Communication and Communities of Chemists

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The Internet has had a profound impact on the way that chemists communicate. Electronic journals, discussion lists, and other resources are fairly well established, but now "virtual communities" are starting to appear. This paper discusses the concept of community both from a social and from an economic viewpoint. In particular, three communities, or clubs, for chemists are compared. These are ChemCenter from the American Chemical Society, chemsoc from the Royal Society of Chemistry, and ChemWeb.com, organized by ChemWeb Inc. We conclude that all the communities are immature, but all are developing fast. Their success will depend on the extent to which they build up member loyalty and intellectual content over the next year or two.

INTRODUCTION

For years, the printed "primary" journal has served as a foundation for the advancement of science. Its main functions used to be archival storage, current awareness, quality control, and author recognition. Until the mid-nineteenth century, journals were archival in character, recording the text of papers presented orally at scientific meetings. Then, scientists started to rely more upon journals rather than meetings for their information, and journals began to develop an alerting or current awareness function. More recently still, journals, with their publication delays of eight months or more (because of quality control and other procedures) have ceased to be so useful for current awareness, and they have more of an archival function. Numerous other methods are useful for maintaining awareness, including "the invisible college", conferences, seminars, informal visits, letters, and telephone calls.

More recently still, the concepts of communication and current awareness have undergone a complete paradigm shift with the explosive expansion of the Internet and the possibility of faster publication in electronic journals. The purpose of this paper is not to discuss the opportunities and threats presented by primary electronic publications, and the blurring of the boundaries between primary and secondary publishing, but rather to consider other means of communicating within the chemical community.

Not only has there been an increase in the printed scientific literature but also the number (and probably the average cost) of meetings and conferences has increased. We know of well over 100 meetings in 1998 that would be of interest to us in the U.S. and Europe alone.[1] Financial constraints prevent many employees in the chemical and pharmaceutical industries from going to more than one or two conferences a year. Yet the thirst for information increases apace. Not surprisingly, chemists are beginning to use list servers and other electronic methods of sharing highly current information.

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GROWTH OF THE INTERNET

The U.S. government has reported that it took 38 years for radio to win 50 million users; 13 years for TV to get 50 million viewers and just 4 years for the Internet to gain 50 million users. Internet[2] usage is doubling every 100 days, with 62 million Americans regularly signing on.[3] This is just one of the many estimates of growth in the Internet which appear in press. There are, however, a number of organizations that seriously aim to track and quantify the Internet.[4]

A recent report[5] states that "More information has been produced in the last 30 years than in the previous 5000. A weekday edition of the *New York Times* has more information in it than the average 17th century man or woman would have come across in an entire lifetime. About 1,000 books are published internationally, every day, and the total of all printed knowledge doubles every five years." The report claims that keeping up with the information explosion has led to soaring executive stress, loss of job satisfaction, and physical ill-health. Apparently 48% of managers believe the Internet will be a prime cause of information overload over the next two years.

Are we indeed "drowning in information while surfing the Internet?" (Exner[6] has done an interesting comparison of the metaphors.) In our experience, chemists have their own ways of saving time and avoiding overload. They are often very selective in their choice of list servers and electronic conferences. In fact, it is inappropriate copying of electronic messages, junk e-mails, and "spam" that often cause the overload problems, not surfing the Net.

The issue of "control" over the Internet is, however, a serious one. According to Koenig and Sione,[7] general enabling technologies such as the railroad or the telephone have a predictable three-stage cycle: "a stage of experimentation and development, a stage of societal concern with issues of equity and access, with concomitant regulation, and a stage when the emphasis shifts to efficiency and effectiveness with concomitant emphasis upon competition and deregulation". The authors perceive that the Internet is at Stage II and "the Net community must distinguish and

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disambiguate the various issues and have specific, constructive, and reasoned responses to those issues".

INTERNET SOURCES

Chemical Information. The Internet has had a profound effect on chemical information.[8,9] The Special Libraries Association (SLA) publishes a select list of tools, including chemistry tools[10] for members of the information profession. The SLA is also apparently moving toward an electronic version of this book. Gary Wiggins' CHEMINFO service on the Internet[11] helps users find and learn how to use chemistry information resources on the Internet and elsewhere.

Discussion Lists. KOVACS, The Directory of Scholarly and Professional E-Conferences,[12] is a large collection of discussion lists and newsgroups available on the World Wide Web (WWW). The "Liszt" main directory[13] lists even more: it has details of 84 792 mailing lists as of June 6. In chemical information the best known list is probably chminf-l.[14] Chemweb is a list for chemical applications of the Internet.[15]

Electronic Journals. ChemConnect maintains a list of about 450 chemistry journals.[16] This paper is not concerned with primary electronic journals per se (many other sources discuss the issues[17−21]), but *aggregations* of journals are beginning to appear on various WWW sites and such collections will be mentioned later. Web browser technology has generated a lot of excitement in industry because it has the potential to provide end users with easy access to both internal and external information. The need for ready access to journal articles in an electronic form is most easily accomplished from a single source, but the market has tended to become fragmented, with individual publishers making their own journals available on their own sites.[22]

Two special electronic journals deserve mention at this point. The first issue of the *Internet Journal of Chemistry* (*IJC*)[19,23] appeared on the Internet in 1998. Aimed at encouraging global interaction within the chemical community, *IJC* presents the latest chemical research findings alongside development of chemical Internet resources. Coverage includes the latest research in all disciplines of chemistry; developments of Internet resources specifically for chemists; plus reviews of the most relevant chemistry WWW sites. With publication not limited to page space, *IJC* also encourages interactive comment and debate on published papers using electronic resources.[19]

Network Science[24] has been offering electronic feature articles since 1995 and is a forerunner of the virtual communities discussed in the next section of this paper. Network Science Corporation, a nonprofit organization, provides a forum for experts to explore and discuss current applications of science and technology with their colleagues worldwide. This forum permits publication of scientific data without the delays inherent in traditional printed media and encourages immediate dialogue using hypertext, multimedia, interactive electronic feedback forms, and automatic electronic mail connections. The Corporation is exploiting new technology for collection, processing, and distribution of scientific information used by professionals in the biotechnology, chemical, and pharmaceutical industries.

Monthly issues of NetSci include feature articles from R&D scientists, product news releases, general industry information and news, literature reviews, and a profile section for people who have moved or have been promoted. All the back issues of NetSci are also available. The NetSci education center offers courses including An Introduction to Drug Development and A Beginners Guide to HTML. The site also holds a collection of general information for the industry. This section contains YellowPage listings for the pharmaceutical and biotechnology industries, resources for combinatorial chemistry and high throughput screening and Repetitive Strain Injuries, chemistry oriented software lists, a calendar of scientific meetings, selected earning reports for public companies, WWW links of interest to the research community, and employment resources. Network Science has seven corporate sponsors.

VIRTUAL COMMUNITIES

Sociology. Oravec has published a book on computer supported cooperative work,[25] discussing how people work in groups and the technology, particularly groupware, that has been developed to help them. A common design practice to create a sense of community in networked applications has been to imitate urban planning, creating town squares, segregated spaces, and public and private discussion spaces. Oravec also briefly discusses whether the Web will replace or complement groupware tools. There are issues of privacy, security, and administration to be considered.

Virtual communities, or online communities, have their origins in simple PC-based bulletin boards which were an early way for enthusiasts to interact before the consumer online services appeared. The explosive growth of the Internet has opened up further scope, but only recently have entrepreneurs, Web developers, publishers, and investors become seriously interested in the new opportunities offered by virtual community.[26,27]

"Virtual communities are the most truly interactive medium so far developed," according to Harry Collier of Infonortics.[27] "Much of what passes for interaction on the Internet today offers the user no chance to participate other than by pressing cyberbuttons. Few have taken up the challenge of enfolding the user into the creative process." Hugh Look, program chairman of the First International Conference on Virtual Communities, says that "newsgroups and discussion forums are not in themselves virtual communities, although they provide a framework in which a virtual community can emerge. Something else is needed, a vital spark of humanity, that brings people together. It need not be a strong emotional bond—it can be built around technical or professional interests. It does, though, demand commitment from the members and perhaps one of the best indicators of a true virtual community is the long-term presence of a core of contributing members."

For some people, computer-mediated communication (CMC) through online services, the Internet, newsgroups and Usenet, mail and messaging services, and bulletin board services has become as important as, or more important than, using the telephone, the postal service, or a fax machine. CMC can promote a notion of community, and it has led to new social formations that Jones has referred to as "Cybersociety".[28]

Howard Rheingold,[29,30] the pre-eminent popular theorist about community in cyberspace, defines virtual communities

as "social aggregations that emerge from the [Internet] when enough people carry on those public discussions long enough, with sufficient human feeling, to form webs of personal relationships in cyberspace". Another definition[31] is "incontrovertible social spaces in which people meet face to face but under new definitions of both "meet" and "face"...[V]irtual communities [are] passage points for collections of common beliefs and practices that united people who were physically separated". Sociologists, ethnographers, communication scholars, and anthropologists are all grappling with the issues involved in the study of electronic communities. Traditional methods of social research may, or may not, be appropriate for studying nontraditional social formations.[32]

Virtual communities have produced new discourse processes and social structures.[33] Discourse processes include the use of jargon (e.g., "flaming"), abbreviations (e.g., IMHO for "in my humble opinion"), "emoticons" (such as ASCII characters for a smiling face), and face-saving mechanisms. Social structures include roles (such as moderators or hackers), neighborhood addresses, and cultural differences, rituals, and rules or norms such as network etiquette ("netiquette").

The evidence of community is apparent in the self-regulation of newsgroups and the establishment of community standards of behavior. McLaughlin et al. have classified reproachable conduct in seven categories: incorrect or novice use of technology, bandwidth waste, violation of network-wide conventions, violation of newsgroup-specific conventions, ethical violations, inappropriate language, and factual errors.[33] Freedom of speech and "censorship" of the Internet are sensitive issues. Communities may well be self-regulating, but it is not unknown for members to use "kill files" to filter out undesired material. Some newsgroups or lists are "moderated", that is, they have a moderator who decides which messages will be posted (or altered) and which will not.[34] The chminf-l list[14] is not moderated (although this has been discussed at length), but it does have a code of conduct for advertisers.

Community users deprived of "social cues", nonverbal cues, and the subtleties of face-to-face interaction develop "alternative" methods of verbal communication and virtual "persona" that may differ from their personalities in the real world. "Personae" have powers, as do real people, but those powers may be different.[34] Since users of CMC are unable to see, hear, or feel one another, they have a degree of anonymity. This can have the advantage of egalitarianism, but it may impede decision-making and lead to undesirable social inhibition (e.g., "flaming"). However, patterns in CMC are not necessarily direct effects of the medium.

Rather, some researchers argue that CMC patterns emerge from complex interactions between five factors: external contexts, temporal structure, system infrastructure, group purposes, and participant characteristics.[35] External contexts are the cultures of the participants, the organizations to which they belong, and their common language. The temporal structure of CMC can be synchronistic, asynchronistic, or a combination of the two. In synchronistic communication (e.g., Internet Relay Chat, IRC) all the participants are online simultaneously and read and respond in real time. In asynchronous communication the participants need not be online simultaneously. Features of system infrastructure are physical configuration, system adaptability, and user-friendliness. The CMC group may have a "task" to perform, or its purpose may be less specific or, in many cases, recreational. Participant characteristics include the number of members, their degree of training, their attitudes, and so on.[35]

While the computer does impose some constraints on communication, members of CMC groups nevertheless exploit the medium, experiment with new forms of expression (e.g., humor, emoticons, jargon, abbreviations), explore public identity (e.g., alternative personality encouraged by reduced inhibition), create unlikely relationships, and create behavioral norms.

In another discussion of "group purposes" Jones[36] maintains that communities are not "places to be" but groups of people seeking to achieve particular goals. In one sense, the participants do not belong to the community but the community belongs to them. There is a characteristic Jones calls "inhabitance", the recognition of being part of a place. A sense of community is created not by the construction of that community but by human occupancy, commitment, and interaction.

Commercial Issues. The virtual community is not just an Internet curiosity of significance to sociologists. There is a great deal of interest in using the concept as a business development tool. Experiments are being carried out on a wide range of business models, including advertising and sponsorship, subscription, adding value to publishing or to commerce, and combinations of all these. Much of the current interest in virtual communities comes from vendors who believe that developing communities will help them to sell related goods and services.[27]

Some observers believe that virtual communities are antithetical to commerce, but others[37] are convinced that a strong commercial element can actually enhance trust and commitment among the members. Virtual communities will create "reverse markets" where customers hold the power base and seek out vendors. The business model is no longer one of vendors "pushing" products but one of the vendor as an agent. Member-to-member communication and the building of member profiles by the community organizer are fundamentally important to the new business model. The community has to be as much concerned about aggregating people as about aggregating information. Readers of this paper comparing the emerging chemical communities should ask themselves whether a new club understands these aggregations. At present, communication among the members of commercial sites is currently not common or encouraged. Also, successful virtual communities will aggregate the broadest range of high-quality resources available, *including those of competing vendors*.

Hagel and Armstrong[37] have defined five characteristics of a true virtual community. First there is a distinctive focus for the membership. Other members with a common interest are then attracted as if by magnetism. The chemical communities to date probably are aiming at too broad a range of members: readers of this article probably see themselves as computational chemists or information professionals not as "chemists". The same may be true of legal communities, according to our lawyer who sees himself as an "IT lawyer".

The second characteristic is integration of content and communication. The third is emphasis on member-generated content. This feature is one that worries traditional vendors

who would prefer not to allow users to publicize their product defects and the advantages of competitors' products. The fourth characteristic is choice of competing vendor offers: customers are thus put in the powerful position of having a rich information base from which to make their choices.

Finally, the community organizers must be commercially motivated. Considerable resource is needed to build up a critical mass of members and information content such that advertising and other revenues can be attracted. At the moment there are probably very few examples of communities that exhibit all five of Hagel and Armstrong's characteristics.

On the technical front, the community operators need to decide whether to host the community on one of the major online services or whether to develop their own presence on the Web.[27] A news server may be used instead of the Web. For operators interested in the Web, several companies now offer virtual community tools off the shelf. In the longer term, as bandwidth and speed improves, virtual reality models will be attractive.

Examples. A few well-established communities will now be described, as examples.

A Legal Community. Link (Legal Information Network) is the world's second largest online system for lawyers.[38] LegalEase, who host the site, won the 1995 award of the Society for Computers and Law for the Link service.[39] Used by about 3000 practicing lawyers, largely U.K. solicitors and barristers, Link is a value-added service enabling the exchange of e-mail within the closed Link arena and to and from the Internet. Link's communication software is available free of charge to lawyers. In addition to e-mail, the system has a number of subject-specific conference areas to which users can contribute as well as a free daily legal update prepared by trained legal journalists. A number of optional value-added services are available, including local telephone call access, corporate registrations (enabling the receipt of e-mail at a corporate Internet address), and domain name registration. Link has no subscription or registration charge, but there is a charge for value-added services.

Engineering Village. Engineering Information Village[40] is an Internet-delivered service of Elsevier Engineering Information, which integrates such features as organized access to over 16 000 technical Web sites with its own descriptive summaries of the sites including imbedded abstract links to over 60 000 points within the sites; librarian and engineering colleague resources; and access to almost 200 databases on either a site-license or transaction basis, including its own Ei Compendex Web. Ei Village also offers regional editions in Spanish and German as well as mirror site regional editions and regional editions in the U.K. and in South Africa. In March 1998 a planned Chinese service was announced. When Elsevier acquired the company early in 1998, one of the first planned services was integration of the full text of Elsevier's technical and engineering publications into Ei databases. Ei's secondary data will also eventually be integrated with Elsevier's journal publishing program. Engineering Information Village differs from some of the other communities discussed in this paper in that it has institutional members and in that it was profitable within the first 18 months. There are about 30 000 regular members.

BioMedNet. This is an Internet community for biological and medical researchers.[41] It is claimed that more than 200 000 members are using BioMedNet's facilities, which include a library of full-text journals, a collection of searchable biological databases, a job exchange containing hundreds of job offers and jobs wanted, *HMS Beagle* a daily scientific "Webzine", and a shopping mall. Other services are Evaluated Medline, a free MEDLINE service with full text links and expert annotations, and BioMedLink, an evaluated and annotated database of Internet resources for biological and medical researchers. Membership of BioMedNet is free, and members can search all its content without charge. However, viewing full-text articles from publishers often requires payment or a subscription.

CLUBS FOR CHEMISTS ON THE WEB

Three Internet sites which aim to be virtual communities for chemists will now be considered in more detail. They are ChemCenter from the American Chemical Society,[42] chemsoc,[43,44] organized by the Royal Society of Chemistry (RSC), and ChemWeb.com.[45,46] In this paper, the chemists' club run by ChemWeb Inc. (a company owned by Elsevier Science) will be referred to as "ChemWeb.com" to distinguish it from the Chemweb software written by the company SoftShell and the Chemweb list server[15] run by Rzepa at Imperial College, London. ChemCenter began operation on August 25, 1996. ChemWeb.com was announced in August 1996 but commenced operations in April 1997. Chemsoc first appeared in April 1998.

It is not possible to do a fair comparison of the three clubs, since chemsoc is too new to be comparable, and ChemCenter and ChemWeb.com seem to have different strategies and are supported in different ways. ChemCenter links with the very useful ACS Publications, ACS Web, and CAS sites, but it has very little content of its own and is staffed by only about five people. However, the Publications Division and CAS sell their own products so the number of people involved with ACS Web sites in total is very much greater than five. One is left with the impression that ACS Publications and CAS get on with the work of running their own, very significant, sites and have little interest in making one coherent, central operation out of ChemCenter. ChemWeb.com, on the other hand, was started up with $6 million capital from Current Science and MDL, and it is undisputedly a commercial operation with a staff of about 25 people.

So, rather than center this discussion on features, we are comparing just a few features and then describing each club in turn. One very important feature to consider is speed of access. All three sites are inadequate in this respect: at busy times access via a modem is tiresomely slow. We conducted a quick independent comparison. There is a site called Websitegarage (http://www.websitegarage.com), which performs a number of tests on Web pages. This gives an independent series of results which are generally considered reliable. One of these tests is for speed of loading. It is a useful test because it takes the size of the Web page (graphics etc. included) and works out load times based on the file sizes, ignoring variables such as time of day, amount of activity on the Net, and so on. It also offers an overall conclusion: poor, fair, good, or excellent. Tests on March 17 and April 7 gave the results shown in Table 1: we have added our own site for comparison.

Table 1. Speed of Loading of Web Sites (in seconds)

	ChemCenter	ChemWeb.com	Chemsoc	warr
14.4k modem	59.98	49.69	43.56	8.78
28.8 modem	34.48	27.48	23.70	5.52
56k modem	24.21	18.54	15.71	4.20
ISDN 128k	10.39	6.83	5.28	2.40
T1 1.44mps	4.54	2.06	1.06	1.63
summary	poor	fair	fair	excellent

The ongoing costs of running ChemWeb.com are financed by income from advertisers and sponsors. The penalty for free membership is the time wasted on watching twitching logos paint across the top of each screen. As for ChemCenter, why the entire operation should be so slow is not entirely clear. Graphics are obviously part of the problem. The many users of the ACS electronic journals service, for example, would be well advised to log on directly to the ACS Publications Web rather than on to ChemCenter.

The organizers of ChemWeb.com and ChemCenter do not reveal usage figures, and even if they did it would be difficult to make comparisons since they seem to handle their statistics differently. In the classified advertisements section of *C&EN* it says that 20 000 chemists visit ChemCenter every day. On page 14 of the ACS Annual Report for 1997 there is mention of "total usage increase from 1996 of ChemCenter, Publications, CAS and ACS Web sites 407%". No figure for "persistent membership" can be derived from these statistics. In May 1998, ChemWeb.com told us that ChemWeb.com usage, measured in user sessions, had increased 5-fold since early July 1997. A user session is defined as 15 min on average. The number of visitors to ChemWeb.com is much higher than the number of user sessions.

Another reason that comparison between the two clubs is not possible is that it is not clear which pages to compare. At one time, ChemWeb.com's magazine *The Alchemist* was definitely the most popular feature on the site, but ChemCenter has no equivalent "webzine" (although it has "hot articles" from ACS magazines). Moreover, should all the features of the four ACS Web sites be used in the comparison?

One marketing gimmick adopted by both the two major communities is "send a Postcard" (ChemWeb.com) or "send a Web card" (ChemCenter). Assuming users have time to waste on such frivolities, they will find that they can waste much more time constructing a Web card than a postcard and the unlucky recipient will have to cut and paste a lengthy number from an e-mail message to read the Web card, whereas the ChemWeb.com e-mail has a colored hyperlink direct to the postcard (a much stronger incentive for the user to pay a visit).

Both ChemWeb.com and the full set of ACS sites are very complicated to navigate, but ChemWeb.com has a well-written and comprehensive Help system and System Guide. ACS has plans to implement a Site Guide for ChemCenter eventually. Chemsoc is a simpler site, relatively easy to navigate, and also has a help feature. One of its advantages is that it allows search within chemsoc of other indexed sites, including those of its "competitors". Chemsoc news is updated daily, ChemWeb.com news two or three times a week. News is updated *hourly* on ChemCenter. This is done automatically from an online "news feed" service, and the information is mainly business news.

CHEMCENTER

Content. ChemCenter provides information about professional services, conferences, publications, databases, education, shopping, and resources. In May 1998, there were also graphics on the home page for the following highlights: Springtime Treasure Hunt, Online Chemistry News, the ACS Strategic Plan 1998−2000, ACS Online Store's First-Ever Sale, New Features/Options Increase Access to Web Journals (a press release), WWW Access to Selected STN Databases, Send or Pick Up a Web Card, This Week in Chemical History, International Chemistry Celebration, and Search/Browse Laboratory Products, Services, and Companies. Full text "hot articles" are available in "What is New". On the browsing day in question, we were delighted to find a very interesting article from *C&EN*.

The Professional Services page has information about careers in chemistry and ACS membership services. ACS members can also access the ACS Job Bank to search employment advertisements. On the Conferences page there are links to ACS-sponsored meetings and to a few other meetings such as Gordon conferences. There are also links to other ACS programs and committees as well as access to chemistry-related Internet newsgroups. There is, in theory, a discussion forum here; in practice it carries no serious discussion.

The Publications page provides access to the technical journals, magazines, electronic directories, books, and articles available from the Society. On the Databases page, users can access Chemical Patents Plus, STN International, and STNEasy, three CAS products to help them search the technical and patent literature as well as ACS journals and electronic directories. The Education page includes links to ACS educational and public outreach programs.

On the Shopping page, users can find products and services offered by ACS and CAS as well as information about products and services offered by advertisers. They can also browse or search for specific laboratory equipment, supplies, products, services, and chemicals via electronic editions of *LabGuide* and *Chemcyclopedia*. The Resources page points to other selected Web sites of interest to the chemical and scientific communities, including indexes, virtual libraries, other professional societies and scientific organizations, and a science smorgasbord. The Web sites ACS has selected seem to be almost exclusively noncommercial ones. ChemWeb.com is not listed, and the RSC link leads to the RSC site not to chemsoc.

The Search facility in the ChemCenter site is inadequate.[51] In May 1998, we found no hits on "Beilstein", although it is an STN database, and there were no hits on either "*TCAW*" or *"Today's Chemist at Work"* (an ACS magazine) or on "databases on STN". Apparently a software upgrade will take place within the next month, but the problem seems to be in *which pages* are actually searched. For example, a search for "STN" produces seven hits; all of them documents on the ChemCenter node, but none of them on the CAS Web.

System Details. The various ACS Web sites use five Sun servers, two for ACS Publications, one for the ACS centrally, one for ChemCenter, and one for ChemPort (based at CAS). There is also an NT server used for the discussion/chat function as part of ACS and ChemCenter operations. The ACS Publications site has a secondary offline server to be

used in the event of system problems on the primary system. There is a "high-availability" system that can be brought into operation in minutes. The ACS site also has a development server (called WebCentral) that contains development copies of what is at http://www.acs.org and http://www.ChemCenter.org.

The ACS Publications site uses a Sun Sparc20 with 4 CPUs and 252 GB of disk in RAID arrays. The Sparc-20 will soon be replaced by a Sun Enterprise 3000 system with multiple CPUs. The current Sparc-20 system is used for all applications on the Publications Division site except for *LabGuide*, *Chemcyclopedia*, and DGRWeb (for the *Directory of Graduate Research*). These latter applications are housed on a Sun Enterprise 3000 server with 2 CPUs and 174 GB of RAID storage.

There are 2 T1 lines into the ACS: a partial T1 from CAS in Columbus and a full T1 from UUNET. The T1 line from UUNET can be dynamically expanded into a second T1 depending on the load. The aim is to achieve 98.0% "uptime" on the Publications Division's Web servers. Uptime this year to date (through May) is 98.35%. ACS journals are currently held as Unix files, but it hoped that they will be in an Oracle database in 1999. The search engine used is Verity.

User Views. The results of a "straw poll" we tried on the chminf-l list server[14] were unhelpful. A question about "ACS Web sites", written in an attempt to see if users could differentiate ChemCenter, produced many positive comments about the ACS Publications Web site, but ChemCenter was only mentioned once (by a person who had had an unfortunate experience trying to locate Supporting Information to an ACS journal going in via ChemCenter). A follow-up question specifically mentioning ChemCenter did prove that the site is well used, but, again, almost all the replies were about ACS Publications.

ChemCenter is not, as has been claimed, a "one-stop Web site" or "the only bookmark you will ever need". You *cannot* "do it all on ChemCenter". Apart from the inherent impossibility of the marketing claims, ACS has adopted a policy of including only those links or resources that ACS feels it can endorse. The Resources page includes only noncommercial resources, and certain companies cannot be found in the product pages even though their vendors have published hard copy advertisements in *Chemical and Engineering News*. ChemCenter is very easily located using the Links page of chemsoc. The converse is not true. It is interesting to note chemsoc's review of ChemCenter:

"ChemCenter is highly designed but still short on distinctive content. Essentially a product of the ACS, most of ChemCenter's 'internal' links take you to parts of the ACS or CAS sites—not a problem in itself, but rather begs the question of whether ChemCenter is trying to deliver anything new. The site uses plenty of graphics, including advertisements, and the images certainly have an impact on its speed. Registration is coming, says ChemCenter, but is still not compulsory, and the site is searchable and has a rather eclectic set of links to other sites."

CHEMSOC

Content. Chemsoc is the newest site for chemists and the "home of the international chemistry societies' electronic network". Registration is currently not necessary but is gently encouraged. The information on the site has been made available by various national chemistry societies for dissemination on a single site. Currently around 30 such societies are providing varying levels of information on chemsoc.

The home page leads to a site gateway, useful links, or the "science park". The site gateway has icons for an information arcade, an education arcade, chembytes (an online magazine), societies (a useful, alphabetical list of society addresses with hyperlinks), and conferences and events, a comprehensive and searchable database of chemistry conferences and events with links to the organizers' Web sites. "Useful links" gives access to chemistry resources on the Web, searchable with the Muscat Search Engine. Extensive site reviews are gradually being added. Science park contains useful information from selected chemsoc advertisers (currently only ChemWeb.com, ChemCenter, the Czech Chemical Society, and RSC).

The information arcade gives direct access to major chemistry information sites (including ACS ChemPort), advertises the RSC's library and search services, and provides career advice and news. Career features include information and advice on career related issues and direct links to career sites on the Web, providing access to thousands of job vacancies worldwide, plus career profiles of recent chemistry graduates. Each week a fully searchable sample of Chemical Business NewsBase (CBNB) is published. The education arcade aims to be a comprehensive resource for teachers and students of chemistry to learn more about their subject. Chembytes has specially commissioned features plus chemistry business and science news "in a bite size format". Chembytes is searchable with Muscat. A "latest products" facility links to recent press releases from various vendors.

Chemsoc has one discussion list in operation at the moment, but access is restricted to student chemical society network members only. The "technology car boot sales" are an extension of a series of meetings of the same name organized by the Royal Society of Chemistry. These meetings encourage networking and technology transfer between suppliers and buyers in a number of industries with University and Government research groups.

System Details. The system uses NT Server, on a 128M RAM Dual Processor Pentium Pro 200 with 10 Gigabytes of disk. Software includes Netscape Enterprise Server, MuscatFX for use with Muscat databases, Perl 5.004 with ODBC extensions, Access 97 databases, NTMail for the discussion lists, and Webboard 3.0 for discussion boards and chat.

CHEMWEB.COM

Content. ChemWeb.com is an online club for the chemical community. Members may take advantage of a library of full-text journals and a collection of searchable chemical databases. There are 3 million abstracts on the site. ChemWeb.com's facilities also include an extensive conference diary, a job exchange containing hundreds of job offers and jobs wanted, and a shopping mall containing books, software, equipment, and services. It also features a weekly chemistry magazine, *The Alchemist*, containing news, reviews, and comment. Membership of the club is free, and

members can search the whole of ChemWeb.com without charge. Payment or subscription may be required, however, to view full-text articles from some publishers.

Among its databases, ChemWeb.com offers ChemDex Plus, a database of chemical resources on the World Wide Web, edited by Dr. Mark Winter and compiled by ChemWeb.com in collaboration with the University of Sheffield. On June 12, when we used this resource to trace chemsoc and ChemCenter, the search engine was unfortunately turned off, and the help-in-context feature was not implemented. Nevertheless we eventually found both chemsoc and ChemCenter by browsing the hierarchical classification. We are not publishing ChemWeb.com's site descriptions here since they are not comparable: full reviews will not be available until later this year.

Entries in the shopping mall and the job exchange are contributed by members (with confidentiality options, if required). Real-time conferencing is also being developed (a topic discussed further below). Interactivity is part of the ChemWeb.com philosophy: "lurkers" may join but communication between members is being actively encouraged. Records for 23 140 members appear to be available as of June 10, 1998. ChemWeb.com also provides an archive of all its information, and the site is checked at least weekly for bad hyperlinks.

ChemWeb.com is the only one of the three communities that offers chemical substructure searching. (ChemCenter gives access to STN services on the CAS Web, but the Web service STN Easy does not have substructure search.) On ChemWeb.com, ISIS/Draw from MDL Information Systems (or a compatible alternative) is used for structure entry, and MDL's Chemscape Chime plug-in is used for structure display. The NCI-3D database (from the NIH National Cancer Institute), MDL's Available Chemicals Directory, and the Investigational Drugs database from Current Drugs are currently substructure searchable.

System Details. The service is powered by a Silicon Graphics Origin 2000 server which supports all ChemWeb.com databases and information management technologies.[46] The live ChemWeb.com system operates on an Intel machine linked to the Silicon Graphics machine by a fast Ethernet link (100 Mbits/second). Server collector technology is used, and the main box has three subsidiary servers on the NT side. The Intel hardware operates under Windows NT 4.0 and contains the Web Server, the BiblioteK text searching software, and all software relating to the operation of the club. The eight-processor Origin 2000 machine contains the Oracle database, the Netscape server, ISIS/Host, Chemscape, and MDL's OHS and ACD databases. Text searching is performed by BiblioteK software which was built specifically for ChemWeb.com's sister club BioMedNet but has been further developed for ChemWeb.com.

User Views. In January 1998, we carried out a "straw poll" (certainly not a statistically significant survey) using 61 names picked at random from the group who registered for the first ChemWeb.com virtual conference (an event described later in this paper). The questions are listed in Figure 1. The 61 people selected were not necessarily ChemWeb.com members. The event was advertised on several list servers, and membership of the club was not needed for registration for the conference.

Q1. If you registered but did not actually logon on December 3, I would be interested to know why you did not logon and I would still like your answers to the following questions.

Q2. Do you communicate through the Internet more nowadays than you did a year ago?

Q3. Is this one-way or two-way communication? Would you define yourself as a "lurker" or as an active participant in electronic discussions?

Q4. Was the experimental virtual conference on December 3 a "success"? Explain.

Q5. Do you think that you belong to a "virtual community"? Explain.

Q6. How often do you visit ChemWeb.com?

Q7. Which page(s) or items on ChemWeb.com have you read recently? Please be very specific.

Q8. Do you find ChemWeb.com useful or interesting? Explain.

Figure 1. Questions in straw poll.

Twenty-two people replied (by e-mail). The distribution of replies was as follows: U.S. commercial 7, U.S. not-for profit 2, U.K. commercial 9, U.K. not-for-profit 2, rest of the world commercial 1, rest of the world academic 1 (a breakdown done from our own knowledge and not simply from analysis of the ".com" and ".edu" domains etc.). The longest replies were about the virtual conference, and they are analyzed later in this paper.

As regards communication through the Internet, 18 out of 22 people use the Internet more than they did a year ago, 1 does not, 1 more does not because he or she already used it a lot a year ago, and 2 use it the same amount. It seems as if only two out of 22 people have been unaffected by an increase in Internet communication. However, in almost every case it is electronic mail that accounts for the increased impact.

Ten people use two-way Internet communication. Seven are "lurkers" (one of them because of management edict); five are between (usually they lurk when it comes to list servers but presumably have to communicate in both directions by e-mail). Ten people think they belong to a virtual community (six of them keenly), 4 do not belong, 5 do not like or do not understand such terminology, and 3 have limited community feeling. (One of these three has electronic discussions on computing, astronomy, and music but says chemistry newsgroups are full of noise.)

The answers on ChemWeb.com were shorter than the others and gave the impression that many respondents had been visiting the virtual conference rather than ChemWeb.com. Question 7 was a check on question 6: if people could not name items on ChemWeb.com it is not likely that they visit often. It was clear that there were six real ChemWeb.com users in the 22. They visit once a week or twice a month. However one of the six needs reminding to visit (by e-mail alert). Another two people tend to visit if they are alerted by e-mail. Four people say they visit monthly or less than monthly. Ten visit rarely or less often than monthly. Of these ten, four expressed a certain regret or "guilt" about not visiting, and one is probably a nonuser confused between the chemweb list server and ChemWeb.com.

In terms of what is used on ChemWeb.com, it was clear that 14 of the 22 are really nonusers. Of the 14, nine are clear nonusers (although one of them made a joke about jobs so he knew jobs were there), and five were there just for the

seminar or transcript. The eight others (the six + two users in the previous question) were divided as follows: 4 read *The Alchemist*; 1 reads *The Alchemist* mainly but occasionally visits the library for journal abstracts; and 1 reads *The Alchemist* but sometimes looks at jobs and conferences. One cited an article about Dynamic HTML as a specific example. One uses material from Current Drugs.

So, is ChemWeb.com useful or interesting? Five said "yes". Two gave a qualified "yes" but do not have time to use it. One said *The Alchemist* alone is useful. Four say ChemWeb.com has potential. Three say is an interesting experiment or model or it seems interesting. One was simply studying it for ideas. One was confused between the chemweb list server and ChemWeb.com. Two did not know or could not answer. Only three said "no" or the equivalent.

Content and usage of ChemWeb.com have increased to such an extent in the four months since this survey was carried out that great care must be exercised in interpreting the answers. Qualitatively, though, the comments are still of considerable interest.

VIRTUAL CONFERENCES

The subject of computer supported cooperative work was introduced earlier in this paper in a groupware context,[25] but newer ideas have also started to appear on the Internet. Dessy has listed some Internet tools for collaborative work.[47] A collaboratory is a laboratory without walls where researchers collaborate with colleagues and share data and computational resources.

Text-based conferencing in real-time has been taking place in fields other than chemistry for some time. To the enthusiast, such an environment is known as a "MUD" (Multi-user Dungeon or Multi-user Domain or Multi-user Dimension) or a "MOO" (Multi-user Object-Oriented Domain). Multi-user Dimension was the name given by Richard Bartle and Roy Trubshaw to a computer game they designed in 1979.[48] The other interpretations of MUD have appeared later. A MUD is an arena for real-time interaction on the Internet.[29,48]

Reid[48] notes that "MUDs rarely resemble scripts or books. In other words, though text-based, MUD discourse combines elements of the written and spoken, which itself points to the 'naturalness' of the environments that MUD users create. The spontaneity with which discourse and dialogue can occur affects the text itself, and MUDs are an arena within which users communicate in real time and with little time to construct carefully written texts".

Extending such an environment to chemistry, and including graphics, poses profound technical problems, but experiments have been carried out recently. The first real-time ChemWeb.com conference took place in December 1997, with a panel of speakers and a moderator. Five more lecture events took place in the first half of 1998, including some live video-broadcasting of parts of a "real" Molecular Graphics and Modeling Society/Chemical Structure Association Conference. Sound, video, rotatable 3D chemical structures, and other features have all been included in the lectures.

The "conference center" used is that provided by Virtual Environments International.[49] The transcript of the lecturer's and moderator's comments and delegates' questions are in a scrolling window to the left of the screen; the slides provided by the lecturer are in a window on the right. Delegates may be in the "main room" or in an overflow room or "viewing gallery". Participants in the main room can pose questions directly into the transcript; viewers must post questions via the moderator. Main delegates are able to use other features such as "whispering" privately to another attendee and "doing" things such as waving to someone. Words in the transcript appear in different colors to distinguish, say, lecturers from delegates and questions from whispers.

In the experiments leading up to the first ChemWeb.com event, it was found that the server was likely to go down if 400 people were allowed to log into the main room. About 350 people did log on to the first event, but only about 100 were allowed in the main room. On the day, the main lecture (by Henry Rzepa), the panel discussions, and the general discussion took place successfully without any disconnections of service. At least one of the following lectures has unfortunately suffered interruption because of overload or technical faults.

This author has logged on for all the lectures to date. Handled with patience, in the spirit of an experiment, they are an exciting development. The software is evidently immature and resource intensive. Inadequate bandwidths mean that the transcript is updated far too slowly; there are often problems with changing the slides, and repeated reloads of the display are sometimes needed. Some users report problems getting through their firewalls. Cynics have commented that it is easier and quicker just to view the conference transcript and slides *after* the event. This author disagrees: there is no substitute for the stimulus of joining in the discussions as they are actually taking place. Being in the overflow room rather than the main room can give a sensation of being "left out". Simply reading a history afterward defeats the whole object: it gives no opportunity for participation. (There is a facility for post-lecture discussions, but, in practice, it is little used.)

Some people still feel that video-conferencing is a more practical real-time solution, especially since it is "face-to-face" as opposed to "face-to-screen". Yet another school of thought is that it is better not to hold conferences in real-time at all. If delegates are not forced into a 2-h time window, people can participate regardless of their time zone, and they have time to "polish their thoughts" or prepare their presentations. Software glitches and network downtime have much less impact. However, the technology is advancing very quickly, and it seems sensible to assume that there is a place for both types of conference environment.

Dessy[50] once pointed out that there are sometimes more questions about the methodology of implementation of a conference than about the scientific content of the "papers". This was certainly true in the straw poll we carried out concerning the first ChemWeb.com event (see Figure 1). The comments about the conference technology were the longest in the poll. Six out of 22 people obviously thought the event was a success, 1 thought it was a success but the technology could do with some improvement, 5 did not log on or were otherwise unqualified to answer, 9 had serious technical problems with the conference and/or the transcript, and 1 lost interest fairly soon because the discussion was "tedious and too cliquish". The last comment reflects the fact that

perhaps a dozen people chat (slowly), while hundreds watch and do not participate (they are "lurkers" in the common parlance). The conclusion may seem somewhat negative, but the fact is that large numbers of people have continued to log on for the following five events.

The ChemWeb.com/VEI events have a particular significance. Of the three chemistry communities, only ChemWeb.com is encouraging active communication among its members. This is mainly done by real-time conferences and by making the profiles of the members searchable: the experimental meeting rooms are little used at the moment. In August a list server (chemind-l) will be added. As we have seen, the concepts of membership, communication, and belonging are very important to the success of a community both sociologically and commercially. The virtual conference experiment is well worth pursuing.

CONCLUSION

All three of the chemical communities discussed in this paper are immature and, one suspects, unprofitable. They are also changing very rapidly, and some of the comments in this paper will almost certainly be incorrect and out-of-date by the time the article appears in print. It is not easy to do a summarized comparison because an element of "comparing chalk and cheese" comes into play.

We will first compare the three services from a commercial viewpoint, as of today, using Hagel and Armstrong's characteristics: a distinctive focus for the membership, integration of content and communication, emphasis on member-generated content, choice of competing vendor offers, and commercial motivation.

ChemCenter aims at the whole community of chemists although it does recognize different ACS Technical Divisions and could eventually capitalize on that. It has an enormous aggregation of content, if one includes all the ACS Publications and CAS offerings, but it is not pursuing a very aggressive drive for members and does not insist on registration. (We recognize that registration is a negative feature for many chemists, but it is essential to the community concept.) It has a distinct ACS bias in some features (e.g., meetings, careers, membership services) and seems to pursue a policy of only advertising those services "for which ACS will vouch" rather than those services members might want. It has no emphasis at all on member-generated content. It does, however, have some competing vendor offers in that ChemPort links to other publishers' sites. Its commercial orientation, according to Hagel and Armstrong's controversial "reverse market" concept, is so poor that it should not survive, but we suspect that it will, in some form or other.

Chemsoc is the newest of the sites and has had the advantage of learning from its rivals' good points and faults. It aims on the whole at a very wide community, but it does have some specialized discussion groups and links to a variety of societies. It does not have very much aggregated content at present and does not insist on registration. It advertises, or links to, meetings and jobs in a wider sense than ChemCenter does. Its Web magazine is poor compared with ChemWeb.com's, but it does offer up-to-date news. It is willing to draw attention to the offerings of its competitors, and it is commercially motivated to some extent even though it is run by a learned society.

ChemWeb.com is theoretically focused on too wide a membership at the moment: in practice, its loyal members are much more focused. It is strong on member acquisition and communication. It is aggressively acquiring both members and useful content. Its magazine, *The Alchemist*, is well regarded. It does not score much higher than the other communities on member-generated content and choice of competing vendor offers (we cannot see it gratuitously advertising ChemCenter, or chemsoc, for example) although it does offer journals and databases from multiple vendors (including RSC). To some extent, the ChemDex Plus service will improve ChemWeb.com's score as regards member-generated content. Apart from a certain fear of competition (a failure, remember, from the Hagel and Armstrong viewpoint), ChemWeb.com scores highly on commercial motivation, especially in terms of resource invested, strategic vision, and understanding of the concepts of community.

Of course, not everyone agrees with Hagel and Armstrong's characteristics, so how do the three communities score in terms of usability and usefulness? Even Hagel and Armstrong believe that the user is "king". We do not believe that any of these communities will become a true "one-stop shop" soon. ChemCenter per se is slow to use and offers little that is not available elsewhere. However, STN Easy, ChemPort, and the various ACS Publications services are useful, one might even say essential. Chemsoc looks as if it might have promise: it does bring together some useful content and has a certain simplicity. It is hard to say yet whether it will eventually offer a significant amount of what chemists need. Chemists are very short of time, and they are not going to pay repeat visits to a club unless it offers them something essential. ChemWeb.com looks best placed to offer many of the essentials, but it (like other sites) will need improvements in the enabling Internet technologies before it can offer these essentials efficiently enough.

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