Gaines, B. R. and Shaw, M. L. G. (2000). HCI and Internet communities: something borrowed, something blue. In Proceedings of OZCHI2000 Paris, C., Ozkan, N., Howard, S. and Lu, S., eds., pp. 364-374.

Human-Computer Interaction and Internet Communities: Something Borrowed, Something Blue

Brian R Gaines and Mildred L G Shaw
Knowledge Science Institute
University of Calgary
Calgary, Alberta, Canada T2N 1N4
gaines@ucalgary.ca, mildred@cpsc.ucalgary.ca

Abstract

Something old, something new: the learning curves of HCI/CHI research predated those of the Internet (net) by some 25 years, and net tools for email, newsgroups and the World Wide Web (web) have benefited from the maturity of HCI technologies. Even though the history of the net recorded in mailing lists shows that the pioneers often developed tools through serendipity rather than informed design, the affordances of the existing HCI widget sets they used had a major influence on the outcomes. The old has effectively supported the new, implicitly if not always explicitly. However, the repurposing of systems designed for one use to other applications that were not in mind when the original tool was designed has also led to some problematic human factors. In addition, the needs of loosely structured net communities raises new human factors issues going beyond both those of individual HCI and those of well-defined work groups in CSCW. This presentation reviews the HCI issues involved in developing systems to support distributed communities communicating through the net, illustrating the role of HCI research, the developmental processes involved, the successes and failures of repurposing, and the emerging issues of the new digital universe.

Keywords: Human-computer interaction, Internet, World Wide Web

1. Introduction

As we enter a new millennium it is timely to reflect on the status of HCI/CHI research during the past four decades since Brian Shackel [53] published what was probably the first paper on human-computer interaction. What are the major research results, how have these been assimilated into practice, what are the processes underlying innovation, and what are the challenges emerging from new technologies and applications?

This presentation provides a range of perspectives on these questions: placing HCI in the context of the overall evolution of information technology; telling the story of the development of the web within this context, exemplifying the processes of technology diffusion and serendipity within that story; illustrating the strengths and weaknesses of these processes; providing models of HCI issues that are applicable to both individuals and communities; and delineating the emergence of new research topics as the underlying technologies and applications change.

2. Information technology learning curves

The number of transistors on an integrated circuit chip has increased exponentially by nine orders of magnitude since the first planar transistor in 1959, a growth curve commonly termed Moore's law. In 1972, 5,000 devices on a chip allowed the first 1 Kilobit memory and microcomputer to be integrated; in 1980, 500,000 allowed major central processing units to be integrated. The projected limit *circa* 2006 is some 10,000,000,000 million devices on a chip as quantum mechanical effects become a barrier to further packing density on silicon planar chips.

The substitution of integrated circuits for discrete components radically accelerated the evolution of computers. The decrease in costs and increase in reliability made it possible to develop computers with greater storage capacity and processing power that also had mean times between failures that allowed them to be used in an interactive mode.

The learning curve of integrated circuits has not been the only factor in the evolution of computing. The nine orders of magnitude increase in the number of transistors on a chip has depended on the use of the computer to support the design and fabrication of such circuits. This is an example of a positive feedback loop within the evolution of computers. The computer industry has achieved a learning curve that is unique in its sustained exponential growth because each advance in computer

technology has been able to support further advances in computer technology.

Such positive feedback is known to give rise to emergent phenomena in biology whereby systems exhibit major new phenomena in their behavior [62]. The history of computing exhibits such emergence through the growth of new industries concerned with activities that depend upon, and support, the basic development but which are qualitatively different in their conceptual frameworks and applications impacts. For example, programming has led to a software industry, human-computer interaction has led to an interactive applications industry, document representation has led to a desktop publishing industry, and so on.

Each of these emergent areas of computing has had its own learning curve [38], and the growth of information systems technology may be seen as the cumulative impact of a tiered succession of learning curves. Each curve is triggered by advances at lower levels, and each supports further advances at lower levels and the eventual triggering of new advances at higher levels [21].

It has also been noted in many disciplines that the qualitative phenomena during the growth of the learning curve vary from stage to stage [27]. The era before the learning curve takes off, when too little is known for planned progress, is that of the inventor having very little chance of success but continuing a search based on intuition and faith. When an inventor makes a *breakthrough*, his or her work is *replicated* at research institutions world-wide. Experience gained leads to *empirical* design rules with little foundation except successes and failures. As enough empirical experience is gained it becomes possible to model the basis of success and failure and develop *theories*. The theoretical models make it possible to *automate* the manufacturing processes. Once automaton has been put in place effort can focus on cost reduction and quality improvements in a *mature* technology.

The breakthrough that initiated HCI research was in continuous *interaction* becoming a possible as the mean time between failures of computers changed from minutes to hours in the early 1960s. The replication phase commencing in 1964 saw a move from batch-processing to direct human-computer interaction with the implementation of MIT MAC, RAND JOSS and Dartmouth BASIC systems [26]. The empirical phase commencing in 1972 saw the study of such systems leading to a few design rules for human-computer interaction in the [32]. The theory phase commencing in 1980 saw the number of design rules increasing beyond 1,000 [58] and their rationalization leading to the emergence of theoretical foundations for HCI [19]. The automation phase commencing in 1988 saw the standardization of widget sets and user interface frameworks across the major operating systems, and we are now in the maturity phase where high-quality HCI is available in very low-cost products.

Figure 1 left shows the tiered succession of learning curves for information technologies in which a breakthrough in one technology is triggered by a supporting technology as it moves from its research to its empirical stage [24]. The initial sequence of technologies is that of *computer science*: digital circuits; computer architecture; software engineering; and human-computer interaction; followed by those of *knowledge science*: knowledge representation; knowledge acquisition; autonomous agents; and socially organized agents. Also shown are trajectories for the eras of *invention*, *research*, *product innovation*, *long-life product lines*, *low-cost products*, and *throw-away products*.

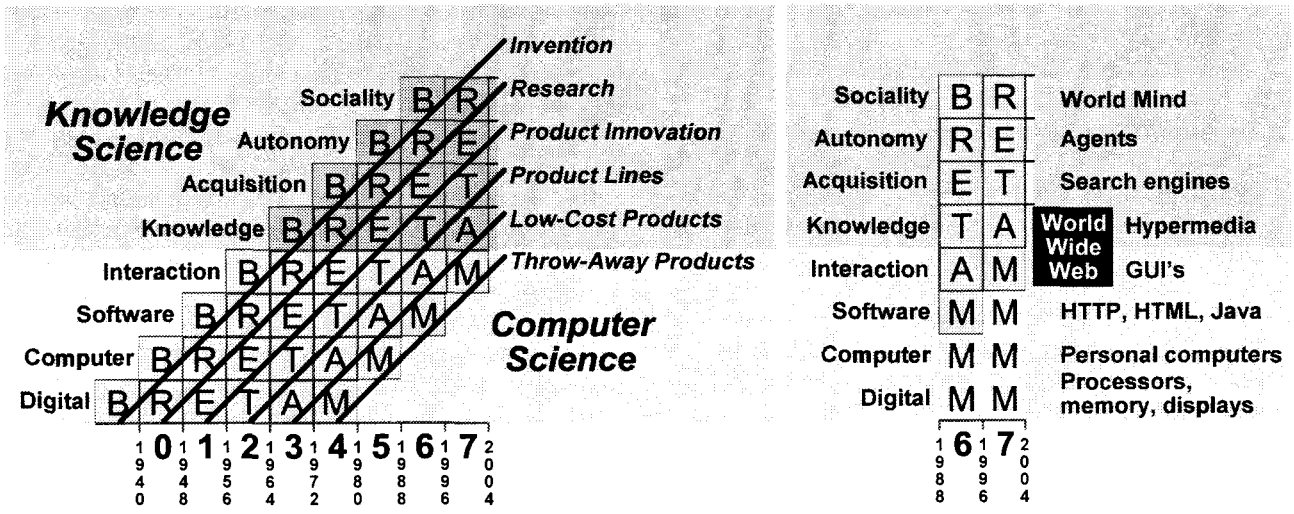

Figure 1 Information technology infrastructure and its role in the World Wide Web

3. Development of the net and web

Krol's [37] *Request for Comments* (RFC) that answers the question "What is the Internet?", offers three different definitions:

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

These three aspects capture the way that the net integrates human communities and their knowledge products.

3.1. Development of the Internet

The net came into being through serendipity rather than design in that the intentions and aspirations of their originators had little relation to what they have become. The Eisenhower administration reacted to the USSR launch of Sputnik, the first artificial earth satellite, in 1957 with the formation of the Advanced Research Projects Agency (ARPA) within the Department of Defense to regain a lead in advanced technology. In 1969 ARPANET [52] was commissioned for research into networking with nodes at UCLA, UCSB and the University of Utah. By 1971 ARPANET had 15 nodes connecting 23 computers and by 1973 international connections to the UK and Norway had been created.

Use of ARPANET 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 Merit and other commercial providers, and in 1993/1994 the network was privatized and its operation taken over by a group of commercial service providers.

Email on the net commenced in 1972, news distribution in 1979, gophers in 1991, and web browsers with multimedia capabilities in 1993. Existing use encouraged further use leading to exponential growth in the number of connected machines of 100% a year. The growth to over one million nodes, the growing commercial usage of the net, and the multimedia capabilities of the web in the 1993/1994 period combined to persuade government and industry that the net was a new commercial force comparable to the telephone and television industries, and the concept of an *information highway* came into widespread use.

Martin's [40] model of a *"wired society"* in 1978 comes closest to forecasting many aspects and impacts of the information highway: *"the technology of communications is changing in ways which will have impact on the entire fabric of society in both developed and developing nations."* However, initial attempts to make available the wired society were presented in terms of greatly exaggerated expectations. For example, in 1979 Fedida and Malik [17] presented Viewdata as having the potential for major social and economic impacts: *"We believe that Viewdata is a major new medium according to the McLuhan definition; one comparable with print, radio, and television, and which could have as significant effects on society and our lives as those did and still do."*

3.2. Development of the World Wide Web

Ten years after Viewdata, in 1989 Tim Berners-Lee [6] presented CERN with a proposal for managing its documents effectively that over the next decade became, through a series of serendipitous processes, the web as we know it today: *"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 web was slow to emerge as a viable technology. Tim Berners-Lee's paper was relegated to a poster at Hypertext'93, and the first major CHI paper on the human factors of the web was at CHI'96 [51]. In the early 1990's the gopher protocol that had been developed for campus-wide information services was rapidly coming into use as a way of sharing structured databases of documents [2].

However, in November 1992 Marc Andreessen joined the *www-talk* list server that Berners-Lee had established in October 1991 asking: *"Anyone written code to construct HTML files in Emacs? I'm hacking something up; let me know if you're interested"*, and the development of the web began to change as Marc moved into the development of what became the *Mosaic* browser and eventually *Netscape* and *Internet Explorer*.

Examination of the *www-talk* archives illustrates serendipity in the design of Mosaic. Features incorporated for one purpose proved even more valuable for unforeseen purposes. A major example is the discussion about where the search terms text box should be placed in the browser window. Marc got annoyed with all the suggestions and complaints and decided to embed it in the document being viewed. At 3am on 19th August 1993 he mailed to the list: *"You may be happy to know that I have before me a Mosaic running a quite revised HTML widget, thanks to Eric's kamikaze work ethic, that includes the following features...(BTW, this also means that putting widgets -- e.g., Motif text entry fields, etc. -- inside the HTML widget suddenly got a lot simpler and therefore should be arriving soon.)"*

The embedding of HCI widgets in documents was revolutionary in allowing them to be used as graphic user interfaces. It radically changed the nature of the web as web browsers became universal interfaces, and HTML became a generic interface programming language.

Our emphasis on the serendipity of net and web development requires balancing with consideration of how mature HCI technologies influenced that

development. When Eric Bina solved the text field problem by incorporating all the Motif widgets in HTML forms, he automatically inherited the products of the HCI research that had led to the development of that user interface technology. This also supported the cultures of the developers fluent in the semiotics of communications through those standard interface elements, and provided a familiar *locale* [29] for users whose IT *habitus* [8] subsumed those elements.

The Gibsonian affordances [28] involved in web development are multi-level: what the Motif widget set afforded Eric; what its incorporation in HTML forms afforded interface designers; and what web interfaces based on these widgets afforded end-users. This is one way in which a technological culture diffuses, through the cumulative affordances of the built environment, whether it be physical or information technology. The web incorporates the outcome of 25 years of HCI research, even though there may have been no explicit use of that knowledge in its initial design.

3.3. The web in the IT infrastructure

The BRETAM tiered learning curves infrastructure of Figure 1 brings together the various phenomena of convergence in an integrated model which has the potential both to explain the past and forecast the future of the web. The relevant learning curves in Figure 1 are the lower four: digital electronics; computer architecture; software; and interaction. The *product innovation* trajectory passes through the last of these in the fourth generation, 1972-1980, and led to the premature development of Viewdata and to Martin's detailed forecasts of the potential for a wired society.

However, the mass market potential for wired society technology at costs comparable to other mass media such as the telephone and television is dependent on the cost reductions possible in the post-maturity phase of the learning curves leading to *throw-away products*. This trajectory passes through the interaction learning curve in the current seventh generation era, 1996-2004, and it is this that has made the information highway economically feasible.

The analysis of product opportunities arising from the existence of the information highway involves the upper learning curves of the BRETAM model: knowledge representation and acquisition, autonomy and sociality. Knowledge representation and processing encompasses all the media that can be transmitted across the web, not just the symbolic logic considered in artificial intelligence studies but also typographic text, pictures, sounds, movies, and the massive diversity of representations of specific material to be communicated.

The significance of discourse in the human communities collaborating through the net has been underestimated in the stress on 'artificial' intelligence in computer research. As prophesied in the early days of timeshared computing [18]: *"If fifty percent of the world's population are connected through terminals, then questions from one location may be answered not by access to an internal data-base but by routing them to users elsewhere—who better to answer a question on abstruse Chinese history than an abstruse Chinese historian."* Net email and web services provide access to a far more powerful 'expert system' of human agents and their products than any currently conceivable through artificial intelligence techniques.

There are socio-economic problems with the web in that much represented material is owned by copyright holders who seek financial reward. The knowledge-level problem for the information highway is not just one of representation and processing but also one of effective commerce. It is important to develop ways of charging for access to material at a low enough rate to encourage widespread use at a high enough volume to compensate the provider. Advertising revenues are currently proving to be one effective mechanism. The human factors issues of advertising are ones of awareness plus the usual concerns of utility, usability and likeability: how to convey useful and usable information in the background in an attractive way.

These considerations indicate that the human factors of the Internet and World Wide Web extend beyond those of individual human interaction to the socio-economic and cultural dimensions of supporting computer-mediated human communities. The following sections analyze some of the emerging issues for HCI.

4. Human factors of the net and web

A good starting point for a comprehensive analysis of the human factors of the net and web [25] is Shackel's [54] 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 [66] and evaluation methodologies [50].

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 human factors [59, 63].

The fact that the computer interface itself does not specifically support the 'netiquette' [56] aspects of electronic discourse does not mean that it is a human factors problem that can be neglected in system design. Minimally, it draws attention to the need for user guidance or training, and technically it 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 as much as the lower layers, 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.

4.1. A layered protocol model

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 [20]. Figure 2 shows a six layer model that partitions each sub-system, person or computing service, into:

- A *cultural* layer which encompasses the milieu of the community within which the system operates and influences user intentions—Bakhtin's *voices of the mind* [65];
- An *intentionality* layer which encompasses the objectives of the agents operating within the system—Dennett's *intentional stance* [14];
- A *knowledge* layer which encompasses the overt background knowledge necessary to translate agent intentions into actions—Newell's *knowledge level* [45];
- An *action* layer which encompasses the skills or services of the agents as they translate intentions into actions and communications—Mischel's *human action* [43];
- An *expression* layer which encompasses the encoding of actions or communications into a specific sequence of discrete acts—the *neurobehavioral expression of action* [35].
- A *physical* layer which encompasses the encoding of actions into physical effects.

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 psychological 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 [20]. This is shown as "resource access" at the bottom of Figure 2 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:-

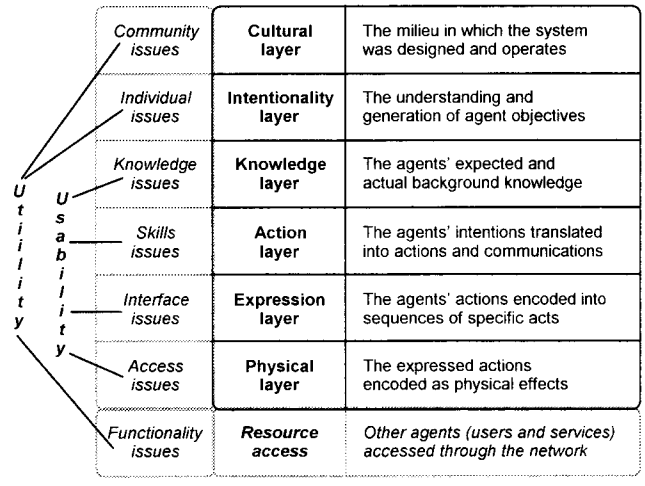

Figure 2 Layered protocol model for HCI

- 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 [12] concept of *flow* as the phenomenon underlying the psychology of optimal experience has been applied to modeling user satisfaction with computer-mediated communication [60]. In their application of the model to flow phenomena in interaction with the web, Hoffman and Novak [33] 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 [23].

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.

4.2. Internet likeability and usability

4.2.1. Electronic mail

The human factors of email may best be understood by contrasting it with similar communications through the telephone [48]. 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.

4.2.2. 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.'

4.2.3. 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.

4.2.4. 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 some eight major issues:

- **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 [55, 57, 58].
- **Typography, layout and visualization** which have human factors guidelines arising in graphic design and information visualization [7, 61].
- **Hypermedia navigation** where issues such as cognitive overload in hyperspace navigation, and the associated guidelines, have also become well-defined in the hypertext community [11, 42].
- **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.

4.3. Modeling net communities

The cultural layer at the top of Figure 2 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. Figure 3 shows the layered protocol model of Figure 2 extended to groups of agents distinguished in this way.

For purposes of human factors analysis one needs a precise behavioral definition of these various form of community. How may they be differentiated conceptually and through empirical observation? One can regard a community as a set of individuals that provide resources to one other 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.

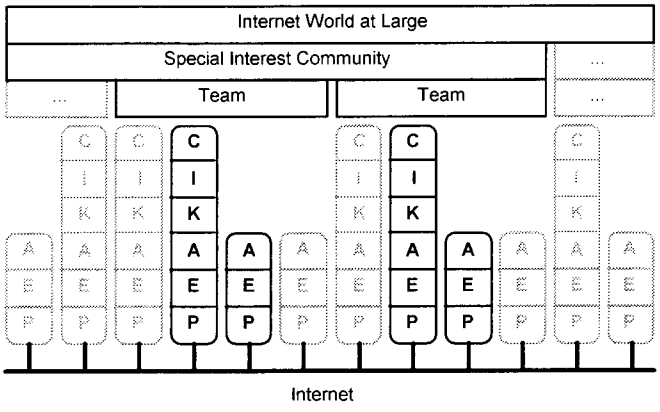

Figure 3 Communities in the protocol (3 layers represent computer services and 6 layers users, gray items represent an indefinite iteration)

A team can be treated from a *collective stance* [22] 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.

The classification of users into types usually corresponds to social norms within the community, such as the ethical responsibilities in a professional community to communicate certain information to appropriate members of 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.

These distinctions are summarized in Figure 4, and it is apparent that the classification of awareness can lead to a richer taxonomy of communities than the basic three-way division defined. Analysis of awareness in these terms allows the structure of a community to be specified in operational terms, and in complex communities there will be complex structures of awareness. The coarse divisions into sub-teams and sub-special interest communities provides a way of reducing this complexity in modeling the community.

	Team	Special-Interest Community	Community at Large
Resource Provider	Extensional awareness of actual users.	Intensional awareness of types of users.	No awareness of users, or only weak intensional awareness of types of users.
Resource User	Extensional awareness of actual resources and providers.	Extensional awareness of actual resources and providers, or intensional awareness of types of resources and providers.	No awareness of resources or providers, or only weak intensional awareness of types of resources and providers.

Figure 4 Communities and awareness

4.4. 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 cycles times against the type of awareness involved provides a basis for characterizing and comparing different net services as shown in Figure 5.

Figure 5 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.

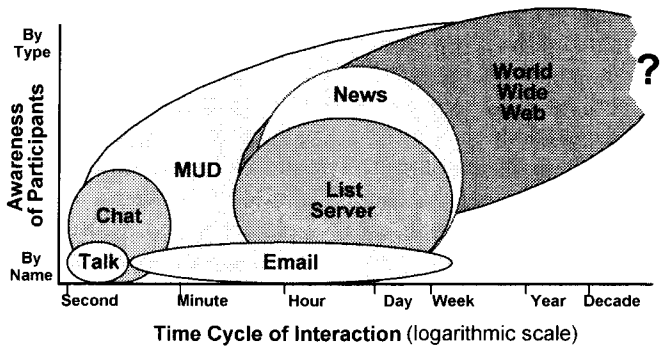

Figure 5 Internet services classified in terms of awareness and time cycle

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 [13]. 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 web the entire spectrum of services shown in Figure 5 will appear to the end-user as an integrated system. However, the human factors distinctions between the different forms of discourse being supported will remain.

5. Summary and conclusions

The dynamics of our post-modern world are often modeled as ones of *convergence*: of the diversity of human cultures amalgamating into some multinational society [16]; of separate national economies coalescing into a global economy [15]; of education combining with entertainment to become edutainment [9]; of telephone and cable television industries merging to provide a unified telecommunications industry [34]; of papers, magazines and books becoming subsumed into digital information distribution [31]; of computer and communications technologies combining to become information technology [3] capable of providing an *information superhighway* [5] supporting all these media, cultural, economic, industrial, and technological phenomena.

In HCI research and practice, convergence issues are arising in many areas at many levels. We have a well-defined set of major widgets: for document design and presentation used in word processors; for tabular data entry and presentation used in spreadsheets and databases; for graphic development and presentation used in drawing and painting packages; for form-filling used in interactive dialogs. On the web all these well-defined HCI technologies converge into an interactive document technology that subsumes their separate characteristics and evolution leading to something that is both old and familiar and also new and unfamiliar.

At a foundational level we have a model of individual human-computer interaction based on a cognitive science itself grounded in the 'person as information processor' metaphor that has served us well and continues to be highly relevant. However, the convergence of communications and computer media has situated individual HCI in community processes that transcend the individual and involve the social, cultural and economic infrastructures within which individuals develop and play out their roles.

5.1. Future HCI curriculum

What will the next generation of HCI researchers need to understand that is not part of the current HCI curriculum if they are to be effective in dealing with the emergent issues of the net and web? The published ACM HCI curriculum [1] dates back to 1992 and shows its age in associating "Social Organization" only with "Work" and in modeling "Human Information Processing" only in terms of "Characteristics of the human as a processor of information", "Language, Communication and Interaction" and "Ergonomics". This was appropriate to the pre-web world of 1992 when even CSCW was only just emerging as a significant new focus for HCI studies. Our students today need to read well outside these topics if they are to develop skills and undertake research that informs the design and management of net and web services.

One may see some of the issues by contrasting two recent books: Jakob Nielsen's *Designing Web Usability* [46] is an valuable application of classical HCI principles to the design of web sites; Amy Kim's *Community Building on the Web* [36] is also valuable in proposing well-grounded good practice for managing the human side of a web community. What is needed now is wider concept of HCI that bridges between these works and provides a principled framework that encompasses both the individual and the socio-cultural HCI issues.

A reading list would include: the social theory of *emergent communication networks* [44]; Granovetter's [30] theory of *weak ties*; Burt's theory of *structural holes* [10]; and Watts' theory of *small worlds* [64]. It would introduce students to the practical techniques for group analysis in: Penman's *Communication Processes and Relationships* [47]; McGrath's *Groups* [41]; Pruit's *Negotiation Behavior* [49]; and Bales and Cohen's *SYMLOG* [4]. It would provide foundations by having students come to terms with: Luhman's analysis of *trust and power* [39]; Gidden's concept of *locales* [29]; and Bourdieu's concept of *habitus* [8].

Such a reading list would provide HCI students with a relevant and stimulating bridge into the rich socio-cultural literature that needs to complement the rich psycho-cognitive literature that informs our curricula today. Then, and only then, will we be able to extend the discipline of HCI to encompass the full range of human-computer interaction phenomena that characterize the Internet and World Wide Web.

In conclusion, the challenges and opportunities for HCI researchers in this millennium are growing as information technology becomes increasingly integrated with all aspects of the everyday life of individuals and communities. A mature discipline in the later stages of its learning curves challenges practitioners through the wealth of knowledge that they must assimilate to be a professional in their chosen field. We do live in interesting times!

6. References

[1] ACM. *ACM SIGCHI Curricula for Human-Computer Interaction*. 1992. ACM. New York.

[2] Anklesaria. F., *et al.* "The Internet Gopher Protocol (a distributed document search and retrieval protocol)". 1993. Internet. Location.

[3] Arnold. E. and K. Guy. *Parallel Convergence: National Strategies in Information Technology*. 1986. Quorum. Westport. CT.

[4] Bales. R.F. and S.P. Cohen. *SYMLOG: A system for the multiple level observation of groups*. 1979. Free Press. New York.

[5] Baran. N.. *Inside the Information Superhighway Revolution*. 1995. Coriolis. Scottsdale. AZ.

[6] Berners-Lee. T. "Information Management: A Proposal". 1989. CERN. Geneva. Location.

[7] Bertin. J.. *Semiology of Graphics*. 1983. University of Wisconsin Press. Madison. Wisconsin.

[8] Bourdieu. P. and L.J.D. Wacquant. *An Invitation to Reflexive Sociology*. 1992. University of Chicago Press. Chicago.

[9] Brown. E.. *That's Edutainment: A Parent's Guide to Educational Software*. 1995. McGraw Hill. New York.

[10] Burt. R.S.. *Structural Holes: The Social Structure of Competition*. 1992. Harvard University Press. Cambridge. Mass.

[11] Conklin. J.. "Hypertext: An introduction and survey". IEEE Computer. 1987. 20(9) pp. 17-41.

[12] Csikszentmihalyi. M.. *Flow: The Psychology of Optimal Experience*. 1990. Harper and Row. New York.

[13] Curtis. P. and D. Nichols. "MUDs grow up: social virtual reality in the real world". in *Proceedings Third International Conference on Cyberspace*. 1993. ftp://parcftp.xerox.com/pub/MOO/papers/MUDsGrowUp.ps.

[14] Dennett. D.C.. *The Intentional Stance*. 1987. Cambridge. Massachusetts. MIT Press.

[15] Didsbury. H.F. (ed.) *The Global Economy: Today. Tomorrow and the Transition*. 1985. World Future Society. Bethesda. MD.

[16] Featherstone. M. (ed.) *Global Culture: Nationalism. Globalization and Modernity*. 1990. Sage. London.

[17] Fedida. S. and R. Malik, *The Viewdata Revolution*, 1979, Associated Business Press, London, UK.

[18] Gaines. B.R.. "Through a teleprinter darkly", Behavioural Technology. 1971. 1(2) pp. 15-16.

[19] Gaines. B.R.. "Perspectives on fifth generation computing". Oxford Surveys in Information Technology, 1984. 1 pp. 1-53.

[20] Gaines. B.R.. "A conceptual framework for person-computer interaction in distributed systems", IEEE Transactions Systems. Man & Cybernetics. 1988. SMC-18(4) pp. 532-541.

[21] Gaines. B.R.. "Modeling and forecasting the information sciences". Information Sciences. 1991. 57-58 pp. 3-22.

[22] Gaines. B.R.. "The collective stance in modeling expertise in individuals and organizations". International Journal of Expert Systems. 1994. 7(1) pp. 21-51.

[23] Gaines. B.R.. "Knowledge management in societies of intelligent adaptive agents". Journal for Intelligent Information Systems. 1997. 9(3) pp. 277-298.

[24] Gaines. B.R.. "The learning curves underlying convergence". Technological Forecasting and Social Change. 1998. 57(1) pp. 7-34.

[25] Gaines. B.R.. L.L.-J. Chen. and M.L.G. Shaw. "Modeling the human factors of scholarly communities supported through the Internet and World Wide Web". Journal American Society Information Science. 1997. 48(11) pp. 987-1003.

[26] Gaines. B.R. and M.L.G. Shaw. "Dialog engineering". in *Designing for Human-Computer Communication*. M. Sime and M.J. Coombs. Editors. 1983. Academic Press. London. pp. 23-53.

[27] Gaines. B.R. and M.L.G. Shaw. "A learning model for forecasting the future of information technology". Future Computing Systems. 1986. 1(1) pp. 31-69.

[28] Gibson. J.J.. *The Ecological Approach to Perception*. 1979. Houghton Mifflin. Boston.

[29] Giddens. A.. *The Constitution of Society : Outline of the Theory of Structuration*. 1986. University of California Press. California.

[30] Granovetter. M.S.. "The strength of weak ties". American Journal of Sociology. 1973. 83 pp. 1444-1465.

[31] Greenberger. M. (ed.) *Electronic Publishing Plus: Media for a Technological Future*. 1985. Knowledge Industry. White Plains. NY.

[32] Hansen. W.J.. "User engineering principles for interactive systems". in *AFIPS Fall Joint Computer Conference*. 1971. AFIPS Press. New Jersey. pp. 523-532.

[33] Hoffman. D.L. and T.P. Novak. "Marketing in Hypermedia Computer-Mediated Environments: Conceptual Foundations". Journal of Marking. 1995 pp. to appear (July).

[34] Intven. H. and R.J. Ménard. *Convergence: Competition and Cooperation*. 1992. Minstry of Supply and Services Canada. Ottawa.

[35] Isaacson. R.L. and N.E. Spear. *The Expression of Knowledge: Neurobehavioral Transformations of Information into Action*. 1982. Plenum Press. New York.

[36] Kim. A.J.. *Community Building on the Web*. 2000. Peachpit Press. Berkeley.

[37] Krol. E. "FYI on "What is the Internet?"". 1993. Internet. Location.

[38] Linstone. H.A. and D. Sahal (eds.). *Technological Substitution: Forecasting Techniques and Applications*. 1976. Elsevier. New York.

[39] Luhmann, N., *Trust and Power*, 1979, Wiley, Chichester, UK.
[40] Martin, J., *The Wired Society: A Challenge for Tomorrow*, 1978, Prentice-Hall, Englewood Cliffs, New Jersey.
[41] McGrath, J.E., *Groups: Interaction and Performance*, 1984, Prentice-Hall, Englewood Cliffs, N.J.
[42] McKnight, C., A. Dillon, and J. Richardson, *Hypertext in Context*, 1991, Cambridge University Press, Cambridge, UK.
[43] Mischel, T., *Human Action*, 1969, Academic Press, New York.
[44] Monge, P.R. and E.M. Eisenberg, "Emergent communication networks", in *Handbook of Organizational Communication*, F.M. Jablin, *et al.*, Editors, 1987, Sage, Newbury Park, CA, pp. 304-342.
[45] Newell, A., "The knowledge Level", Artificial Intelligence, 1982, 18(1) pp. 87-127.
[46] Nielsen, J., *Designing Web Usability*, 2000, New Riders, Indianapolis.
[47] Penman, R., *Communication Processes and Relationships*, 1980, Academic Press, New York.
[48] Pool, I.S. (ed.) *The Social Impact of the Telephone*, 1977, MIT Press, Cambridge, MA.
[49] Pruitt, D.G., *Negotiation Behavior*, 1981, Academic Press, New York.
[50] Ravden, S. and G. Johnson, *Evaluating Usability of Human-Computer Interfaces*, 1989, Ellis Horwood, Chichester, UK.
[51] Rice, J., *et al.*, "Using the web instead of a window system", in *Proceedings of CHI'96*, 1996, ACM, New York, pp. 103-117.
[52] Salus, P., *Casting the Net: From ARPANET to INTERNET and Beyond*, 1995, Addison-Wesley, Reading, MA.
[53] Shackel, B., "Ergonomics for a computer", Design, 1959, 120 pp. 36-39.
[54] Shackel, B., "Usability—context, framework, definition, design and evaluation", in *Human Factors for Informatics Usability*, B. Shackel and S. Richardson, Editors, 1991, Cambridge University Press, Cambridge, UK, pp. 21-37.
[55] Shackel, B. and S. Richardson (eds.), *Human Factors for Informatics Usability*, 1991, Cambridge University Press, Cambridge, UK.
[56] Shea, V., *Netiquette*, 1994, Albion Books, San Francisco.
[57] Shneiderman, B., "Direct manipulation: a step beyond programming languages", Computer, 1983, 16(8) pp. 57-69.
[58] Smith, S.L. and J.N. Mosier, "Guidelines for Designing User Interface Software", 1986, Mitre Corporation, Location.
[59] Spears, R. and M. Lea, "Panacea or panopticon? The hidden power in computer-mediated communication", Communication Research, 1994, 21(4) pp. 427-459.
[60] Trevino, L.K. and J. Webster, "Flow in computer-mediated communication", Communication Research, 1992, 19(5) pp. 539-575.
[61] Tufte, E.R., *Envisioning Information*, 1990, Graphics Press, Cheshire, Connecticut.
[62] Ulanowicz, R.E., "Formal agency in ecosystem development", in *Theoretical Studies of Ecosystems: The Network Perspective*, M. Higashi and T.P. Burns, Editors, 1991, Cambridge University Press, Cambridge, pp. 58-70.
[63] Walther, J.B., "Interpersonal effects in computer-mediated communication: A relational perspective", Communication Research, 1992, 19(1) pp. 52-90.
[64] Watts, D.J., *Small Worlds : The Dynamics of Networks between Order and Randomness*, 1999, Princeton University Press, Princeton, N.J.
[65] Wertsch, J.V. (ed.) *Voices of the Mind: A Sociocultural Approach to Mediated Action*, 1991, Harvard University Press, Cambridge, MA.
[66] Wiklund, M.E. (ed.) *Usability in Practice: How Companies Develop User-Friendly Products*, 1994, Academic Press, Boston.