Interdisziplinäres Institut für Raumordnung

Stadt- und Regionalentwicklung

Wirtschaftsuniversität Wien

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1992

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Wide Area Networks and Regional Science

Recent Developments and Future Prospects

IIR-Discussion 47 1992

*Paper prepared for the 32nd European Conference of the Regional Science Association, Brussels, Belgium, August 25-28, 1992.

Publikation gefördert durch das
Bundesministerium für Wissenschaft
und Forschung, Wien

1 Introduction

In recent years we have seen tremendous growth in the area of telecommunications. Computer networking is a significant part of this. Not only have computers in a local computing environment been integrated into Local Area Networks (LAN), many of these networks have been interconnected in order to form a Wide Area Network (WAN) which links computers over thousands of kilometers. This is particularly true for Universities and other research institutions. Today they have access to a worldwide computer network, called Internet.

Although there is an abundance of literature in Regional Science about the spatial implications of telecommunications (e.g., Hotz-Hart, Schmid, 1987; Castells, 1989; Brunn, Leinbach, 1991), it seems that the consequences telecommunications and computer networks in particular may have on Regional Science as a scientific discipline have been largely overlooked. In this paper we want to focus on this – yet neglected – aspect of the computer revolution.

In section 2 we will discuss traditional forms of scholarly communication. It is the aim of this discussion to identify the basic characteristics of our traditional forms of scholarly communication. We will discuss face-to-face communication, telephone, telefax, mail as traditional communication channels, and working groups, conference, monograph, and journal as traditional forms. In section 3 we perform the parallel analysis for electronic communication over WANs, where we concentrate on the dominant WAN in the academic world, the Internet. We start the discussion by talking about the basic structure of the Internet (section 3.1), and its basic network services (section 3.2). More advanced network services being analyzed in section 3.3. Section 3.4 compares traditional and electronic forms of scholarly communication, and draws some general conclusions.

Section 4 of the paper focuses on the current usage of electronic communication in sciences. We try to give some empirical account about which scientific disciplines are engaged in network-based scholarly communication and which instruments they have developed until now. Also, we want to find out the role Regional Sciences plays in this field. In section 5 we present CERRO, a Regional Science oriented electronic discussion group and archive. The development and current status of this application are described. Also, we present the results of a survey among subscribers to the electronic discussion list. Section 6 discusses some potential developments of electronic communication in Regional Science. We concentrate on those instruments, for which there is software readily available and which are easy to implement. The paper ends with a summarizing section.

In an appendix we provide a few tips and tricks for newcomers to electronic communication. We list sources for free network software and electronic journals, and give basic LISTSERV commands. The information in the appendix is intended as a starting point for a deeper exploration of the Internet resources.

2 Traditional Forms of Scholarly Communication

Scholarly communication is a specific form of communication[1] in general. Borgman (1989, p. 586) defines scholarly communication as "how scholars in any field (e.g., physical, biological, social, and behavioral sciences; humanities; technology) use and disseminate information through formal and informal channels." As pointed out by Griffith (1989) communication is a key element of the scientific creation of knowledge: "Communication is the only general scientific behavior." (Griffith 1989, p. 600).

Communication Sciences have developed various concepts of structuring communication. In our presentation we will use Shannon's classic "sender-receiver-model" as a conceptual guideline[2] (Shannon, Weaver, 1947; Herrlitz, 1979a,b; see also Fig. 1). Basically, Shannon distinguishes between a *sender* (SE) and a *receiver* (RE) who are connected through a *channel.* Over this channel they transmit a *signal* (SIG) which is related to a certain information ("content") either in verbal or non-verbal form. The sender obtains his information from a *source* (S), the receiver *processes* the information (P) once it has arrived. Via a *code* they both associate a certain meaning to a signal.

Over the centuries, scholarly communication has developed a number of different forms, which today constitute a quasi-standard. Four major forms of scholarly communication can be distinguished: (1) small scale working groups, (2) conferences, (3) monographs, and (4) journals. As far as communication channels are concerned they use (1) face-to-face communication, (2) the telephone call, (3) telefax, and (4) postal matter. In the rest of this section we will first discuss the characteristics of the communication channels, then those of the four major forms of traditional scholarly

[1] "communication is a transactional, symbolic process which allows people to relate to and manage their environments by (1) establishing human contact, (2) exchanging information, (3) reinforcing the attitudes and behaviors of others, and (4) changing the attitudes and behaviors of others." (Book 1980, p. 8)

[2] An alternative and more complex view of human communication relying on open systems theory can be found in Watzlawick, Beavin and Jackson, 1967.

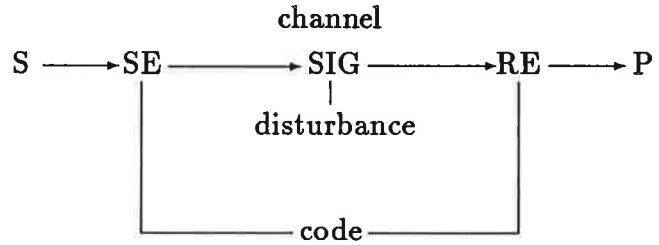

Figure 1: The basic communication model; source: Herrlitz 1979a, p. 36

communication[3]. We will categorize them according to eight characteristics: (1) the number of senders, (2) the number of receivers, (3) whether the sender is bound to a certain place, (4) whether the receiver is bound to a certain place, (5) whether the receiver's presence is indispensable, (6) immediacy of feedback, (7) transmission time, and (8) transmission cost. In later sections we will classify electronic communication according to the same scheme, allowing a comparative view of traditional and new forms of scholarly communication.

2.1 Traditional communication channels

2.1.1 Face-to-face communication

This is the conversation between two (or more) scholars who are both present at the same time *at the same place.* It allows for verbal and non-verbal communication, the latter being of minor importance for scholarly use. There is constant change in the roles of sender and receiver, though there is only one sender and one receiver at a time. The presence of both communicators at the time of transmission is indispensable. Transmission time is small and feedback is most immediate. Monetary costs – except for transportation costs to bring the scholars to one place – do not exist.

2.1.2 Telephone call

A phone-call links two (or more) communicating persons who reside at different locations. Transmission is verbal and oral, normally there does not

[3]Because we are all very familiar with these communication forms and channels we will keep this discussion very brief.

exist any written protocol of the conversation. Although in the actual communication the roles of sender and receiver alternate in the same way as with face-to-face communication, we will treat the person who has initiated the communication as sender. He/she is not bound to a certain place. The receiver, however, needs to be near the phone at the time of the call. Feedback is most immediate, which minimizes the time of communication. Cost usually depends on the distance between sender and receiver (in addition to a number of other factors).

2.1.3 Telefax

The Telefax transmits *written* information (either text or pictures/handwritten or printed). The original is encoded into a telephone transportable signal (scanned) by the sender's machine, transported via telephone line to the receiving machine, where a copy of the original is restored from the incoming signal. It is important to note that the document is transmitted as a picture (series of dark and bright dots). In many cases this type of transmission is quite inefficient and it prevents the direct retrieval of text in computer readable form. Transmission cost is the cost of the telephone call. Although it is technically feasible (but costly) to send one fax to several recipients, telefaxes are typically used for one-to-one communication. Similar to the phone-call, the receiver is bound to a certain place but does not necessarily have to be present at the time of "faxing". Technical transmission errors are still frequent which often leads to delays. Immediate feedback is not possible with fax.

2.1.4 postal matter

Communication by postal matter is the oldest way to convey a message to someone spatially separated. Written documents are physically transported to a specified addressee without the use of any telecommunication infrastructure. Communication is strictly one-to-one. The receiver is bound to a certain location, but does not have to be present at the time of delivery. Transmission takes at least one day and depending on the distance may take up to a few weeks. Because of this, feedback is most delayed.

2.2 Traditional forms of Scholarly communication

2.2.1 Working groups

Usually working groups are either related to a research project or to a research organization. They bring together scientists who share the same

disciplinary interests, to exchange ideas, discuss a research proposal, or present some preliminary results.

The main purpose of working groups is to discuss issues. Because of this focus the number of participants is usually rather small. In a working group senders and receivers of messages are typically at one place. Because only one scholar at a time can contribute to the discussion, feedback is delayed and sometimes inhibited. So, there is a constraint in both time and space. Cost involved in this form of communication are typically cost for travel and accommodation.

2.2.2 Conference

The conference is an officially organized environment where a large quantity of scholarly information is transmitted in a very short period of time. As distinguished from the working group, the number of participants is larger and topics are more varied. Information is presented with the help of a "paper" distributed to all participants of a "session". Typically, more advanced or finished studies are presented and communicated at conferences. Access to yet unpublished research findings is a major incentive for participation.

The characteristics of a conference are very similar to those of a working group. The number of receivers typically exceeds the number of senders, but both of them are again bound to a certain place. In addition to travel expenses and accommodation, participants usually have to pay a conference fee. Because of the larger number of participants and the division into sessions, feedback is more delayed than in a working group.

2.2.3 Monograph

Monographs and Journals are both written forms of scholarly communication. As the oldest formal form, the monograph used to be published, printed and sold by the professor who had written it. Before the existence of the journal, the monograph was the only way to succeed with "priority claims" (Manten, 1980, p. 8).

Today, a monograph is either a scientific scripture by one or more authors, or a collection of several contributions to one general topic under the auspices of an editor. In any case, it represents completed research, shows the results that authors (senders) chose to transmit to other scholars (receivers). It constitutes scholarly communication at the last stage of research.

With a monograph, the number of senders is restricted to a few, whereas the number of receivers is technically unlimited. Their actual number de-

pends to a considerable extent upon the reputation, organization and marketing of the company publishing the monograph.

Feedback is severely delayed, mainly because of the low speed of transmission. Once research is completed, publication of the results may take between a few months and several years. Costs (or royalties) for the sender vary greatly, depending primarily on the subject and the popularity of the author. Cost for the receiver is the purchase price of the book, where prices for scientific monographs have increased quite dramatically over recent years. In this context it is important to mention the role of publishing companies, who control *what to publish*, *in which form*, and *in what numbers*. University libraries, on the other hand, buy scientific monographs (and journals) and make the single copy available to a number of users at no (or little) cost[4].

2.2.4 Journal

The typical scientific journal contains several articles about different topics in a specific discipline. It is administered by a board of editors who decide which papers to be printed. A reviewing process is intended to support the work of the editors and to guarantee a high level of quality.

The characteristics of journals are practically identical to those of monographs. When one takes into consideration the time it takes to produce a manuscript, the distribution time for a journal article is usually lower than for a monograph, although the review process and a backlog of articles may add up to delays of one year or more. Because they appear periodically, journals can publish comments on earlier articles and thus reflect the scientific discussion in some way.

Cost is an important consideration with journals as well. Prices have increased quite dramatically over the last 10 years, partly due to "higher per-issue costs resulting from greater specialization and shorter press runs; and increased scholarly output, requiring larger issues of journals than in the past." (Bennett, Matheson, 1992, p. B2). This development (and the structural features of sciences that support it) has lead to several authors talking about a general crisis of scientific publishing (Doughtery, 1992; Okerson, 1991b; Byrd, 1990; Bennett, Matheson, 1992; Levin, 1992).

[4]We will come back to the role of publishing companies and libraries in section 4.3 of the paper.

3 Electronic Communication over Wide Area Networks

In this section we want to provide a brief introduction into Wide Area Networks, their basic components and the fundamental services they provide. We will look at WANs from the user's perspective, leaving out most of the underlying technical aspects. They are documented and discussed in an extensive body of literature (e.g., Tanenbaum, 1988; Comer, 1991; Comer, Stevens, 1991; Santifaller, 1991; Black, 1992). We will concentrate on the dominant Wide Area Network in the academic world, which is usually referred to as Internet[5].

3.1 The basic structure of the Internet

The Internet is a heterogeneous worldwide network consisting of a large number of host computers and Local Area Networks. The Internet uses the TCP/IP suite of protocols. This allows the integration of a large number of different computers into one single network with highly efficient communication between them. This way, the user can access information on all kinds of host computers from a desktop PC, Macintosh, or whatever he/she has available.

TCP/IP, the communication standard underlying the Internet, originates from work done at the US-Department of Defense in the late 1960s. The first version of the Internet was built by the DoD in 1969 and consisted of just 4 computers (Davidson, 1988, p. 2). In 1982 a set of specifications and protocols have been implemented, which became known as TCP/IP in reference to their two major elements, the "Transmission Control Protocol" (TCP) and the "Internet Protocol" (IP). The development and implementation of TCP/IP stimulated a massive growth process for the Internet. "By late 1987 it was estimated that the growth (of the Internet) had reached 15% per month and remained high for the following two years. By 1990, the connected Internet included over 3,000 active networks and over 200,000 computers" (Comer, 1991, p. 8). By January 1992 the number of hosts on the Internet was 727,000 (Lottor, 1992), doubling about every 7 months. Various groups of users are connected to the Internet: Universities and other educational institutions, Government agencies, the Military, and at an increasing number private businesses.

[5]One feature that makes the Internet particularly attractive in the academic world is its open structure. All technical specifications are available over the network free of cost in, so called, RFCs.

Actually, it is difficult to define the Internet and its size. Kehoe (1992, p. 8) calls it "a large 'network of networks"', consisting of "regional nets like SuraNet, PrepNet, NearNet, et al." They "are all inter-connected (nay, 'inter-networked') together into one great living thing, communicating at amazing speeds with the TCP/IP protocol". We will use the term "Internet" for those computers that communicate by use of TCP/IP. For some functions (particularly electronic mail) the Internet is connected by gateways to a number of other networks using different protocols (e.g., BITNET). As a consequence, for those functions the network available to the single user is much larger than the Internet.

The various nodes of the Internet are typically connected by leased telephone lines with communication speeds ranging from 56kbps to 45Mbps. However, it is also possible to use dial-up connections and standard modems for temporarily extending the network to a specific site. Today TCP/IP is available for all major operating systems ranging from MS-DOS and Apple's System Software to multi-user multi-tasking operating systems like CMS, UNIX etc. Also, Novell Netware supports TCP/IP.

The most fundamental function of the Internet is to pass electronic information from one computer to another. Every computer on the network is identified by a 32 bit Internet Address or IP-Number. This number is commonly represented as four numbers joined by periods (e.g., 137.208.3.2). The Internet uses these numbers to guide information through the network ("routing"). For human users, however, such numbers are usually difficult to keep in mind. Therefore, computers are also identified by Domain Names, which are to some extent similar to mailing addresses. The domain name corresponding to the above mentioned IP-address, for example, is `awiwuw11.wu-wien.ac.at`, where `.at` identifies the computer to be located in Austria, `.ac` identifies an academic institution (Naming schemes are somewhat different in other countries). Special programs, called "Name Servers", translate domain names into IP-addresses.

3.2 The basic network services

Typical TCP/IP implementations provide a number of basic services. From the point of view of the general user the most important ones are

- electronic mail
- terminal emulation, and
- file transfer.

We will describe these functions very briefly. In section 3.3 we will

discuss some network services that are using these basic functions for more sophisticated applications.

3.2.1 Electronic Mail

Electronic mail (e-mail) is probably the most commonly used network service. As mentioned above, this service is not confined to the Internet. Gateways, i.e. well defined transition points between networks, allow e-mail messages to travel from one network to another.

E-mail messages are usually sent not just to a computer, but to a user on a computer. Therefore, e-mail addresses consist of (at least) two parts (separated by `@`), one identifying the user, and the other one identifying the computer. Within the Internet the latter part is just the domain name of the respective computer. To give an example, the authors of this paper can be reached at `maier@nestroy.wu-wien.ac.at` and `wildberg@nestroy.wu-wien.ac.at`, respectively.

The standard use of e-mail is for person-to-person communication. The message is usually delivered within minutes, even when the recipient is located thousands of miles from the sender. E-mail represents a much faster alternative to regular mail. In contrast to telephone communication the recipient of e-mail does not need to be available in person. Incoming e-mail is usually stored on a suitable computer ("mail server") until it is read by the recipient. Another advantage is that e-mail can usually be forwarded automatically: when a researcher spends some time at another institution, he/she can still receive his/her electronic mail without delay or the intervention of someone else.

In many computing environments incoming e-mail can trigger activities from the system or some programs. This feature allows the creation of various sophisticated services. We will discuss them in the next section.

A number of attempts have been made recently to provide the equivalent of a telephone directory for e-mail addresses ("white page services"). Of course, these services are themselves made available over the Internet. Until now no clear standard has emerged yet.

3.2.2 Terminal Emulation – Telnet

Telnet, the Internet's terminal emulation protocol can be used for creating an interactive terminal session on a remote computer. "It gives the user the opportunity to be on one computer system and do work on another, which may be across the street or thousands of miles away." (Kehoe, 1992, p. 45). When you telnet from anywhere in the world to your home university's mainframe computer, provided it is on the Internet, what you will see on

the screen will be very similar to what you are used to seeing on one of the terminals at home. Telnet implementations are available for a few standard terminal types (most notably DEC's VT-100 and the IBM 3270). Practically all computers that allow remote access understand at least one of these standards.

In order to run your own computing jobs on a remote computer you usually need to be a registered user. Many internet sites, however, allow the general public to telnet into their computer(s) for a specific purpose: usually to query some data-base. Most common in this group is access to a computerized card catalog. Practically all the important US-universities allow you to access and search their library card catalog in this way (see appendix).

A number of other services can be accessed via Telnet in addition to library card catalogs. Some are free, some charge a fee. Examples are databases, new services and bulletin boards. We will discuss the potential impact of such services in section 3.4 of the paper.

3.2.3 File Transfer – FTP

When communicating with a remote host at a general level via terminal emulation, one needs to know all the specific aspects of the host computer's operating system. Because of the many different operating systems available, this can be very disturbing and may limit the acceptance of a service for potential users. For transferring files, a standardized set of commands, "File Transfer Protocol" (FTP), is defined for the Internet that makes file transfer and management (largely) independent from the host computer's operating system.

In FTP a user's requests do not go to the host computer's operating system directly, but through a software program ("FTP-server") that translates between the specific operating system and FTP-commands or output. This way, the user faces an (almost) identical environment, irrespective of the type of computer he/she is connected to. For example, with the FTP-command **DIR** a user can always list the file directory.

For the general public the most important aspect of FTP is that it allows for anonymous access ("anonymous FTP"). On many Internet sites system administrators allow an anonymous user (user name: **anonymous**) to enter FTP without any specific password – it has become common practice that users send their e-mail address as password – and to access, read, and download or upload a specific set of files. With anonymous FTP, people can make information, programs, pictures etc. publicly available without hassle. On the other hand, each Internet user has available a library of many

thousand Megabytes of freeware/shareware programs, data, and whatever other information their colleagues have decided to make available.

As with e-mail and Telnet, the most difficult part of anonymous FTP is to identify all the available information and sources. "Archie", a service originating from McGill University in Canada and now available from numerous other Internet sites, helps ease this problem. "Archie tracks the content of over 800 anonymous FTP archive sites containing over a million files stored across the Internet. Collectively, these files represent well over 50 gigabytes of information with new entries being added daily" (Kehoe, 1992, p. 25). This database can be searched in various ways and outputs the names of anonymous FTP sites carrying the requested file. Archie can be queried interactively (Telnet) or via e-mail.

3.3 Advanced Network Services

In this section we want to discuss a few of the more advanced network services that are built on top of the basic network services described in the previous section. We concentrate on those services that are of particular potential importance for research and scholarly communication.

3.3.1 E-mail discussion groups

As mentioned above, e-mail communication extends well beyond the reach of the Internet, i.e. those computers that communicate over TCP/IP. We have also mentioned that incoming e-mail can be used to trigger specific actions on a computer. These features are used in various ways for implementing e-mail based discussion groups. We will discuss briefly the most common implementation for administering such discussion groups, a system called LISTSERV.

LISTSERV is a computer program for the management of e-mail discussion groups, mail archival, and file storing and distributing ("list server"). It is actually a BITNET rather than an Internet feature. Because of the many gateways between the two networks, however, LISTSERV services are readily available on the Internet. The program is installed on a number of computers throughout the world and each one of them handles various e-mail discussion groups.

An e-mail discussion group (or mailing list) is a group of people who exchange information, and discuss a specific topic by the use of electronic mail. LISTSERV provides functions for administering such a group. It manages subscriptions, distributes incoming e-mail to subscribers, archives the mail and makes it available for later retrieval. When a new discussion

list is created, the LISTSERV-administrator generates an account with the name of the discussion group. E-mail that is sent to this "user", is being distributed to all the subscribers of the discussion group. Every network participant with e-mail access can subscribe to the discussion group. This is done by sending a specific e-mail message to LISTSERV. In order to contribute, a user does not have to be a subscriber to the group.

The LISTSERVs at various network nodes do not operate in isolation. Each LISTSERV keeps track of all the other LISTSERVs on the network and is able to exchange information with them. This allows large e-mail discussion groups to be operated by various LISTSERVs. Each LISTSERV serves a specific geographical area and distributes incoming mail to subscribers within this area and the other LISTSERVs carrying this group, which in turn distribute it to their local subscribers. This way the load on the network can be reduced considerably. The interaction between LISTSERVs has other advantages as well. It allows a user to get information about all the lists residing on any LISTSERV in the world[6], or to subscribe to a list even when he/she does not know where it resides. When a subscription is sent to the wrong LISTSERV, it is automatically forwarded to the correct one.

3.3.2 Usenet News

Usenet serves a similar purpose like e-mail discussion groups. The major difference is that a user does not need to subscribe to a specific news-group. He/she can read the discussions on all the news-groups carried by his/her news server. Contributions to Usenet ("articles") are distributed among news servers quite similarly to the operation of interacting LISTSERVs. News is not delivered to a user's e-mail mailbox, however. Instead they are kept on a news server for a specific time period and each user has to look up the news he/she is interested in.

Usenet discussions are organized in "news-groups", each of which belongs to one out of a number of major categories, ranging from 'sci' for scientific discussions, and 'comp' for computing, all the way to 'rec' for recreational activities and hobbies. Newsgroups in these categories are created after a tedious process of discussion and a voting period to determine popular support. Whether a news-group succeeds depends on how many sites carry it and how many contributions it is able to generate. Since there is no central agency that determines which news-groups to create, the fate of a news-group depends largely upon its general acceptance.

[6]We will take advantage of this feature on section 4.1 of our paper.

Recently, e-mail discussion groups and usenet news-groups have become more and more integrated. Gateways between the two systems allow contributions to one system to be passed on to the other automatically.

3.3.3 Gopher

Programmers at the University of Minnesota have developed Gopher, a set of programs that allows a user to utilize various Internet services and resources in an intuitive and efficient way. Gopher integrates many of the Internet services that we have discussed so far. It also allows related services that are scattered over different Internet sites to be logically combined in such a way that they appear to be integrated to the user.

Gopher is based on a client-server concept, with server programs running on various host computers. It uses the concept of file directories with which most computer users are familiar. Once a user starts his/her Gopher client program, the program connects to one of the Gopher servers and receives a list of menu items (directory entries), and terminates the connection. The menu items may refer to a specific file, another directory, a database inquiry module, etc. These elements, however, may reside on any other computer on the Internet. When the user selects one of the menu items, the Gopher client connects to the respective computer, receives the requested information, and terminates the connection again. The user usually does not know where the requested information actually comes from. One Gopher directory may list information residing at computers in different parts of the world. For the user they appear as if they were files in one subdirectory on the hard disk.

Recently, gateways to other Internet services like anonymous FTP and Usenet News, have been integrated into Gopher. Also Telnet sessions can be initiated out of Gopher, with the Internet address passed along from Gopher to Telnet. In this way Gopher is moving toward becoming a standard user interface for Internet services that hides all the technical aspects as well as the physical structure of the Internet from the user.

3.4 Traditional and Electronic Scholarly Communication: A Comparison

Although the potentials of Wide Area Networks in general and the Internet in particular are by no means fully explored and utilized yet, the basic characteristics of communication over these media are quite clearly visible. When discussing the characteristics of electronic communication one has to keep in mind that the various forms are becoming increasingly inter-

woven. With the appropriate gateways, senders and receivers of electronic information can choose the transmission channel most suited to their needs.

As far as the number of senders and receivers are concerned, electronic communication covers the whole range from one-to-one (e-mail) to many-to-many (discussion groups, Usenet news). Under normal circumstances transmission of information is fast and reliable. Neither sender nor receiver are bound to a certain place. All they need is access to the network. With forwarding of e-mail, remote terminal access over thousands of kilometers, Usenet news, anonymous FTP archives etc., information can be accessed from anywhere on the network.

Since electronically transmitted information can be stored very easily, the receiver's presence is not indispensable for the transmission of information. The information is usually waiting at some storage location for the receiver to read it. Because of the speed of transmission, feedback to messages can be almost immediate. Delays occur for reasons outside of the network (receiver not reading the message, no time to respond, etc.) which may hamper traditional communication channels as well.

Wide Area Networks transmit information in a very efficient way. This reduces transmission times and the load on the various links. Data compression techniques add to this effect. Another advantage is that information is received in machine readable form and can therefore be processed further by the receiver.

Since the network links are almost entirely based on leased telephone lines, the marginal cost of transmitting one unit of information are extremely low. In an academic environment the use of Internet services is usually free of charge, both for the sender as well as the receiver. This does not mean that there are no costs involved. However, it seems that because of the difficulty of assigning cost to various uses and users, and because of the perceived benefit of network access, most Universities, Government agencies, etc. who are involved have decided to provide access free of charge. This is to some extent similar to the way how University libraries provide their services.

When we compare electronic communication over Wide Area Networks against the traditional forms of scholarly communication, we see that electronic communication has major advantages in terms of speed of transmission and cost. As a consequence of higher speed, electronic communication allows for much more immediate feedback than comparable traditional. In traditional communication the number of people involved (as senders and/or receivers) constitutes a discriminating factor between various forms and channels. In contrast, because of the flexibility and programmability of the electronic environment, electronic communication can be expanded

quite easily in terms of the number of people involved. With the same effort an e-mail user can send a message to one recipient, or all the subscribers of a discussion list. It is important to realize that high speed, low cost, and flexibility translate into economic advantages of electronic communication over traditional forms.

4 The Current Usage of Electronic Communication in Science

The potential advantages of electronic communication have been recognized by researchers and scholars in a number of disciplines. In recent years, many attempts have been made to develop instruments that improve upon, complement and even substitute traditional forms of scholarly communication.

In this section we will briefly review the current status of scholarly discussion over the Internet and connected networks. After having described various network services in the previous section, we will now try to answer the question of how these services are used in scholarly communication today. We will concentrate on LISTSERV based e-mail discussion groups (see 3.3.1), and electronic journals, a traditional form transferred and adapted to networks. Finally, we will touch upon the discussion about the potential impact of these "revolutionary" (Harnad 1991) developments on scholarly publishing and the role of libraries.

4.1 LISTSERV discussion groups: a brief analysis

In section 3.3.1, we have described the program LISTSERV as a sophisticated system for managing e-mail discussion groups. We have used the program's powerful feature to inquire LISTSERVs at other network sites and to generate a directory of all the lists residing on any LISTSERV in the world. This led to a 52 page document with name and brief description of more than 3000 different e-mail discussion lists.

Discussion topics on these lists vary widely. In order to see some structure, we decided to classify the lists into four different categories, which – of course – cannot be viewed as clearly separated and well defined domains.

Not very surprisingly, the largest number of lists belong to the field of Computer Sciences (about 70%), covering areas like hardware, software, programming, application, administration, networks, etc.. Other large users are Natural Sciences, such as physics, chemistry, and biology (10%), and medicine-related subjects (5%). The remaining part consists of

a wide variety of scientific disciplines, and general discussion topics such as politics, education, history, linguistics, literature, and religion.

We found only 6 discussion groups being somehow affiliated to Regional Science (defined in a very broad sense). They represent about 0.2% of all LISTSERV discussion lists. They are

- ACDGIS-L (@AWIIMC12.BITNET) with the list title "Geographische Informationssysteme",
- CERRO-L (@AEARN.BITNET), the "Central European Regional Research Organization" (see section 5),
- GIS-L (@UBVM.BITNET), a "Geographic Information Systems Discussion",
- URBAN-L (@TREARN.BITNET), an "Urban Planning Discussion List",
- URBANET (@MSU.BITNET), the "Urban Planning Student Network", and
- URBAREG (@UQUEBEC.BITNET), "Etudes urbaines et régionales".

It becomes obvious that the Social Sciences are severely underrepresented among networked discussion lists. Even within this weak group, Regional Science takes on a weak position.

4.2 Electronic Journals (e-journals)

In the mid 1980s several "innovative researchers and scholars" (Okerson 1991a, p. 11) realized, that lancing an electronic journal would be a revolutionary answer to the dilemma of scientific publishing as we have described it briefly in section 2.2 (Hugo, Newell, 1991). The high costs of a journal could be met by publishing it over the network. The copyright could remain with the authors, and scholars could "subscribe" at a very low fee or even absolutely free of charge. Harnad (1991, p. 48) describes writing for an e-journal as "skywriting" because "just as if each contribution were being written in the sky" it can immediately be seen and reviewed by several scholars at the same time. First experiences with e-journals are discussed by Hugo, Newell, 1991, Jennings 1991, and Savage 1991.

The Association of Research Libraries (ARL) has compiled a Directory of Electronic Journals and Newsletters[7]. It lists 36 e-journals, 11 of which are peer reviewed. Two e-journals are indicated to charge a subscription

[7]Electronic newsletters are similar to e-journals and will not be discussed here.

fee. Subjects range from contemporary art, communication theory, technical studies, to psychology, religious studies, and textual studies. Only one e-journal in this directory resides in the vicinity of Regional Science: "SOLSTICE: An Electronic Journal of Geography and Mathematics". Its purpose is to promote interaction between geography and mathematics. Articles in which elements of one discipline are used to shed light on the other are particularly sought, but original contributions that are purely geographical or purely mathematical are also welcome. All original articles can be submitted via Internet and are being refereed (Strangelove 1992).

4.3 Scholarly publishing and libraries in the era of cyberspace

The developments in electronic communication and their application in some scientific disciplines, which have been classified as a "fourth revolution in the means of production of knowledge" (Harnad 1991, p. 39), stimulated a lively discussion in the Library Sciences. It has raised some fundamental questions that are of relevance for all scientific disciplines. Here, we can mention only the most important aspects. For a fuller discussion see, e.g., Amiran, 1991; Doughtery, 1992; Gilbert, Lymann, 1989; Harnad, 1991; Harrison, et al., 1991; Hilts, 1992; Levin, 1992; Okerson, 1991a,b).

There seems to be a consensus that WAN-based scholarly communication will be of lasting and increasing importance in the future. It may have tremendous implications for libraries, scientific publishing and thus all scientific disciplines.

For the electronic journal two visions exist (Okerson, 1991a, pp. 9-10). The conservative one views the e-journal as an article-based parallel to the printed journal which is issue-based (article-based means, that an article is delivered as soon as it has been reviewed and polished), increasing efficiency of distribution and enabling scholars to organize a "virtual library". The progressive view proposes that "online journals might be used to disseminate brief summaries of research and information about research in progress, to engage in more limited exchanges of information, or, more ambitiously, to support and institutionalize informal scholarly communication activities that typically take place in interpersonal contexts" (Harrison, et al., 1991, p. 28). "Such a revolutionary e-journal concept offers the potential to re-think the informal and formal systems of scholarly communication. [...] the whole process of scholarly communication (is) undergoing dramatic change, becoming instant, global, interactive." (Okerson 1991a, pp. 9-10).

Some authors (e.g., Amiran, 1991; Doughtery, 1992; Harnad, 1991; Harrison, et al., 1991; Levin, 1992; Okerson, 1991a,b; Bennett, Matheson, 1992)

see electronic communication and publishing as a way out of the crisis of scientific publishing that we have mentioned in section 2.2.4, and for University libraries to overcome their fundamental dilemma[8]. Universities may regain "control of university-produced research, [...] (by) holding in trust the copyrights on research published by scholars, (and) making topquality studies available through university networks at affordable prices". (Doughtery 1992, p. B1). This is likely to have implications for the legal concept of copyright which may be forced to dynamic adaptation, perhaps being substituted by licenses which shall control the sharing of electronic publications among institutions (Okerson 1991a, p. 13). Existing publishers will have to stress "flexible parallel publication activity" (Okerson 1991a, p. 13). Publishing both in printed and electronic form might be their only chance to keep an important role in the realm of scholarly publishing.

Also the role of libraries will change in reaction to advancing electronic communication and publishing. They will have to provide integrated services, offering not only the storage of monographs and journals, but also playing a more active role in gathering, searching, merging and linking documents, in providing fast and reliable access to scholarly data. Although many university libraries are moving in this direction, few are offering these services over Wide Area Networks. An exception worth mentioning is UNCOVER, a service provided by the "Colorado Alliance of Research Libraries" (CARL). UNCOVER stores bibliographic information about journal articles which can be searched by registered[9] users via telnet. Once an article is found, UNCOVER can be asked to fax a copy of this article for an additional fee.

5 CERRO, a Regional Science oriented Internet application

In a few discussions in the summer and early fall of 1991, Gunther Maier, University of Economics and Business Administration, Vienna, Austria, Martin Ma ek, Slovak Academy of Sciences, Bratislava, SFR, and Edward M. Bergman, The University of North Carolina, Chapel Hill, NC, USA, developed the idea of using Internet services for promoting discussion about the regional aspects of the restructuring following the removal of the Iron

[8] "It is ironic that by subscribing to journals, libraries in effect buy back the scholarship that university faculty members have created and given away. Because publishers hold the copyrights of the material that libraries need, libraries have little choice except to pay rapidly rising subscription prices or not subscribe at all." (Bennett, Matheson 1992: B2).

[9] CARL charges a moderate annual fee for this service.

Curtain, and to distribute information about this area. The name CERRO ("Central European Regional Research Organization") was chosen for this initiative. In September and October 1991 the (minimal) organizational steps were taken in order to provide two services:

1. an e-mail discussion list (see section 3.3.1) named CERRO-L, and
2. an electronic archive accessible via anonymous FTP (see section 3.2.3) supposed to store and provide names, addresses, and areas of specialization of researchers, draft versions of papers, project descriptions, conference programs, etc.

CERRO constitutes one of the first applications of Internet services in Regional Science (see section 4.1). Therefore, the experiences with the operation of CERRO and its development over its first few months of existence are of particular interest.

CERRO was first announced publicly in November 1991 at the North American Conference of the Regional Science Association in New Orleans, USA. A folder describing CERRO services was distributed at the conference.

The reaction from the Regional Science community was very limited. Although access to and use of WANs and the Internet in particular is much more common in US universities, distribution of the folders at this conference generated only one subscriber (from Scandinavia). In the following months, CERRO activities concentrated on finding information for storing in the archive. The discussion list lay virtually dormant.

In March and April 1992, the CERRO organizers used a different approach. They collected e-mail addresses of other regional scientists and e-mailed information about CERRO to them. Obviously, the fact that these colleagues were already using network services (most of them just e-mail) helped to stimulate their interest in CERRO. The number of subscribers grew quite rapidly to about 40.

After some technical problems with the type of software used so far, in late April CERRO-L, the CERRO discussion list, was transferred to LISTSERV (see section 3.3.1). This transition in itself made CERRO-L more visible to the Internet/BITNET community. Moreover, the LISTSERV-based list NEW-LISTS distributes information about new discussion lists and is read by system operators at many Internet sites. Information about CERRO was sent to this list as well as to MIDEUR-L and E-EUROPE, two lists that deal with the same geographical area as CERRO-L, although from a political and business point of view rather than a scholarly one. These steps proved to be very successful. Apparently, news about CERRO-L spread widely. By the end of May 1992 the number of subscribers has

grown to 100 and is currently (July 24, 1992) at 120. A breakdown by country shows the strong dominance of US subscribers which can be attributed to earlier introduction and wider acceptance of the Internet there.

Country	#	Country	#
Australia	1	Italy	1
Austria	9	Netherlands	6
Brazil	2	Norway	2
Canada	6	(Ex-)Soviet Union	4
SFR	8	Sweden	1
Finland	2	United Kingdom	3
Germany	4	USA	64
Hungary	3	(Ex-)Yugoslavia	1
Israel	1	unclear	2

Since a number of earlier subscribers have signed off – in part "over the summer" to avoid their mailbox from overflowing – the total number of people who have been in contact with CERRO-L is considerably larger.

44 users have actively participated in the discussions, a few quite intensively. At average, 2 messages per day have been distributed by the CERRO-L discussion group. The following diagram categorizes users by the number of messages they have sent:

# of messages	1-5	5-10	10-15	15-20
# of users	38	3	1	2

In order to learn more about our subscribers, in early June we have sent out a questionnaire (a copy can be found in the appendix). A reminder was mailed mid July. 38 subscribers have responded (response rate: 32%). 60.6% of them are from the USA and Canada, 10.6% from post-socialist countries, and 28.9% from the rest of Europe. 32 respondents (84.2%) are affiliated with a university, 71% of them in a faculty or staff position.

It is interesting to see how the information about CERRO-L has spread through the network: 28.9% of the respondents say that they have learned about CERRO from its organizers, 15.8% from list NEW-LISTS, 10.5% from a colleague or friend. 44.7%, however, indicate that they have learned about it from some other source, most often from some other list, where many different list names are mentioned.

This indicates, that CERRO-L has reached primarily those people, who have had network exposure before. This is underlined by the answers given to questions 2 and 3: 71.1% of the respondents indicate that CERRO-L was not the first electronic discussion list they have ever signed up to,

only 21.1% say that they are signed up to no other list but CERRO-L. 30 respondents (78.9%) monitor other lists as well, 8 of them in the average. Another indicator for the considerable network experience of respondents is that in average they have been in contact with this mode of communication for 16 months. The number of "newcomers", however, is quite large as well. 23.7% have 1 month or less of network experience.

Overwhelmingly, respondents view electronic discussion lists a serious and important medium: 78.9% indicate that they use them because of professional interest, only 10.5% out of curiosity. When asked the same question about CERRO-L, only 22.2% indicate that they are subscribed for "solely professional" reasons. For 41.7% the motivation is "mainly professional", for 27.8% "mainly private". 8.3% of the respondents even see no relationship to their profession; they say to be subscribed for "solely private" reasons. These results again seem to indicate that CERRO-L has not yet attracted Regional Scientists, but mainly "network literate" people with an interest in Central Europe and/or regional questions. Three quarters of respondents mention interest in either Central Europe (50%) or regional questions (26.3%) as the main reason for their signing up to CERRO-L.

For the future, 94.6 of the respondents expect a list like CERRO-L to have "great" (43.2%) or "some" (51.4%) significance for the scientific communication and cooperation. Only 2 respondents (5.4%) think that it will be just of "little" significance. The category "no significance" remained empty.

Also CERRO's electronic archive has grown over the months, mainly because of (draft) papers that were provided by users. Because CERRO has operated without any budget, the organizers could not systematically build up a stock of information yet. Hopefully, we will be able to overcome this deficit in the near future.

The experience with CERRO shows that this medium has great potentials for scholarly communication in Regional Science as well. It will be necessary, however, to integrate the Regional Science community more strongly, in order to realize the full benefits of electronic communication.

6 Future prospects for electronic communication in Regional Science

The e-mail discussion group and electronic archive organized by CERRO are just two of many possible ways of using WANs and electronic communication in a scientific discipline like Regional Science. In this section we

want to suggest a few additional network services. We will only discuss those possibilities which can be implemented with existing software.

One obvious possibility is the publication of an electronic journal. There is enough experience in other disciplines (see e.g. Jennings, 1991; Okerson, 1991a; Hugo, Newell, 1991; Savage, 1991; Harrison et al., 1991) which can be utilized. In order to avoid a low level of reputation for this journal and electronic publishing in general, publication in this journal should be subject to a reviewing process.

The management and editing of such an electronic journal as well as electronic communication within the discipline would be facilitated by a directory of e-mail addresses. For the Regional Science Association, such a directory could be built step by step in a decentralized way by the different sections. The Southern Regional Science Association has decided to take steps in this direction and we have proposed to the German Speaking Section to do the same. With programs like Gopher (see section 3.3.3) such locally maintained directories can be integrated into one information service that is available to the general public.

In a similar way, the conference organizers could provide conference programs for electronic inquiry. Again, locally maintained information could be integrated very easily. Such a service is also a logical next step from library catalogs (see section 3.2.2), and directories of journal articles (see section 4.3). Since such a service would reflect current research interests and activities most closely, it could be of considerable value to journal editors, conference organizers, and publishers throughout the discipline.

A logical extension of the concept of e-mail discussion groups would be to run an electronic conference. Rather than bringing participants together at one location and having them carry along copies of their papers, in an electronic conference the various contributions would be submitted, distributed and discussed over the network. Such a conference would be much less resource intensive than a traditional one. Chances are that without the strict time constraints of a traditional conference discussions in an electronic conference are more fruitful and substantive. Among others, there are 2 possible organizational frameworks available[10]. One is to use a discussion list and communicate via e-mail. A more sophisticated form of conference could use software that has been developed for playing games over the network. This software allows for interaction in real time and has the potential to simulate many aspects of "real" conferences.

[10]Currently, there is a discussion about technical and design aspects of remote conferencing systems that attempt to integrate multimedia (see, e.g., Chang, Whaley, 1992)

7 Summary

In this paper we have discussed the potential implications of Wide Area networks on scholarly communication in general and on communication in Regional Science in particular. By comparing the two forms we have seen that the network based electronic media offer considerable advantages over traditional scholarly communication. Most important are advantages in terms of transmission speed, cost, and flexibility.

It becomes obvious in section 4 of the paper that Regional Science severly trails other disciplines (e.g., Computer Sciences, Physics, Biology) in the use of electronic communication and Wide Area Computer Networks. One of the few attempts to use WANs in Regional Science is presented and analyzed in section 5: CERRO offers an electronic archive and a discussion group concerning regional aspects of the restructuring process in Central Europe. This initiative turns out to be fairly successful, although it did not reach many participants from Regional Science yet.

The comparatively low level of usage of WANs and electronic communication in Regional Science does not imply that these media are less suited for our discipline. We are convinced that it is important for a discipline like Regional Science to get involved with these new developments. Not only could the use of WANs speed up communication among scholars in Regional Science considerably and allow for a better integration of the discipline. With the changes in scholarly communication, publishing, and information management that are likely to follow from the increasing availablility of WANs, early involvment is essential for Regional Science in order to keep and strengthen its position within the spectrum of scientific disciplines.

To overcome the low acceptance level, a few strategic initiatives are necessary. Publication of an e-journal, e-mail directories, additional discussion groups etc. (see section 6) would considerably raise the level of acceptance of electronic scholarly discussion in Regional Science.

Appendix 1: Internet Tips and Tricks

Access: To get access to the Internet, talk to your computer center. If your University does not have Internet access, keep in mind that e-mail is available at a much larger scale and that many services are accessible via e-mail.

Basic Information: An excellent introduction for novice users provides Brendan Kehoe, *Zen and the Art of the Internet*, 2nd edition 1992, Prentice Hall.

Network Software: The most important network software is available over the network free of charge. Good sources for software via anonymous FTP are `WUARCHIVE.WUSTL.EDU` (for MS-DOS) and `SUMEX-AIM.STANFORD.EDU` (for Macintosh). When downloading programs set the transfer mode to BINARY!

Archie: Is installed at various nodes (e.g. `ARCHIE.FUNET.FI` in Finland, `ARCHIE.MCGILL.CA` in canada). To find out more either Telnet to an Archie site near you and login as **archie**, or send the word **help** in an e-mail to `ARCHIE@NIC.FUNET.FI` or to `ARCHIE@CS.MCGILL.EDU`.

Library Catalogs: Hundreds of university libraries around the world allow their electronic card catalogs to be accessed via Internet. Information about domain names and login procedures are available for anonymous FTP from, e.g., `NIC.CERF.NET` (file `cerfnet/cerfnet-info/library-catalog`) or `VAXB.ACS.UNT.EDU` (`/library/libraries.txt`). An alternative way is via the Bulletin Board of The University of North Carolina (`BBS.OIT.UNC.EDU`). It offers menu driven access to many libraries around the world as well as other data-bases.

LISTSERV: The program resides on various sites (e.g., `AEARN.BITNET` in Austria, `UOTTAWA.BITNET` in Canada, `VM1.NODAK.EDU` or `NCSUVM.BITNET` in the US). For general information try to use a site near you. To get a general introduction to LISTSERV send **HELP** or **INFO GENINTRO** in an e-mail to `LISTSERV@listserv-site`. To receive a list of all discussion lists available send **LIST GLOBAL** to `LISTSERV@list- serv-site`. A list of all the files stored for a specific discussion list can be retrieved by sending **INDEX list-name** to `LISTSERV@respective- site`.

Usenet news: The usenet news service must be installed by your system administrator. Ask your computer center. The UNC Bulletin Board (`BBS.OIT.UNC.EDU`) offers access to usenet news.

Gopher: In order to use Gopher you need an Internet access and the correct client program. Client programs for various operating systems can be downloaded via anonymous FTP (mode: BINARY!) from `BOOMBOX.MICRO.UMN.EDU`.

Discussion Lists: To subscribe to a discussion list send an e-mail saying **SUBSCRIBE list-name your-name** to the LISTSERV handling the discussion list. To subscribe to CERRO-L (see section 5), for example, user "John Smith" sends an e-mail message saying **SUBSCRIBE CERRO-L John Smith** to `LISTSERV@AEARN.BITNET`. His e-mail address is added to the list of subscribers to CERRO-L. A copy of any future e-mail sent to CERRO-L@AEARN.BITNET is passed on to John Smith's e-mail account. If John Smith wants to contribute to the discussion on CERRO-L, he simply sends his contribution to `CERRO-L@AEARN.BITNET`, and everyone subscribed to the discussion list will receive a copy.

Electronic Journals: A list of electronic journals can be received via e-mail. Send **GET EJOURNL1 DIRECTRY** and **GET EJOURNL2 DIRECTRY** to `LISTSERV@UOTTAWA.BITNET`. This list also provides information about orientation, reviewing, subscription, etc. To get information about SOLSTICE and for subscription send e-mail to `SOLSTICE@UMICHUM.BITNET`.

CERRO: Offers an e-mail discussion group and an electronic archive dealing with regional aspects of Central European restructuring. To subscribe to the discussion list CERRO-L send **SUBSCRIBE CERRO-L your-name** to `LISTSERV@AEARN.BITNET`. The electronic archive is available via anonymous FTP to `FTP.WU-WIEN.AC.AT`, change to directory `/pub/cerro`.

Appendix 2: Questionnaire

QUESTIONNAIRE

June 1992

1. How did you learn about CERRO-L?
   - _ from its organizers
   - _ from list NEW-LISTS
   - _ from a colleague/friend
   - _ other, please specify: _____

2. Is CERRO-L the first electronic discussion list you ever signed
up to?
_ yes _ no

3. Are you currently signed up to any other electronic discussion list?
_ yes _ no
If yes, how many (approximately)? _____
Which ones do you find most intersting/important?
---

4. What is the main reason for your use of electronic discussion lists?
_ professional interest,
_ hobby,
_ curiosity,
_ private interest,
_ other, please specify: _____

5. What was the main reason that made you sign up to CERRO-L? (if more than one, please use 1,2,3,... to indicate importance)
Your interest in
_ computers, networks, electronic lists?
_ regional questions?
_ Central Europe?
_ other, please specify: _____

6. Are you subscribed to CERRO-L for
_ solely professional
_ mainly professional
_ mainly private
_ solely private reason?

7. Where are you located?
Please specify country: _____

8. Are you affiliated with a University?
_ yes _ no
If yes, are you

_ faculty, staff
_ student?

9. What do you think the significance of a list like CERRO-L will be for scientific communication and cooperation in the near future?
_ great
_ some
_ little
_ no significance.

10. How long ago did you first subscribe to any electronic discussion group?

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IIR-DISKUSSIONSPAPIERE

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The Interdisciplinary Institute for Urban and Regional Studies (IIR), University of Economics, Vienna, is publishing a series of discussion papers since 1977. Should you be interested in our work please indicate the paper you wish to order in the enclosed list of publications. Please transfer the amounts indicated to the following account:

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