THE NETWORK-BASED SCIENTIFIC COMMUNITY ECONOMIC CLIMATE AND SOCIAL
STRUCTURE

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ABSTRACT

The effort is made in this paper to identify those elements of the
scientific community requiring computer services; evaluate the economies
of using computing network facilities to satisfy those needs; and to pro-
vide some suggestions as to the substantive advantages of network use.

ECONOMIC CLIMATE

Several social and economic fac-
tors make networking an attractive
way to organize scientific re-
search. The declining academic job
market has resulted in a dispersion
of talent from the major research
universities into a wide variety of
university, government, and indus-
trial settings. Many small insti-
tutions are now staffed by young
Ph.D.s with first-class training in
research. However, many of the
smaller institutions lack research
facilities and a tradition of or-
ganizing for the conduct of re-
search. Since there are not suffi-
cient resources to provide every
institution with a complete set of
research facilities, some form of
sharing is necessary. In the past,
such sharing has been accomplished
by allowing outsiders to use major
research facilities on a visiting
basis. However, increasing energy
costs will make travel ever more
expensive.

At the same time that the cost
of energy has increased, the costs
of computation and communication
have been declining. Communication
and computation costs have been
dropping by one half every five
years, a trend which is expected to
continue indefinitely. Thus, to
the extent that communication and
computation can substitute for
travel and the duplication of fa-
cilities, it is possible to expand
access to research facilities to
small and service oriented institu-
tions.

Communication networks and data
bases are natural monopolies; they
function best when a single source
serves the largest possible clien-
tele. Groups of scientific workers
are probably best suited to an en-
vironment of pure competition in
which there are no barriers to the
setting up of new groups. The nec-
essary communication network is al-
ready in place and is expanding
rapidly. Several major university
and commercial data archives have
been established and are providing
satisfactory services to a growing
number of clients. Thus, the major
task in establishing network-based
communities of scientific research-
ers is to inform people, organize
them, finance them, and provide
them with the specific resources
they need.

Even though resources are grow-
ing increasingly scarce, there is
still an ever-increasing need for
new scientific knowledge and for
the dissemination of research and
evaluation findings into commercial
and government operations. Legal
and institutional requirements for
such things as program evaluations,
technology assessments, and envi-
ronmental impact statements will
result in an increasing demand for
social science research. To the
extent that networking is an effi-
cient way to conduct such research,
networking will receive financial
support.

USERS OF SCIENTIFIC NETWORKS

In this discussion, users of
scientific networks will be classi-
fied by their relation to the net-
work, rather than by job title or
institutional affiliation.

Scientists

An obvious clientele for a sci-
entific research network is people
whose primary interest is in the
discovery of new scientific knowl-
edge. Most scientists are employed
in universities, government agen-
cies and laboratories, and in in-
dustry. Networking also makes pos-
sible the support and integration
of amateur scientists, people with
professional training in science
but without institutional affilia-
tions as scientists.

Scientist-professional

An increasing number of doctoral level graduates are going directly into social service and clinical positions. While many people in such positions are not active producers of research, they are often avid consumers and critics of scientific research. Scientist-professionals have many interests which are not shared by pure and applied scientists, and would probably form their own network based groups. However, it would be easy to maintain communication between groups of scientists and scientist-professionals when dictated by common interests.

Practitioners

Practioners, as used here, are people whose interest is primarily in the use, rather than in the discovery or analysis of specific knowledge. A network of professionals would obviously wish to make use of scientific research results. Occasionally, groups of professionals might wish to obtain consulting help from scientists. Contacts between network-based groups of scientists and groups of professionals would probably tend to be mediated by institutional facilities such as librarians and transfer agents, more than by personal acquaintance.

Librarians and transfer agents

These are people whose primary interest is in providing services to network clients. Reference librarians would be able to act much as they do now, but would have better access to potential clients and better knowledge of current issues. The term "transfer agent" applies to someone who would be part organizational development specialist and part extension agent. The transfer agent would act as referral service, social director, and spreader of information. Transfer agents will become increasingly necessary as the demand for information and the complexity of information sources both increase.

It can be expected that librarians and transfer agents, having issues of their own, will form their own network-based groups.

SOCIAL STRUCTURES IN NETWORK-BASED GROUPS

The physical and computational resources required to support a scientific network are organized in a formal fashion, since they are subject to a host of financial and legal constraints. However, the social structure of network-based scientific groups is still not clear. We have had little experience with forming and operating such groups, and there is no requirement for any strict division into types. However, it is possible to guess at some types of groups which may evolve.

Task Groups

Task groups are network-based research projects. Several people would use the network to coordinate their joint work on a scientific problem. Although task groups would consist of people at different locations and perhaps different institutions, their research would probably be funded and operated as a joint project.

Consortia

Groups of workers might form consortia for the purpose of contracting for data. The members of the consortium would pay for the data collection and for the establishment of a common data base, but would pursue the independent analysis of their own data.

Invisible colleges

The most obvious form of organization, and the one which is presently most common, is the "invisible college." Groups of people with common interests use the network to exchange messages, manuscripts, screeds, broadsides, and gossip. People pay their own expenses and pursue their own interests, using whatever public facilities they need. The invisible college forms a ground for recruiting members into more formally organized groups such as task groups and consortia.

Network journals

By combining the document processing, information retrieval, and communications facilities of a computer network with a system of edi-

tors and referees, it is possible to produce a network-based journal. Several schemes have been proposed for the establishment and operation of such a journal. One of the most attractive schemes would allow the journal to "publish" all submissions, but with the addition of a referee's score. A network journal would allow formal and impersonal contact between network clients on the basis of evaluated research findings, rather than personal acquaintance.

Brain trust

The ability to send messages to large groups of people makes possible the use of an invisible college as a source of otherwise unobtainable information. Someone with a question may begin by asking colleagues or the reference librarian. If all else fails, it is possible to broadcast a message asking for help with the problem. Not only may someone out there have an answer, but other people with the same problem may now share the answer. One of the chief tasks of transfer agents may be to bid out and pass on questions and answers.

USERS OF A SCIENTIFIC NETWORK

Membership in network-based research communities, while far better than isolation and inactivity, will provide neither for all needs of scientists nor for the needs of all scientists. The most obvious shortcoming of scientific networks is that there is no way that they can provide direct access to laboratories and instrumentation. Scientists can be classified into five categories with respect to their dependence on instrumentation.

Theoreticians

Some scientists, either mathematicians or theoreticians, require access only to libraries and colleagues. Participation in a network-based community provides them with a peer group and an audience. A network-based clientele of theoreticians would be relatively easy to support. In fact, social support is perhaps the only unique service a network would provide to the unaffiliated theoretician.

Archival analysts

A second clientele for a research network is social scientists who analyze machine-readable archival data. Such clients would find access to a network highly rewarding for both research and communication activities. Since the network provides data archive and computational facilities which are equivalent to those at a major university, archival analysts will find the network's facilities equal or superior to those of their own institutions. Archival analysts should find affiliation with a network both professionally and socially rewarding.

Local producers of data

A third category of scientists consists of those who can meet their own instrumentation needs locally. Instrumentation as used here includes all those facilities and activities required to produce data either in machine-readable form or in form suitable for key entry. Scientists in this category are able to raise their own rats, use their own instruments, or administer and code their own questionnaires. Such scientists can use the network solely as a communication medium, to analyze their own data, or to collaborate and share locally produced data with others.

Data contractors

A fourth category of potential network clients consists of scientists who can contract for data. Work of this type requires the exact specification of data collection procedures, but does not necessarily require that the investigator actually operate the equipment. Many physical scientists essentially contract for data, buying time on such facilities as telescopes and nuclar reactors. Survey researchers often buy interview time and questions on national surveys.

Most of today's data contracting facilities are national resources, so huge and costly as to be beyond the means of most universities. Examples of such facilities are the Mt. Palomar telescope, the Stanford linear accelerator, and the National Election Survey. It might be feasible to establish data contracting facilities equivalent to those at a major university. Such facilities would provide contract

data on a scale and at a price affordable by the individual or by small groups of researchers. Contract laboratories staffed by research assistants, technicians, and a supervisor would perform experiments according to protocols provided by remote researchers. While it is not clear which, if any, sorts of research could be pursued in such a fashion, the feasibility of such contract facilities must be investigated.

A second way in which scientists might successfully contract for data is through the formation of consortia. A network-affiliated scientist could propose that a group of researchers jointly support the costs of contracting for data, which they could then analyze jointly or as individuals.

Hands-on experimentalists

A fifth type of scientist requires personal access to equipment found only in the research laboratories of a major university. It is difficult to see how such scientists could use network facilities for anything other than scientific and social communication.

FINANCING

Terminal costs

None of these things will happen unless there is money available to pay for them. People's major concern is with the acquisition of terminals and with paying for network access. The price of terminals has declined precipitously over the last five years. A terminal which cost about $3000 five years ago can now be bought for less than $1000. It is unlikely that the decline in the prices of terminals will continue to be as steep; however, the price of excellent printing terminals is fast approaching that of ordinary office electric typewriters, and will probably soon be below the cost of present typewriters. Thus, the office typewriter of the near future will be nothing more than a computer terminal lacking communications equipment. Turning the office typewriter into a terminal will require nothing more than the installation of a one- or two-hundred-dollar communications circuit board.

Internal funding

Access to networks will be difficult for those who operate entirely within institutional budgets, without control of their own funds. Most universities greet the very mention of purchasing external computing services with fear and loathing. Deans and department heads do not see why "real" money should be used to buy computing when "free" computing is available locally. There are no easy answers to such questions, and the individual scientist or faculty member is in a poor position to change institutional constraints.

External funding

One strategy suitable to external funding is to have the sponsor write a special condition to the grant requiring the principal investigator to have discretion over where computing money may be spent. Another alternative is to have the funding agency execute a separate contract with the network facility, setting up an account for the researcher. The researcher's university thus never exports any computing funds because it never imported any computing funds.

Computer conferencing

The on line conference not only allows for consulting over a network and for scientific communication of a new and powerful kind, but also provides a point of access to networking. By definition, a local computing facility cannot provide access to a conference taking place on a remote computer. Thus, the would-be conference user cannot be told that the remote site has no unique facility. Also it should be difficult for a university administration to state that it has a policy of denying faculty members access to professional meetings.

There are no easy answers or easy predictions as to when networks will grow large enough and powerful enough to attract a major fraction of scientists as users. However, the example of Telenet, growing from five to 85 cities in two years, gives some cause for optimism.