonable to propose that likeability correlates with a flow state in which a motivated user undertakes a task whose level of difficulty is at a level that suits their individual needs. Too low a level results in boredom, too high a level in anxiety, and the optimal level results in the intense satisfaction with the activity that Csikszentmihalyi terms *flow*. It is interesting to note that the level of difficulty that is optimal for flow also maximizes the rate of learning (Gaines, 1997).

In the flow model, likeability is not associated with a particular layer of the protocol but rather with the appropriate level of activity involving the protocol. This explains some of the paradoxical aspects of usability analysis – high usability does not imply high likeability, and many well-liked interfaces and systems are poor from a usability standpoint. From a flow perspective, a simple task which is boring through a highly usable interface may be enhanced in its likeability by decreasing the interface usability to present a greater challenge to the user. More constructively, likeability might be enhanced by engaging the user's spare capacity in a secondary loading task, e.g. viewing advertising.

Similar considerations apply to flexibility which generally increases utility but may decrease usability because it involves the use of the system in modes for which it was not designed. The dimensions of human factors evaluation are not monotonically related and there are generally trade-offs between them.

5. LIKEABILITY AND USABILITY OF INTERNET SERVICES

This section considers the likeability and usability of the major Internet services.

5.1 Electronic mail

The human factors of email may best be understood by contrasting it with similar communications through the telephone (Pool, 1977). The phone is essentially synchronous and when the phone rings the caller is generally unknown and it is too late once the information is known to decide whether the call should be answered or not. Caller information or filtering through a secretary or answering machine improves the situation, but if the decision is not to answer instantly then arrangements have to be made to call back. Email is attractive because it is asynchronous and replies can be prioritized on the basis of full information with a simple facility to call back. For professionals faced with substantial personal resource allocation problems, email has proved a very effective substitute for the telephone. It has the additional advantage that all discourse may be archived and indexed for later retrieval.

However, the volume of email may in itself be a problem, and the flow model may be applied to the likeability of email. New users of email may find it very attractive due to the reasons noted above, but if few colleagues use it they will become bored with it and cease to use it. However, at the other extreme for an initially satisfied user as the volume grows it may reach a level where the challenge of dealing with it exceeds the user's capacity and causes such anxiety that they again cease to use it. For high volume users, tools to automatically filter and archive email are very important.

5.2 News

Net news is also a valuable resource but again the volume of news can be overwhelming if the user interface is inadequate. Good news reader systems provide simple mechanisms for printing and filing interesting news items similar to those of a mail reader. Because news access is under the control of the user it does not have the flow problems noted for email, and because the volume and diversity of news groups is so high it is easy for users with effective browsers to adjust the access to an optimal level and achieve Csikszentmihalyi's state of *flow*. This may be the reason why news reading is commonly regarded as 'addictive.'

5.3 List servers

Significant usability problems have arisen in repurposing existing net technology to support new functions. For example, a usability problem has been introduced into the operation of list servers by the use of mail readers to access them. Because of the length and complexity of the information, mail browsers generally show only abbreviated headers which are adequate for normal mail but problematic for mail from list servers. This is because the servers use a simple trick to allow a reply to a message from the list to be addressed to the list rather than to the originator.

The net mail protocol allows both a "From:" field and a "Reply-To:" field to be specified in the mail header. In normal mail usage the "Reply-To:" field is absent and a reply is sent to the address in the "From:" field. In list servers the "From:" field is filled with the originator and the "Reply-To:" field is filled with the list server address so that replies go to the list. However, mail readers generally show the "From:" field as the origin of the mail, and it appears to the user as if they are replying to the individual who sent the mail to the list. This often leads to embarrassingly personal messages intended only for one person being mailed to the entire list. It would be better if mail

readers were configured to show the "Reply-To:" field in preference to the "From:" field, perhaps indicating that the "From:" field is different.

Some list administrators set the "Reply-To" field to be the originator to avoid this problem, but this reduces the usability of the interface since most replies are intended for the community, and having to enter the list server address in a reply is an impediment to spontaneous discourse. Some list administrators overcome the problem by "moderating" their lists and examining each item of mail before authorizing it to go to the list. This is again a serious impediment to discourse since it introduces delays, taking the list turnaround time from minutes to days.

The usability problems created by mail readers' failure to represent the "Reply-To:" field adequately, and by attempts to fix this, may be seen as a conflict between the *knowledge* and *skills* layers in the layered protocol model. The user is required to disrupt the skilled activity of discourse by a knowledge-driven override. The problems may also be seen as arising from the *flexibility* of the mail readers which enables them to be used as list server browsers. Flexibility is generally positive for utility because it widens the range of applications, but it is often negative for usability in that it involves operating the system outside the range of situations for which it was designed to be usable.

5.4 World Wide Web

The web has similar likeability characteristics to news since it offers a much richer variety of material with access under user control. The complexity of the services offered through the web leads to many usability issues which cannot be detailed in this article. Web document preparation and browsing involve major design issues, such as:

- **Graphic user interfaces** subject to the guidelines that have been developed over the years. The usual issues of uniformity in style of layout, presentation, vocabulary, use of color, and so on apply, and human factors design may be modeled on existing practice (Nielsen, 2000).
- **Typography, layout and visualization** which have human factors guidelines arising in graphic design and information visualization (Tutte, 1990).
- **Hypermedia navigation** where issues such as cognitive overload in hyperspace navigation, and the associated guidelines, have also become well-defined in the hypertext community (McKnight, Dillon and Richardson, 1991).
- **HTML writing skills** required to create a web document involve concepts that are foreign to users experienced with WYSIWYG word processors.
- **Indexing and tracking changes** in the large and changing corpus of documents available on the web.
- **Communication delays** which can be long and variable, and are crucially dependent on features of the data structures and client architectures. System designers need to be aware of far more detail about the web operation than is apparent at first sight.
- **Integration with other applications** which can present or process file types accessible on the web that are not directly presentable by the browser.
- **Interaction with active documents offering web services** going beyond document presentation to offer client server interaction with a range of complex applications.

Web-based community support also involves major social issues, such as:

- **Community management** to facilitate the social processes of a distributed community most members of which have never met in person (Kim, 2000).
- **Development of trust** both between users and between users and site providers, for example, in ecommerce applications (Egger, 2000).

- **Knowledge management** to attempt to ensure that the web-based systems integrates with and supports the knowledge processes of the community (Boisot, 1998).
- **Legal content management** to attempt to ensure that the material used complies with copyright and other relevant law, and is itself adequately protected (Rosenoer, 1997).
- **Business model management** to attempt to ensure the underlying financial relationship between the resource provider and the community is sustainable (Kosiur, 1997).

There are certain features appropriate to the document model of the web which can become problematic when the additional interactive features are used to support transaction processing. For example, the "Back" button that takes the user back to a previous document is a simple and natural feature in a static document environment. However, it is also available and expected to be available in transaction processing, and the natural user model is that it provides an "Undo" facility. It is important that this expectation is adequately supported by the application, but many do not do so, generally through oversight in design since the support of "Undo" features in stand-alone applications is now well understood. A simple mechanism to support "Back" as "Undo" is to incorporate a hidden field in a document that indexes the transaction state and use this to either undo the transaction back to the appropriate state, or inform the user that the transaction cannot be undone if an action has been fully committed.

6. MODELING ONLINE COMMUNITIES

The cultural layer at the top of Figure 1 itself requires partitioning when one considers the different forms of community supported through computer-mediated communication. At least three types of community need to be distinguished: the highly-coordinated, goal-directed *teams;* the more loosely coordinated *special-interest communities,* such as professional sub-disciplines; and the largely uncoordinated *Internet world at large* whose members have in common only the use of computer-mediated communication. For purposes of human factors analysis one needs a precise behavioral definition of these various forms of community. How may they be differentiated conceptually and through empirical observation?

6.1 Awareness in online communities

One can regard a community as a network of individuals that provide resources to one another with the most significant dimension relating to the coordination of the community being that of the *awareness* of who is providing a particular resource and who is using it. In the tightly-coupled team, each person is usually aware of who will provide a particular resource and often of when they will provide it. In logical terms, this can be termed *extensional awareness* because the specific resource and provider are known, as contrasted to *intensional awareness* in which only the characteristics of suitable resources or providers are known.

A team can be treated from a *collective stance* (Gaines, 1994) as a single psychological individual that behaves as a compound role generated by the distributed activities of roles in a number of people. Each resource provider in a team has an *extensional awareness* of their actual resource users, and each resource user has an *extensional awareness* of the resource and who will provide it.

In a special interest community resource providers usually do not have such extensional awareness of the resource users, and, if they do, can be regarded as forming teams operating within the community. Instead, resource providers usually have an *intensional awareness* of the resource users in terms of their characteristics as *types* of user within the community. Resource users in a special interest community may have an extensional awareness of particular resources or resource

providers, or an intensional awareness of the types of resource provider likely to provide the resources they require. This asymmetry between providers and users characterizes a special interest community and also leads to differentiation of the community in terms of core members of whom many users are extensionally aware, and sub-communities specializing in particular forms of resource.

In the community of users at large, there is little awareness of particular resources or providers and only a general awareness of the rich set of resources is available. Awareness of the characteristics of resources and providers is vague, corresponding to *weak intensional awareness*.

These distinctions lead to human factors consequences in terms of the appropriate awareness mechanisms that need to be established on the network for the communities to function. In a team, resources may be identified precisely by location and name. In a special-interest community, resources may be identified by an intensional indexing scheme that classifies them in terms of the distinctions made by that community. In the community of users at large, resources may be identified both by indexing their content type using a wide variety of taxonomies and by indexing their actual content.

6.2 Internet services distinguished by cycle times and awareness

It is common to distinguish computer-mediated communication as being synchronous when users interact conversationally in real-time, and asynchronous when they interact at prolonged intervals. However, there is a continuum of cycle times of interaction between the synchronized turn-taking of talk and chat facilities and the long-term interaction of discovering and commenting on resources on the web. A plot of the normal range of cycle times against the type of awareness involved provides a basis for characterizing and comparing different net services as shown in Figure 2.

Figure 2 shows *talk* and *email* involving extensional awareness of the individuals involved but with the email cycle time being longer, corresponding to *talk* being 'synchronous' but *email* 'asynchronous.' *Chat* is shown as overlapping talk but usually involving some lesser awareness of other participants and longer time cycles in discourse. *List servers* and *news groups* operate on time cycles of hours to days and involve extensional awareness of only a few participants but reasonably strong intensional awareness of the type of participant.

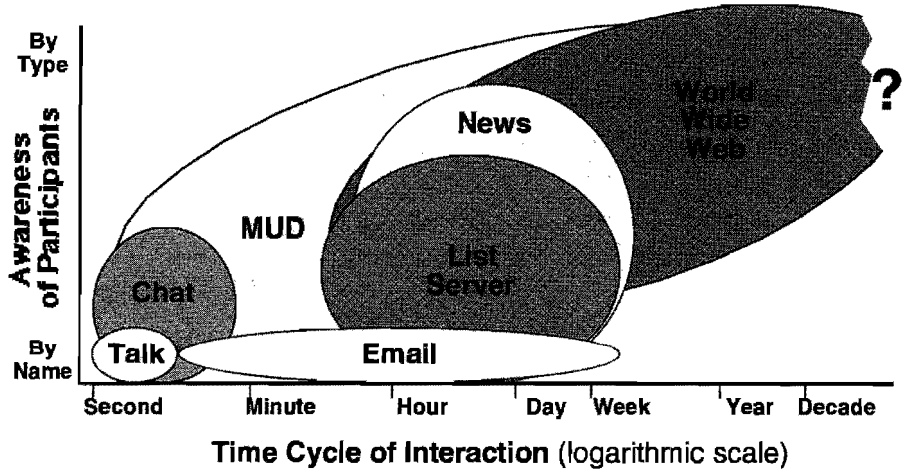

Figure 2: Internet services classified in terms of awareness and time cycle

The *web* operates on even longer time scales from a day up to years and generally involves little extensional awareness of participants—readers may know particular authors, but writers generally do not know their readers. The question mark indicates that the web has been operating for such a short period that any long term estimates of its impact as a publication medium are speculative projections.

MUDs (multi-user dimensions) combine chat- and web-like services, and span a major part of the plot. Web browsers have been extended to integrate the chat facilities of *MUDs* as well as providing access to email, news, collaborative tools and audio-visual interaction. Through the use of an integrated web browser the entire spectrum of services shown in Figure 2 can be made to appear to the end-user as an integrated system. However, the human factors distinctions between the different forms of discourse being supported will remain.

6.3 Tools to support awareness of community processes

Modeling net communities in terms of members' awareness draws attention to the need to model and support awareness. *Situation awareness* has proved a powerful concept in modeling the human factors of teams: "The critical thing about doing shared tasks is to keep everyone informed about the complete state of things" (Norman, 1993), and tools have been incorporated in synchronous groupware to support *workspace awareness* (Gutwin and Greenberg, 1998).

In the looser organization of online communities tools are required that keep members in touch with significant activities in the community that may interest them, for example, making them aware that new documents have been posted to particular areas of the web. The appropriate support for such *chronological awareness* depends on the expected rate of change of the area of interest. If changes are very infrequent then automatically generating email draws attention to changes without requiring user action, e.g.URL-Minder (NetMind, 1995) sends email when the content at specified URLs change. If changes are frequent then the automatic generation of a 'what's new' page is more appropriate, e.g. CHRONO (Chen and Gaines, 1996) automatically maintains a reverse chronological index of specified directories of a web site as shown in Figure 3.

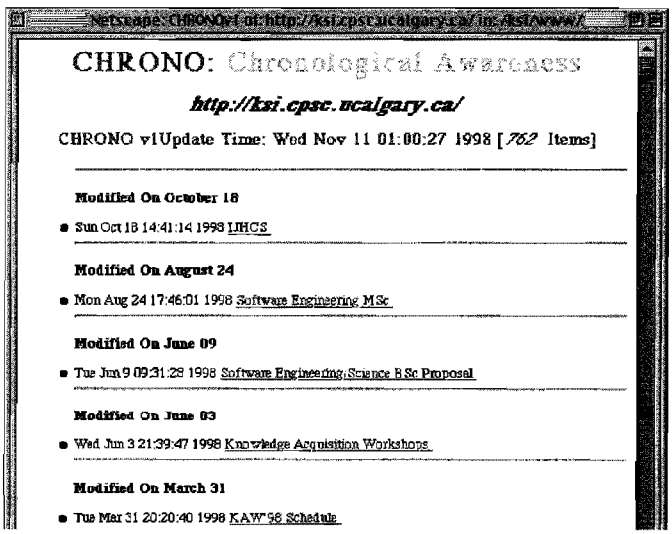

Figure 3: CHRONO automatic "what's new" chronological awareness support

CHRONO was one of a number of tools developed to support an intelligent manufacturing systems community modeled as a 'society of research agents' (Gaines and Norrie, 1997). We experimented with the use of knowledge acquisition tools to extract these structures from the project planning documents (Gaines and Shaw, 1994) and generated concept maps that provided hypertext links to material on the web (Gaines and Shaw, 1995). We also moved our conceptual modeling tools to the web to allow newcomers to compare their conceptual models with those of existing group members (Shaw and Gaines, 1995).

In the still looser world of the Internet community at large the most severe problem is that of becoming aware of what out of the wide range of resources available is relevant to a particular requirement. The number of documents on the web has grown 1,000% a year since its inception (Gaines, 1998) and now numbers some 500 billion. Many tools have been developed to index materials on the entire web or particular document collections (Marchionini, 1995), and techniques have been developed to model individual users and expedite their access to web materials (Maglio and Barrett, 1997). The techniques range from information retrieval based on content to the maintenance of selective collections of links by users representing different perspectives on community interests.

In particular, a community may maintain documents answering frequently asked questions (FAQs) to help newcomers and discouraging the use of the list for elementary queries from new members. *Answer Garden* provides a structured dynamic FAQ where questions not already answered are sent to an appropriate expert whose answers are posted back to the FAQ, and has been developed to operate as an *organizational memory* supporting collaborative help through the web (Ackerman, 1998). Web search engines have gone through several generations of development and the most successful ones, such as Google, use a wide range of data about documents and their linkages to retrieve documents that users find appropriate to their queries (Thelwall, 2001).

One important impact of the successful development of search engines has been to alleviate one of the most apparent HCI problems of uniform resource locators (URLs) as indices to web documents. The web is highly dynamic and URLs go out of date as sites are reorganized and individuals change their service providers. In the early days of the web this seemed a major impediment to use requiring new URL technologies such as symbolic locators that could be redirected to actual locations. However, the effort of updating such locators in itself would have undermined their effectiveness. Instead, contextual search through document content allows relocated documents to be found through an automated process requiring no manual intervention. It will be interesting to see whether the continuing development of a *semantic web* (Berners-Lee, 1999) with improved knowledge structuring and indexing has any significant impact on web architecture and usage. One approach to web semantics that is based on community processes rather than technical indexing is *collaborative filtering* in which one user is aided in their access from models automatically generated by tracking similar users (Kumar, Raghavan, Rajagopalan and Tomkins, 1998).

7 SUMMARY AND CONCLUSIONS

The world of human activities and supporting technologies grows pragmatically at its own frenetic pace and does not wait for the formation of theories. Human-computer interaction sciences have always been pressured to keep up with the rapidly changing world of computer applications, and have generally been retrospective, rationalising the experience of yesterday into the wisdom of today. They have only very rarely provided the impetus for future developments. However, it is important that the lessons of the past are consolidated into solid foundations for the innovations of the future.

There is now a mature discipline supporting individual interaction with personal computers through graphic user interfaces. However, the growth of online communities on the Internet and World Wide Web has introduced new human-computer interaction issues at a community level. This article has provided a framework for modeling HCI in general and used it to address both the individual HCI issues of interaction with Internet services, such as those arising out of the repurposing of existing technologies, and the community HCI issues, such as those of awareness of community activities and resources.

In future, as embedded, mobile, personal interfaces to the net support continuous computer-mediated communication as an integral component of all human activity, many additional HCI issues will emerge. We hope this paper helps to stimulate the development of both the conceptual frameworks and technologies for such future-generation systems.

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