CHAPTER TWELVE

Modeling and Supporting Virtual Cooperative Interaction Through the World Wide Web

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The growth of the Internet has provided major new channels for the dissemination of knowledge. Increasing international connectivity has made the Internet accessible to special-interest communities world wide, and electronic mail and list servers now provide a major communications medium supporting discourse in these communities. Until recently, limitations on the presentation quality of on-line file formats restricted the publication capabilities of the Internet to rapid dissemination of files printable in paper form. However, advances in on-line presentation capabilities now allow high-quality typographic documents with embedded figures and hyperlinks to be created, distributed, and read on-line. Moreover, it has become possible to issue *active documents* containing animation and simulations and supporting user interaction with computer services through the document interface. The major part of this functionality has become accessible through the protocols of the World Wide Web, and the web itself is seen as a precursor to an *information highway* subsuming all existing communications media.

The development of the Internet has been very rapid, with little central planning. Despite its widespread use, there is little information about the social dynamics of Internet technologies. Many systems have been developed to cope with the information overload generated by direct access to the Internet. One common feature among the wide variety of indexing and search tools now available is the support they provide for selective attention and awareness in the communities using the net. It would be useful to analyze the design issues and principles involved in these tools in terms of the knowledge and discourse processes in the communities using these tools.

This chapter provides a model of the virtual cooperative interaction on the World Wide Web in terms of discourse and awareness and uses it to classify the types of support tools existing and required.

Computer-Mediated Communication (CMC)

It is tempting to consider the Internet as a new publication medium in which electronic documents emulate paper ones, and where the issues of basic human factors are those of indexing and information retrieval. This makes the vast existing literature on information retrieval, its techniques and human factors, relevant to the net. However, this addresses only one aspect of computer-mediated communication (CMC), neglecting its function of supporting discourse within communities. Much of the information retrieved from the net is generated as needed through discourse on list servers—the Internet is a mixed community of publications and intelligent human agents that both store knowledge and generate it on demand. When the information needed cannot be found through retrieval, then it may be requested through discourse, a phenomenon prophesied in the early days of timeshared computing:

> No company offering time-shared computer services has yet taken advantage of the communion possible between all users of the machine ... 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. (Gaines, 1971)

The society of distributed intelligent agents that is the Internet community at large provides an "expert system" with a scope and scale well beyond that yet conceivable with computer-based systems alone. Computer-based discovery, indexing and retrieval systems have a major role to play in that community, but are only one aspect of Internet information systems.

Krol (1993) captures the essence of these considerations in Internet RFC1462, which replies to the question "What is the Internet" with three definitions:

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

These are complementary perspectives on the net in terms of its technological infrastructure, its communities of users, and their access to resources, respectively. Models of CMC must take into account all three perspectives: how agents interface to the network; how discourse occurs within communities; and how resources are discovered and accessed (Gaines and Chen, 1996).

In recent years we have witnessed new phenomena on the emerging net and novel social studies about them, for example, interactivity in CMC (Rafaeli, 1988; Rafaeli and Sudweeks, 1997); *flaming* (Mabry, 1997); theatrical performance on IRC (Danet, Ruedenberg and Rosenbaum-Tamari, 1997);

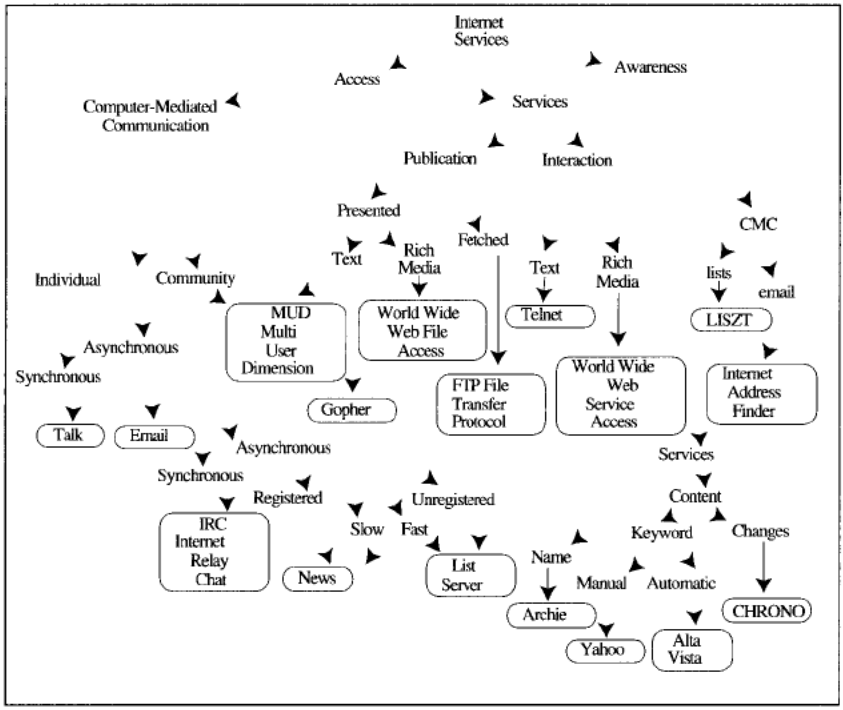

Figure 1. Internet services in terms of dimensions of computer-mediated communication.

rhetorical dimensions and control structures on news group (Jones, 1997; Smith, McLaughlin and Osborne, 1997); and theoretical mirrored social constructs in MUD (MacKinnon, 1997). Those and many other engaging issues are covered in chapters throughout this book.

Dimensions of CMC

In examining the utility of the Internet and World Wide Web, it is useful to classify all the major services. They are classified by the significant distinctions that determine the relative utilities that characterize major net services in terms of their utility for CMC, access to services, or search (Gaines, Shaw and Chen, 1996).

Figure 1 is a concept map presenting the major services on the Internet in terms of a small set of fundamental distinctions:

- At the top level, the major Internet services are characterized in terms of their utility for access to resources or awareness of resources.

- Access is subclassified as to discourse, publications or services.
- Discourse is subclassified by whether it is agent-to-agent discourse or community discourse—synchronous with the agents conversing in real time or asynchronous with substantial time delays in responses.
- Asynchronous community discourse is subclassified by whether the channel is slow or fast, and whether the community is centrally registered or not.
- Publications are subclassified by whether they are just fetched or presented when fetched as text or rich media.
- Services are subclassified by whether they are text or rich media.
- Resource awareness is subclassified by whether it is by resource name or content; by keywords or by change in contents; by keywords generated manually or automatically.

The less well-known systems classified are: *Internet Address Finder,* which provides an index of e-mail addresses; LISZT, which assists users in-searching for a list server by its name; and *CHRONO* (Chen, 1995), which indexes a World Wide Web site in reverse chronological order to provide automatic "what's new" pages. MUDs, multi-user dungeons/dimensions, are interesting because they provide a mix of services supporting both discourse and resource access. World Wide Web browsers such as Netscape are interesting because they provide a single tool that can access nearly all the services shown except talk and chat (Gaines, Chen and Shaw, 1997).

Cooperative Interactions and Communities on the Internet

The exponential growth of the World Wide Web and the growing availability of collaborative tools and services on the Internet have facilitated innovative knowledge creation and dissemination infrastructures. These infrastructures include electronic libraries, digital journals, resource discovery environments, distributed coauthoring systems, and virtual scientific communities. Collectively, the World Wide Web and Internet can be considered a large scale groupware for supporting special interest communities.

Large scale groupware differs not only in the quantity, but also in the quality of cooperative interaction (Dennis, Valacich and Nunamaker, 1990). The fundamental nature of interaction on the World Wide Web can be characterized as *virtual cooperative interaction.* The word "virtual" has two senses here: first, it denotes the notion of *virtual space,* i.e., cooperative interaction occuring in a nonphysical space that allows participants to be situated in geographically separate locations; second, it denotes that the *intent* to engage in

cooperative interaction itself may not necessarily pre-exist or be conscious. Traditional notions of groupware focus on the first sense (telepresence in virtual space), but there is a need to extend the notion of cooperative interaction to encompass the latter sense of virtual cooperative interaction (Chen and Gaines, 1996a).

Frequently, information resource contribution and exchange on the World Wide Web involve cooperative interaction without preplanned coordination. In fact, participants on the World Wide Web may have no intent to cooperate in the first place. Quite often, a resource provider and a resource user are unaware of each other's existence until their first interaction. Nevertheless, the interactive process between them is still loosely cooperative in nature. It differs from traditional team-oriented cooperation where group tasks, goals, and purposes are usually well defined.

A classical *social exchange* model like the Interactional Matrix model (Kelly and Thibaut, 1978; Cook, 1987) cannot readily account for this unusual form of cooperation, where resource providers might not know the identity of their resource users but continue to contribute anyway. On the World Wide Web, the only feedback might be the frequency of accesses to the provider's information resources. What do providers gain in return for such a seemingly one-way cooperative interaction? Is it simply an expression of altruism? What are some possible motivations to contribute to the World Wide Web? In general, how would one ensure the continual contribution of an information provider? These questions can be answered more clearly in the context of *socioware*, which we define as computer-mediated environments for supporting community-wide processes that expedite virtual cooperative interactions. Information inquiry and response, dissemination of ideas, and social networking are examples of virtual cooperative interactions. USENET news groups and list servers are two prototypes of socioware that support dialogues within well-defined special-interest communities on the Internet.

The proliferation of personal home pages with cross-linkage of World Wide Web pages by people who share common interests has made the exploration process on the World Wide Web (i.e., net surfing) a *social experience*. Such a seemingly intrinsically rewarding experience can often be characterized as serendipitous, not necessarily task-oriented (as in traditional groupware).

Through home pages, individuals create their own *virtual persona* on the World Wide Web without any awareness of who their eventual audience might actually be (i.e. without *extensional awareness* of particular recipients). However they often have a sense of who the potential audience might be (i.e. with *intensional awareness* of the type of recipient). Sometimes individuals provide information resources as a by-product during some self-organization processes of their own knowledge. As observed earlier, this form of

apparently cooperative behavior is prevalent on the World Wide Web.

In essence, the goal of socioware is to facilitate emergent prosocial behaviors for self-organized, virtual collaborative communities.

Conceptual Model of Virtual Cooperative Interaction

This section describes a detailed model for encompassing collaborative activities supported by traditional groupware and emergent socioware. The model analyzes the following five basic elements for virtual cooperative interactions in computer-mediated environments (CMEs):

1. Discourse patterns,
2. Time-dimension of virtual interactions,
3. Awareness hierarchy,
4. Motivations for cooperative behaviors,
5. Emergence and maintenance of virtual cooperative interaction.

Together these elements present three aspects (what, why, and how) of the conceptual model: (1) the descriptive aspect, comprised of the first three elements which characterize and classify virtual cooperative interactions; (2) the prescriptive aspect that provide motivational reasons for individuals to participate in virtual cooperative interactions; and (3) the operational aspect of how virtual cooperative interactions initiate and function.

Some Definitions

Before describing the conceptual model in detail, the definitions of some frequently used terms in the model are introduced in this subsection.

The term *social entrainment* refers to some endogenous biological and behavioral processes that are captured and modified in their phase and periodicity, by powerful (internal or external) cycles or pacer signals. The notion of entrainment contains two kind of synchrony: (1) The *mutual entrainment* of endogenous rhythms to one another; and (2) the *external entrainment* of such a rhythm by powerful external *signals* or *pacers* (McGrath, 1990).

When individuals participate in virtual cooperative interactions, depending on the nature of their present focus (e.g., discussing an idea or coreviewing a book), a natural cognitive processing time is involved in each activity. This processing time generates an endogenous rhythm within individual participants. This natural rhythm of interactions, in turn, creates *mutual entrainment* in sustaining continuation of virtual cooperative interactions. The processes of social entrainment are important in the time-dimension of virtual cooperative interaction.

A collaborative community can be seen as a group of individuals who provide resources to one other. The most significant dimension of the community is the *awareness* of who is providing a particular resource and who is using it (Chen and Gaines, 1997). Logically, resource awareness can be further distinguished as *extensional awareness* because the specific resource and provider are known. It is contrasted to *intensional awareness* in which only the characteristics of suitable resources or providers are known.

A Punctuated Discourse Model of CMCs

Recent developments on the Internet have been moving away from conversation and toward demonstration. This general trend is typified by the recent virtual explosion of voice, color, picture, and motion that seemingly overshadow plain ASCII traffic in ideas and emotions. Nevertheless the essence of the net remains categorically a medium for conversation (McLaughlin, 1984). Interactivity is one of the key qualities of discourse made possible by CMCs (Rafaeli, 1988; Rafaeli and Sudweeks, 1997). It remains a defining feature for conversations generally, and an especially curious one when the conversations are not held in physical proximity (Rafaeli, McLaughlin and Sudweeks, 1997). In this section, we propose an integrative model of discourse patterns that incorporates the current major innovations and services on the Internet.

Figure 1 presents a conventional model of Internet services in terms of their utility, but it does not provide an integrative model of the way in which they support communities. Such a model can be developed by noting what distinguishes discourse from publication. In discourse it is expected that the recipient will respond to the originator. Publication, however, is generally a one-way communication. However, on list servers some material is published by originators who expect no specific response, yet other materials are published where response is elicited or received.

One useful perspective for studying group CMC is interactivity. As noted previously (Rafaeli, 1988), there are at least three modes of communications on the net: one-way, two-way (reactive), and interactive (Rafaeli and Sudweeks, 1997). Hence CMC offers a very flexible medium that breaks down the conventions of other media. The following diagrams show the different characteristics of the main Internet services in terms of these issues.

Figure 2 shows e-mail discourse as a cycle of origination and response between a pair of agents communicating through a computer-mediated channel.

Figure 3 extends figure 2 to show list server discourse as a cycle of origination and response between agents that is shared with a community through a computer-mediated channel. The community involvement leads to more complex discourse patterns in that the originator may not direct the message to a particular recipient; there may be multiple responses to a message; and

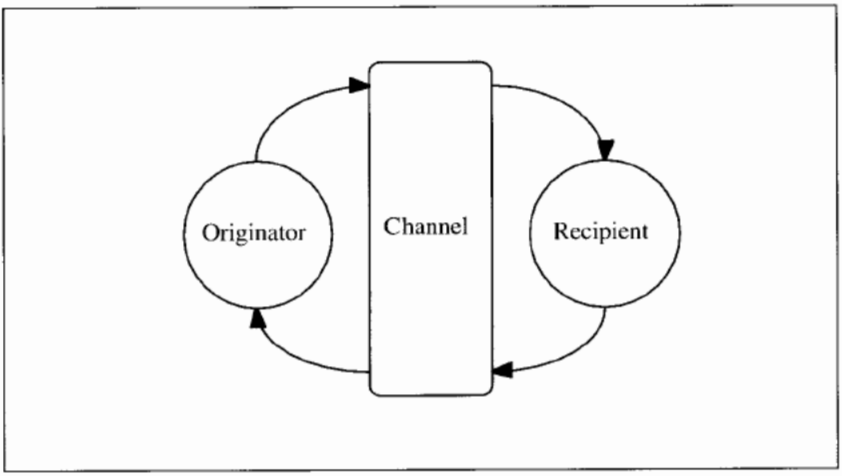

Figure 2. E-mail discourse.

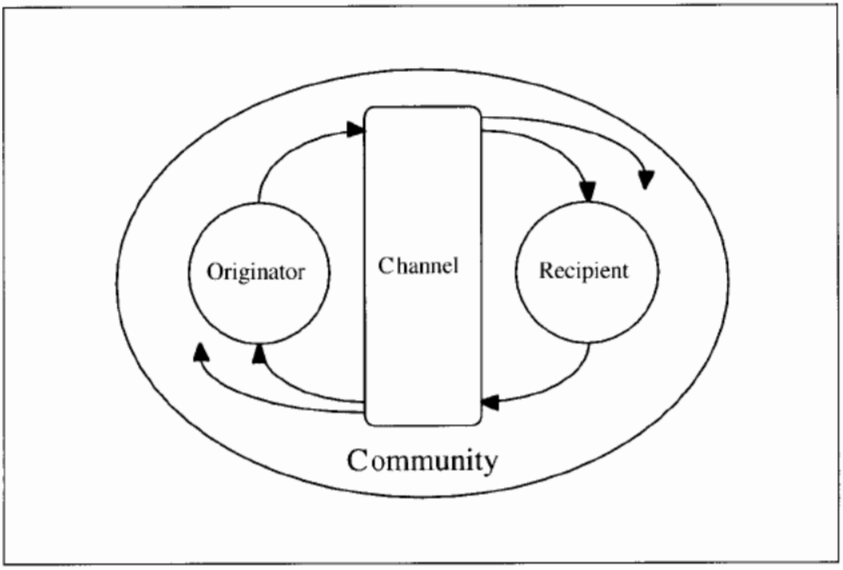

Figure 3. List server discourse.

the response from the recipient may itself trigger responses from others who did not originate the discourse. For a particular discourse sequence this leads to a natural division of the community into active participants who respond and passive participants who do not.

Figure 4 modifies figure 3 to show World Wide Web publication as an ac-

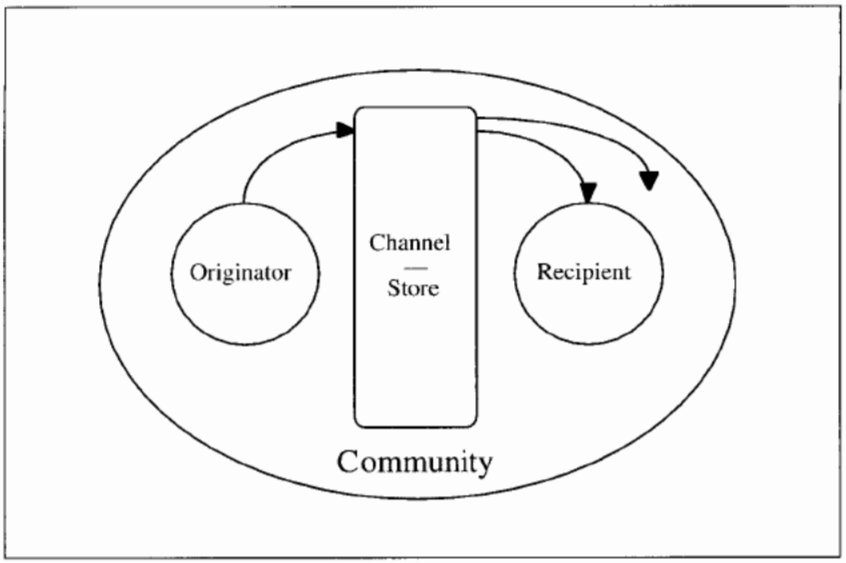

Figure 4. World Wide Web publication.

tivity in which the channel is buffered to act as a store also. The material published is available to a community and the originator is unlikely to target it to a particular recipient. Recipients are not expected to respond directly to the originator, but responses may occur through e-mail or list servers or through the publication of material linked to the original. Because the published material is not automatically distributed to a list, recipients have to actively search for and discover the material.

The common structure adopted for the diagrams is intended to draw attention to the commonalties between the services. List server discourse is usually archived and often converted to hypermail on the web. World Wide Web publications do trigger responses through other services or through links on the World Wide Web. A search on the web may not discover a specific item but rather a related item on a news group or list or by an author, and result in an request for information to the news group, list, or author. Individuals and communities use many of the available Internet services in an integrated way to support their knowledge processes.

Figure 5 subsumes figures 2 through 4 to provide an integrated model of Internet knowledge processes that capture all the issues discussed. It models the processes as discourse punctuated by the intervention of a store allowing an indefinite time delay between the emission of a message and its receipt. It introduces two major dimensions of analysis: the *times* for each step in a discourse cycle; and the *awareness* by originators of recipients and vice versa.

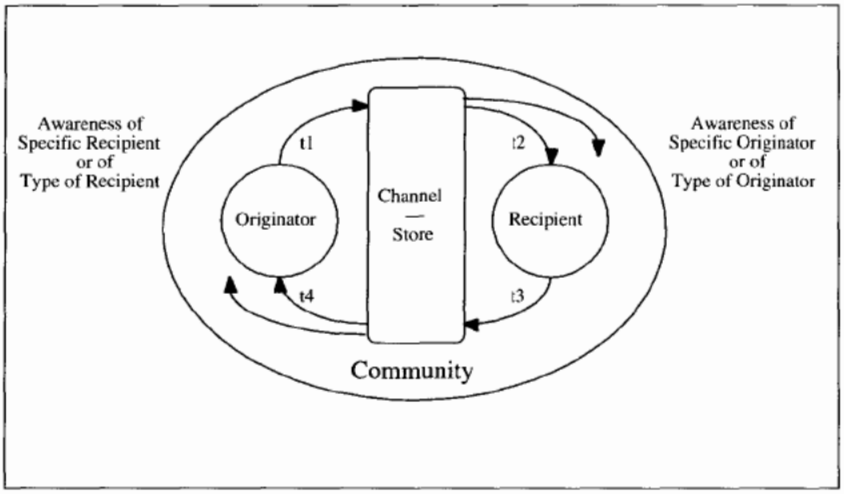

Figure 5. Punctuated discourse.

Time Structure of Punctuated Discourse

The four times shown in figure 5 are:

*t*1: the origination time—the time from a concept to its expression and availability

*t*2: the discovery time—the time from availability to receipt

*t*3: the response time—the time from receipt to expression and availability of a response

*t*4: the response discovery time—the time from response availability to receipt

Note that agent processing times and channel delays have been lumped. A study focusing on the impact of communication delays would want to consider them separately; otherwise there is no significant distinction—a general principle might be that communication delays should not be greater than agent processing times. Note also that the diagram is, to a large extent, symmetrical—the recipient becomes an originator when responding.

An important overall parameter is *time cycle:* the round-trip discourse time, $t1 + t2 + t3 + t4$. If this is small, (a few seconds or less) we talk in terms of synchronous communication. If it is large, (a few hours or more) we talk in terms of asynchronous communication. If it is infinite, (no response), we talk in terms of publication. However, this analysis shows that there is a continuous spectrum from synchronous through asynchronous to publication.

The discovery times *t*2 and *t*4 are very significant to publication-mode discourse. Attempts to reduce them have lead to a wide range of awareness-sup-

port tools that aid potential recipients in discovering relevant material and originators to make material easier to discover.

The Time Dimension in Virtual Cooperative Interaction

Awareness and coordination of cooperative interaction involve the processes of *social entrainment*. This subsection examines the relationship between the time cycle of virtual cooperative interactions and the relative strength of extensional and intensional awareness.

When two or more individuals participate in virtual cooperative interaction, they often take on the dual roles of originator and recipient in punctuated discourse. Gradually they become locked into *social entrainment* processes. Computer-mediated environments, such as news groups (Resnick et al, 1994) and shared drawing systems (Ishii and Kobayashi, 1992), provide specific external signals that set the pace for virtual cooperative interactions between participants. For example, the average *time cycle* for posting to a news group and receiving feedback is about one to a few days, whereas the partial time cycle ($t1+ t2$) for moving a mouse cursor in a real-time shared drawing system is approximately one to ten seconds. *External entrainment* occurs when the *actual* time cycle of a virtual interaction falls into the range of the *expected* time cycle anticipated by individual participants. When there is a wide discrepancy between the expected and the actual time cycle of interaction, participants often feel frustrated and decrease their desire to interact. For example, if cursor movements in a shared drawing system begin to take more than a few seconds to complete, the participants will tend to stop their interaction.

Continuation of virtual cooperative interaction can also break down when mutual and external entrainment processes are not synchronized with one another. When coreviewing a book, the natural time cycle for mutual entrainment is in days and weeks, since it often take that amount of time to read a book and absorb the material properly. It is unlikely that coreviewers will want to use Internet Relay Chat (Reid, 1991) to disseminate and exchange their reviews. Such a fast time cycle of interaction is not well suited for activities involving deep, reflective cognitive processes.

The relationship between the time cycle and the relative strength of *extensional/intensional awareness* in virtual cooperative interactions can be illustrated in a time-dimension diagram (figure 6). If the time cycle is relatively short, say in few seconds or minutes, we have an interaction that can be characterized as synchronous (real-time). If it is longer, we have interaction that is often described as asynchronous (delay-time). The key notion here is that the types of virtual cooperative interactions are differentiated on a temporal continuum rather than by discrete categories.

In intensionally oriented interactions, the level of intensional awareness is

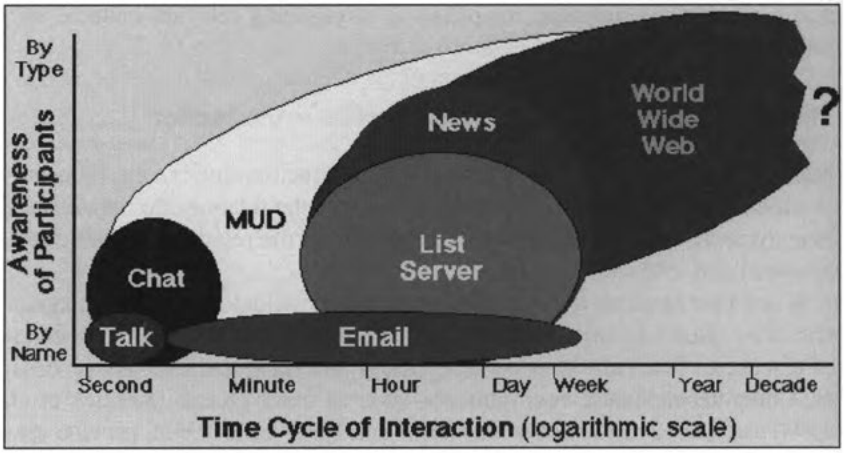

Figure 6. Time Dimension of Virtual Cooperative Interaction.

relatively high compared to extensional awareness, whereas in extensionally oriented interactions, extensional awareness predominates. Many groupware systems (e.g., coauthoring systems and shared workspace systems) have been designed to support collaborative teams in which interactions are between known group members. Therefore, in these CMEs, the virtual cooperative interactions focus on extensional awareness. In contrast, interactions in USENET news groups involve both extensional and intensional awareness of the targeted audience. For example, one can respond to a question from a specific individual (an extensionally oriented interaction) but do so publicly with the intention to address others who may have a similar question in mind (intensionally oriented interaction).

The time cycle in virtual cooperative interaction often varies according to cognitive processes involved in any given moment of an activity. For example, during a collaborative writing session (Neuwirth et al., 1994), when coauthors' focus is on correcting sentences or paragraphs, the time cycle involved is usually around a few minutes; when they focus on reviewing chapters, the time cycle involved shifts to hours. Therefore, coauthoring systems are classified in the range of time cycles from seconds to days, in addition to being extensional oriented.

The time dimension diagram of virtual cooperative interactions allows us to visualize CMEs in terms of an *interaction area* that they encompass as shown in figure 6. The area denotes the range of time cycle and the degree of intensional versus extensional awareness (Chen and Gaines, 1996a). In the figure, the question mark indicates that the World Wide Web has been operating for such a short period that any long-term estimates of its impact as a publication medium are speculative projections (Gaines, Chen, and Shaw, 1997).

Awareness Structure of Punctuated Discourse

A community can be regarded as a set of agents that provide resources to one other. The most significant dimension relating to the coordination of the community is that of the *awareness* of who is providing a particular resource and who is using it. In a tightly-coupled team, each person is usually aware of who will provide a particular resource and often 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.

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 users 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 forms of 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 providers likely to provide the resources they require. This asymmetry between providers and users characterizes a special-interest community. It also leads to differentiation of the community in terms of core members of whom many users are extensionally aware, and subcommunities specializing in particular forms of resources.

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

These distinctions are summarized in table 1. It is clear that the classification of awareness can lead to a richer taxonomy of communities than the defined three-way division. Analysis of awareness in such 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 subteams and subspecial-interest communities provides a way of reducing this complexity in modeling the community.

The differentiation of communities in terms of awareness draws attention to the significance of supporting various aspects of awareness in a CME system. *Resource awareness*—the awareness that specific resources exist—may be supported by various indexing and search procedures. However, there is also a need to support *chronological awareness*, the awareness that a resource has changed or come into existence (Chen and Gaines, 1997). Table 1

Locus of responsibility	Team	Special-Interest Community	Community at Large
Originator	*Extensional awareness of actual recipients.* Use email to notify. Use CHRONO to index.	*Intensional awareness of types of recipient.* Broadcast to list server. Establish HTML links. Use CHRONO to index.	*No awareness of recipients, or only weak intensional awareness of types of recipients.* Broadcast to news groups. Register in Yahoo. Initialize Alta Vista.
Recipient	*Extensional awareness of actual resources and originators.* Use email to inquire. Check CHRONO index.	*Extensional awareness of actual resources and originators, or intensional awareness of types of resources and originators.* Subscribe to list server. Follow HTML links. Check CHRONO index. Use WebWatch, Katipo or URL-Minder	*No awareness of resources or originators, or only weak intensional awareness of types of resources and originators.* Read news groups. Browse Yahoo. Search with Alta Vista. Search with MetaCrawler.

Table 1. Communities and tools distinguished in terms of awareness.

also shows how current tools for awareness support are classified within this framework.

CHRONO: Chronological Awareness Support Tools

CHRONO is an HTTP server-side system that generates chronological listings of World Wide Web pages that have been changed recently at specific sites. It provides a basic awareness support that lets visitors of a web site (e.g., members of a group, an organization, or other net surfers) see which web pages have been modified since their last visit. Currently, the CHRONO system is implemented on a UNIX platform and has been made widely available for use at other sites. As shown in figure 7, CHRONO presents to the visitors an HTML document that lists the site's web-page titles in reverse chronological order. This chronological listing of web pages also functions as a collection of hyperlinks to the listed pages.

This time-line dimension allows frequent visitors to a World Wide Web site immediate knowledge of what has changed since their latest visit. The changes they see may be pages in which they have particular prior interest, or it may be new pages that they have never seen before but will appeal to them. Hence this *chronological browsing* characteristic is analogous to a *spatial (subject-category) browsing* characteristic that library patrons often experience when looking for books on open bookshelves (i.e., accidentally finding [even more] relevant books near the books that they were looking for originally).

What is different here is that instead of finding relevant information by browsing the nearby subject-categories, users may now find relevant infor-

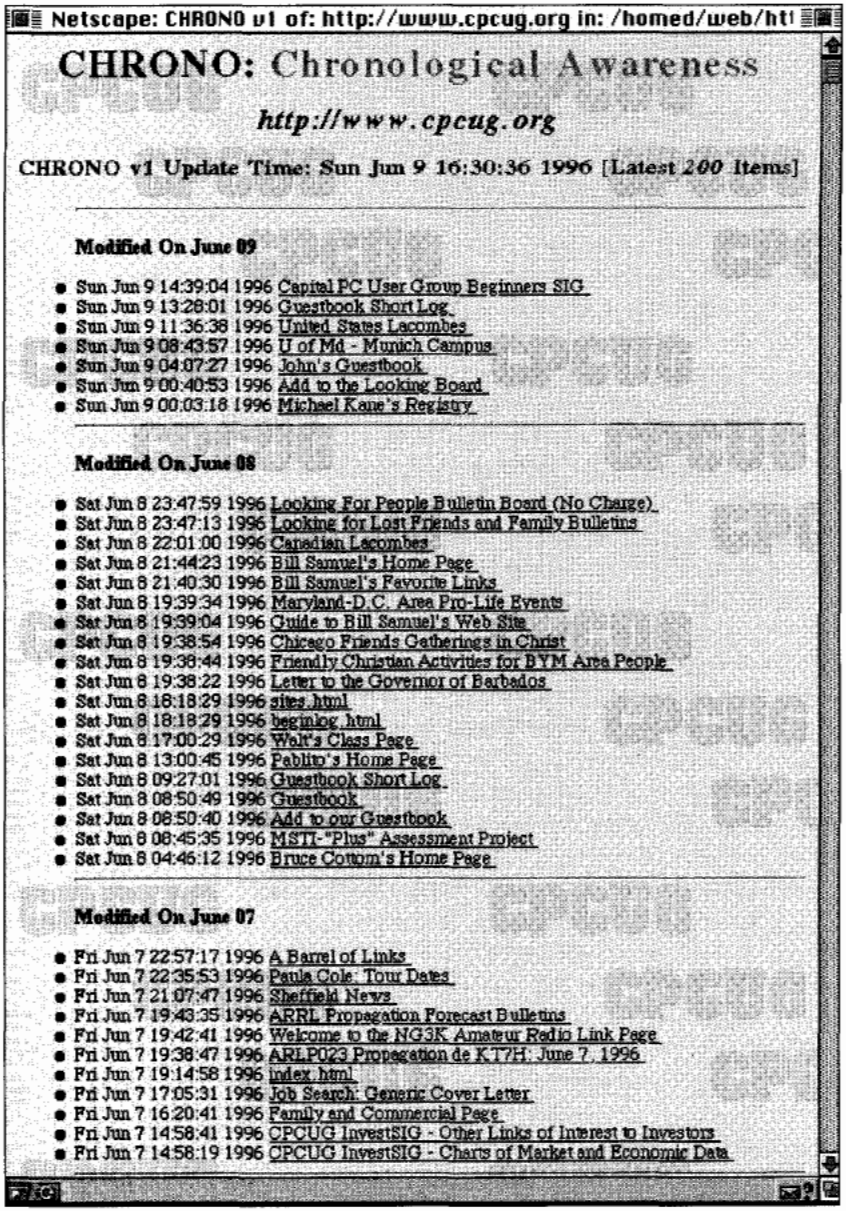

Figure 7. CHRONO in use at a PC user group site.

mation by browsing the recently modified or created web pages. Sometimes, conceptually related documents are created (or modified) around the same time: however their author(s) may not remember to update the HTML links

to them. Unlike a manually updated *what's new* page, in which the users have to rely on the timely updates made by a webmaster (or by the document authors), CHRONO provides the time-line dimension to the users automatically, in a reliable, periodic fashion.

WebWatch (Specter, 1995), *Katipo* (Newberry, 1995), and *URL-Minder* (NetMind, 1995) are other chronological awareness tools that track changes in specified documents. WebWatch is a client-side chronological awareness system that keeps track of changes in selected web documents. When given an HTML document referencing URLs on the World Wide Web, it produces a filtered list that contains only those URLs that have been modified since a given time. Katipo is another client-side chronological awareness system built for Macintosh that shares many similar concepts with WebWatch. It reads through the global history file maintained by some World Wide Web browsers, checking for documents that have changed since the last time a user viewed them. It writes a report file (in HTML format) listing all such documents in a format that allows the user to visit the updated documents easily. URL-Minder is a centralized system that keeps track of resources on the World Wide Web, and sends registered users e-mail whenever their personally registered resources change. World Wide Web users can have the URL-Minder keep track of any World Wide Web resource accessible via HTTP. The resources can be anything—not just web pages that users personally maintain (Chen and Gaines, 1996b).

Each chronological awareness support system examined so far has various degrees of advantages and disadvantages. CHRONO has the advantages of: (1) simplicity of user interface; (2) support of accidental discovery where users need no extensional awareness of the newly created pages; and (3) server-side chronological awareness information on demand. It is nicely complemented by the efficiency of the targeting approach and customization capabilities of WebWatch and Katipo. Finally, URL-Minder uses e-mail as its notification channel. This feature is useful for users who use their e-mail systems more frequently than their World Wide Web browsers. Together as a whole, these chronological awareness support systems have covered a wide range of approaches in respect to major features of chronological awareness support (Chen and Gaines, 1996b).

Further Developments

The CHRONO research program is now measuring the structures and time constants of discourse on the Internet from empirical data. The rates of diffusion of information and the various knowledge acquisition paths and processes whereby individuals become aware of information on the net arecurrently being compiled and studied. List server archives are being analyzed to determine the fine structure of discourse and to track the trajectories of ideas.

CHRONO was issued in May 1996 and is now being used at a number of sites. META-CHRONO, a new program under development, will collect and collate information from multiple sites running CHRONO and provide awareness of activities being carried out on a distributed basis (Chen, 1996).

Motivations for Participation in Virtual Communities

This subsection examines the motivational dimension of virtual cooperative interaction. Here, a theory of *collective social exchange* attempts to explain the behaviors of participants in terms of exchange theory, effects of norms in virtual community, capacity of power, and social influence. These motivational explanations, together with *social learning theory* (in the next subsection), examine the fairness and reinforcement issues involved in virtual cooperative interactions.

When many individuals participate in a multitude of punctuated discourses (figure 5), a chain reaction occurs. The cumulative effect generated by this chain of inquiry-response-reaction-response-reaction (and so on) is an evolving topical thread that can become a part of *shared knowledge* among community members. Through automatic archival services such as Hypermail, or some individual efforts such as FAQs (frequently asked questions) and World Wide Web pages, the shared knowledge persists and grows. Why should individuals contribute to this pro-social process? How does the virtual community ensure that its participants will contribute to the growth of the knowledge pool?

First, why would individuals want to participate in virtual cooperative interactions? Generally, interpersonal behavior can be characterized as a *social exchange* between people, and these social exchanges typically involve both rewards and costs to participants. Generally, an individual will perform those actions that produce the greatest rewards for the least cost (Shaver, 1987). Therefore, according to this cost-benefit calculation, a perceived potential for reward must exist for individuals to participate and contribute in a cooperative relationship.

In contrast with *classical social exchange theories* (Cook, 1987) (e.g., Kelly and Thibaut's (1978) *Interactional Matrix* model), which emphasize dyadic interactions between individuals, *collective social exchange theory* focuses on interactions between individuals and their community. Conceptually, the Internet community is viewed from a *collective stance* (Gaines, 1994) as an entity with "whom" individual participants exchange information resources. This collective entity offers participants a valuable informational service, namely as *a pool of human knowledge* (Berners-Lee et al., 1994) in exchange for their contributions.

The *norm of reciprocity* is fundamental to social exchange and leads to contributing behavior. The reciprocity norm creates an obligation for repay-

ment that must be satisfied if the interaction is to continue (Shaver, 1987). However, the way reciprocity operates in collective social exchange is more subtle than in conventional social exchange between individuals. Why should one reciprocate (through contribution) in a situation where social responsibility is relatively *diffused* among community members?

Positive *self-image* (Jones and Pittman, 1982) is one motivation for contributing to the Internet. In this case, an individual has internalized the norm of reciprocity and acts according to the principle of *equity theory*: that is, an individual will seek to maintain the ratio of rewards to costs at the same as that of relevant comparison persons (Walster, Walster and Berscheid, 1978). A sense of *guilt* would occur if individuals perceive they have not contributed enough to the community, and hence, they would want to reciprocate fairly.

Another more subtle motivation is that of contribution as an investment in *social power,* that is, the *capacity* of a person or group to affect the behavior of another person or group (Schopler, 1965). Contributions made by an individual may not only help others but also help that person to gain name recognition from his or her peers. The more one contributes publicly and receives recognition, the more one gains the capacity to influence others or the community as a whole. The added weight in recognizing who is first to contribute relevant information also motivates individuals to volunteer information resources more readily. The competition for priority in contribution has been well documented in Merton's studies on the reward system in scientific discovery (Merton, 1973).

The motivational dimension of the model illustrates the importance of *feedback loops* (Losada, Sanchez and Noble, 1990) in the reinforcement of virtual cooperative interactions. It provides a coherent explanation for the apparent altruistic behavior of information providers on the World Wide Web and Internet.

Reinforcement of Virtual Cooperative Interaction

One question raised earlier in the chapter is why people publish information resource to the World Wide Web in the first place. Usually resource providers might never know the identity of their resource users; nevertheless providers contribute even without any potential and apparent paybacks for their efforts. Two possible motivations described earlier for providing information resources on the web are: (1) to gain positive self-image; and (2) to gain name recognition. How does such a pro-social behavior initiate and continue?

The concern here is with the relationship between the *effect* of an individual's behavior in a *virtual cooperative community* and its impact on the individual's later behavior. This is the basis of *operant conditioning,* the learning process by which behavior is modified by the consequences of previous similar behavior (Ritzer, 1992). An individual emits some behavior. The community in which the behavior occurs in turn "acts" back in various ways. The reac-

tion—positive, negative, or neutral—affects the individual's later behavior.

Social learning theory suggests that novel social behavior is first learned through imitation of actions taken by others who act as (social) models (Bandura and Walters, 1963). The reinforcement received by a model serves as information to the person about which behaviors are acceptable and appropriate for the circumstances. Once a novel action has been acquired through imitation, the probability of its continuation is dependent on the reinforcement it receives. *Vicarious reinforcement*, as well as direct reward or punishment, can play a part in social learning (Shaver, 1987).

On the World Wide Web, an individual's first successful encounter with a home page full of relevant information resources provides a positive role model for imitation. Subsequent positive net-surfing experiences will further increase the individual's exposure to other positive models. Once an individual internalizes the web culture, which encourages construction of a personal home page (and coincidentally also provides a virtual persona for self-image), that person's contribution to the web will be viewed as a pro-social behavior. The dynamic of *social exchange* then comes into play. If the costs (for example, the necessary skills and resources) of putting up information resources (such as research papers or hyperlinks to relevant web pages) are relatively low, the individual will contribute to the web. In addition, original intent to contribute to the World Wide Web community does not need to exist; using a home page to organize knowledge resources may only coincidentally contribute to the World Wide Web community (as an after thought or by-product). In this situation, the extensional audience is the individual, together with a vague sense of intensional awareness of other potential resource users.

How does reinforcement come into the picture? Frequently, one encounters home pages that have been constructed months or years ago without any revisions or new contributions. Their authors have neglected them and ceased to contribute. Once a novel behavior has been acquired, it needs to have *intermittent positive reinforcements* to sustain the behavior (Bandura and Walters, 1963). In order for reinforcement to take place, a feedback loop must exist. The round-trip cycle of virtual cooperative interaction provides an individual the necessary awareness of the *effectiveness of investment in social power,* which is crucial to reinforcing the behavior and leading to similar future actions.

An observable measurement of the effectiveness of social power on the World Wide Web is the relative popularity of web sites. The popularity of a home page can be inferred from its visitor frequency counter, commentaries in its public guest-book, awards given by reviewers of popular web sites, the number of other web pages linked to the page, etc. These gauges of popularity (which measure the relative power for social influence) provide direct reinforcements (either positive or negative) to an information provider. They also offer indirect vicarious reinforcements to other information providers by providing social models for comparisons.

Summary of the Conceptual Model

The past decade has seen the emergence of large scale collaborative activities on the Internet using e-mail, list servers, news groups, and the World Wide Web. There have also been developments of systems using some of these technologies to support smaller closely-coupled teams. In terms of the standard time and space taxonomy for CSCW, such uses of the Internet are generally virtual in space. They range from highly synchronous to highly asynchronous interactions. However, many of the major applications of the Internet raise new issues that are not adequately addressed by existing models and taxonomies of CSCW.

Small groups of individuals working together generally have well-defined roles and are mutually aware of roles, tasks, and activities. However, on an Internet list server, a discussion may be initiated with only a vague concept of other potential participants but with strong expectations that a collaborative activity will result. On the World Wide Web, material may be published with only a vague conception of potential users, yet that material may play an essential role in a collaborative activity in some community, possibility not involving the originator, and perhaps in a community of which the originator is not part. Such phenomena are common in various collaborative scientific communities conducting interdisciplinary research. Those loosely collaborative communities are moving their knowledge acquisition processes to the Internet. It would be interesting to know whether they can be modeled and supported using some extended CSCW frameworks (Chen and Gaines, 1997).

This chapter presented a conceptual model for virtual cooperative interaction that encompasses the collaborative knowledge acquisition activities of closely-coupled teams and those of the very diverse communities. It analyzed these activities in terms of the punctuated discourse processes, breaking down the cycles of action and response involved into a continuous temporal dimension. It analyzed them also in terms of awareness by originators of recipients and vice versa. The temporal dimension and awareness hierarchy enable the existing taxonomies and models of CSCW to be extended to encompass a very wide range of systems operating in both the short- and long-term and ranging from small teams to large communities. The model analyzes motivational aspects of virtual cooperative interactions. It gives rise to natural structural analyses of the activities, which allow the types of communities involved to be identified from their observed activities. It can also be used to categorize computer-mediated environments roughly into groupware and socioware (table 2).

The conceptual model presented in this chapter implies that for successful maintenance of continual virtual cooperative interactions, the following criteria must exist:

- Establishment of resource awareness for initial encounter

	Groupware	Socioware
Awareness	strong mutual extensional	weak mutual intensional
Time cycle of Interaction	short to medium (seconds to days)	medium to long (hours to years)
Motivation for Cooperation	individual social exchange	collective social exchange
Power Relations	well-defined roles as part of team definition	emergent roles from investment in social power capacity

Table 1. Groupware and socioware comparisons.

- Establishment of mutual awareness as a feedback loop for continual virtual cooperative interactions
- Compatibility between the expected and the actual time cycles of virtual cooperative interactions
- Properly situated expectation of fairness in terms of collective social exchange
- Accumulation of positive feedback for reinforcements in virtual cooperative interactions

The current model also identifies the types of socioware systems that are needed to expedite collaborative activities and provides a framework for classifying existing tools in use on the Internet. It focuses on participants' motivations and power relationships, which determine their social roles, goals, and expectations in virtual cooperative interactions. They are generally implicitly defined in groupware by the nature of group tasks (Mandviwalla and Olfman, 1994) and organizational structures (Kling, 1980). The chapter contributes to Internet research by drawing attention to significance in large-scale socioware like the World Wide Web where social and organizational structures are fluid and less well-defined. The conceptual model for virtual cooperative interaction expands the scope of groupware research. It provides a framework encompassing all forms of virtual knowledge acquisition processes from teams through organizational work groups to diffused, evolving communities (Chen and Gaines, 1997).

Conclusions

The purpose of the research reported in this chapter has been to develop a finer-grained conceptual model of the processes that support virtual coopera-

tive interaction in Internet communities in order to support and improve those processes through new and better services. The model developed suggests three levels of analysis of services:

- *Message quality*: the improvement of the multimedia capabilities of the basic message channel. There have been continuous improvements from simple text to typography, images, movies, sounds, animations, simulations, and so forth.
- *Relationship modeling*: the incorporation of linkage information preserving discourse relationships. The hypertext links of the original web technology introduced this capability, and clickable maps extended it; there is scope for further extension based on greater understanding of the roles the links play in enabling people to grasp the argument forms of information on the web.
- *Awareness support*: the systematic reduction of the time ($t2$ and $t4$ in figure 5) for a potential recipient to become aware of relevant information. Manual and automatic indexing and various forms of search engines have made massive advances in coping with the information overload resulting from the growth of the web; however, there is scope for many different tools supporting the various ways in which people manage their awareness.

The key question to ask in developing new awareness support tools is "what is the starting point for a person seeking information? That is, what existing information is the basis for the search?" A support tool, then, is one that takes that existing information and uses it to present further information that is likely to be relevant. Such information may include relevant concepts, text, existing documents, people, sites, list servers, news groups, and so on. The support system may provide links to further examples of all of these based on content, categorization or linguistic or logical inference. The outcome of the search may be access to a document but it may also be e-mail to a person, a list, or a news group.

The net is a vehicle for discourse in which the goals of individual agents are supported through social knowledge processes, and support tool design needs to be based on increasingly refined models of those processes. Much of our current research is concerned with the empirical studies of discourse processes on the net through analysis of information diffusion, list server archives, and so on. We conjecture that tools that develop models of such processes and are made available to the participants may themselves result in improved usage of net resources.

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