123594

R&D NETWORKS AND ISSUES

Draft Ideas Paper Prepared for

The International Development Research Centre

October 1994

Edward J. Weber

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INTRODUCTION

Networks are essentially about facilitating communication, idea sharing and human interaction. They can be identified in many cultures and time periods throughout human history. Only in recent times, however, have networks multiplied with the availability of technologies that facilitate their functions and with the exploding mass of information and knowledge which can be drawn on and integrated into the specification of problems and their resolution.

As a conceptual model, the "network" idea is basically simple and intuitive which is probably why it is used so ubiquitously to characterize all types of interconnected or linked phenomena. Telecommunications, and what is currently being referred to as the "information highway", is the most commonly encountered application of the concept in the public information stream today. But it has also been used to describe transportation, institutional, interpersonal, scientific, and many other types of linkages involving interaction and exchange. In its simplest form, a network involves nodes joined by links or edges in any number of configurations. Nodes can be individuals, institutions, associations, organizations of any kind, scientists or research groups, projects - just about any actor, group, or source of information and activity imaginable. The degree of connectivity of a network is defined by how many nodes are linked to all other nodes and how easily information, people, ideas, goods and services can flow between them.

In development work and community level R&D, networking can be characterized variously as: an instrument for technical or other cooperation; a tool for resource mobilization and information dissemination; a structure of activities; a channel for sharing experience and knowledge; a forum for the expression of democratic principles; or, as an impulse for social movements to promote self-organization and self-help instead of dependancy on outside resources. A network is usually put together to serve specific purposes: it collects; it catches; it carries; and, it spans over a distance (GATE, 4/92).

Networks have been judged to be an effective means of organizing and applying R&D activities to efficiently achieve results. The most commonly assumed or mentioned benefits include efficiency of resource use, synergistic effects, strengthening of national institutions, program flexibility and technology transfer. While a literature on evaluation and assessment of networks is developing, there appear to be many gaps and much of what has been done on the topic in IDRC and elsewhere related to donor activity and development related research in developing countries has been focussed on agriculture research networks. This has the effect of defining network experiences in terms of specific kinds of institutions and the kind of work they do. It also implies a focus on western science and how knowledge is generated, tested, applied and disseminated in that knowledge system. It carries with it a heavy cultural bias which should at least be explored as to its implications in developing country contexts.

The very success of some networks, especially in the strengthening of national institutions and research systems, leads to questions about limitations or drawbacks to networks as they have been introduced, sometimes in a heavy-handed way, by donor institutions and the participation or role of weaker institutions. How problems are defined, what research is to be undertaken and the role of science and technology and how it is presented in more traditional societies raises a series of concerns related to the steamroller effect of the advance of modern western based ideas of development and progress inherent in many research network objectives and approaches.

This paper attempts to overview and synthesize a range of network experiences and theoretical thought without delving into any one area in particular detail. Rather than focus on particular structures or recipes for network success, the discussion will look at networks as social relationships which, in order to be successful or productive, must follow certain norms of synergistic interaction. The effectiveness of networks depends on mutual agreement on objectives and what is to be achieved. Networks of individuals tend to evolve agreement relatively informally while institutions, groups, and organizations require more formal and structured communication structures. The more formal the relationships and distant the participants, the more clearly the network purpose needs to be defined. Addressing the "why" of any network both at the outset and from time to time is essential before the "how" of operational issues comes into play. While the eventual purpose of the paper is to focus on the use of networks to make R&D support of donors for developing country institutions more effective, some attention will be given to communication networks as they are evolving globally driven by rapidly developing technologies. They can be used in positive as well as negative ways in the battle to achieve a more democratic, equitable, eco-sensitive and sustainable world. It constitutes a review of current thinking about networks and networking as a means of promoting social and policy innovation, disseminating and exchanging information and technology, and facilitating capacity-building in the third world.

NETWORK CHARACTERISTICS AND PURPOSE

Networks have evolved for almost every conceivable purpose and in a plethora of formats each with a set of characteristics reflecting its origins, focus and context. A range of these will be briefly described as examples of past experience.

Structured Research Networks

Much of the analysis of donor-funded networks has focussed on agricultural research networks because of the large proportion of support and effort which has gone into this mode of research funding. By nature, these networks are institution based and take on many characteristics of institutionalization as they evolve. Some of the various characterizations which have been made of these networks are given below as drawn from documents written by Plucknett et al., Smutylo and Koala, OECD, and Faris. These are mainly based on activities carried out.

Information Exchange Networks - concentrate on the sharing of information. These are often passive operations in which information is sent out from a coordinator to individuals from a centralized information management centre. Interaction with others in the network is limited.

Material Exchange Networks - primarily concerned with germplasm exchange and testing of plant materials at various sites. These networks serve as evaluators and a facilitation mechanism for other research programs such as plant breeding.

Scientific Consultation Networks - allow researchers in autonomous usually pre-existing projects and national programs to share information and ideas in order to reduce isolation and realize new insights. Workshops or conferences may be organized on a regular basis to facilitate discussion.

Collaborative Research Networks - involve jointly planned and executed research activities. Research methodology is generally uniform and participants are actively involved in establishing priorities and dividing responsibilities. This kind of network has the greatest potential for upgrading the skills of participants and arriving at widely applicable solutions to overcoming agricultural production constraints.

Horizontal Networks - link researchers or institutions in different countries working on a common problem or in the same field or discipline.

Vertical Networks - link institutions working on different aspects of the same problem or on interrelated problems.

Training Networks - provide training and supervisory services to participants working independently in their own research areas.

Other networks - may be organized around a particular commodity, a research discipline or the development and application of a particular methodology. In fact. a network can be formed around any topic, or set of topics, which have meaning and purpose for any group of people who wish to communicate with each other on the subject agreed to. Anything from macro to micro scale and anywhere in between is feasible among a well-defined group of people or a broadly open configuration. The key is overall agreement of participants on the general boundaries of content and the core purpose.

Purposes of Structured Research Networking

Networks usually fulfil various purposes simultaneously and each of the participants will have their own special set and ranking of their importance. For effective network operation, it is

important that member interests coincide in key substantive areas. Given that discrepancies usually exist between institutions in terms of capability and priorities, each may have a somewhat different set of purposes and needs for participation. Martinez has summarized these purposes in a fairly comprehensive way.

> To increase scientific and technological capability in specific areas, from basic research to transfer of technology.
>
> To integrate scientific and technological capabilities through horizontal articulation and linkage of different countries allowing division of labour and resource allocation. Networks are one of the means for small countries to gain access to knowledge which can only be obtained by investments well beyond their individual possibilities. International centres in networks give access to a range of basic, strategic and applied research which can be adapted locally.
>
> To improve the effectiveness of research by providing access and contributing to a critical mass of research and accumulated knowledge in a problem area. Networks facilitate dealing with problems from a multidisciplinary perspective and take wider environmental variations and applications into account.
>
> To increase research productivity through better use of available resources, improved management and concentration of efforts.
>
> To facilitate access to research inputs such as information, physical facilities, genetic material, guidelines and research methodologies for improved program organization and implementation.
>
> To promote the dissemination of knowledge and the transfer of technologies by facilitating linkages between researchers and practitioners working in basic, strategic, applied and adaptive research.
>
> Institutional legitimacy can be lent to national institutions through network links to similar organizations in other countries , international centres and foreign or multilateral donors. This can transfer into greater stability in domestic funding and staffing as well as influence in policies and decision making.
>
> Glover et al mention networks as institutional surrogates in poor and very small countries which cannot afford a full-blown system of research institutions and agencies. A network can provide extra elements which domestic institutions often do not provide such as access to literature, peer review of research plans and work, publications outlets, international contacts, legitimacy and moral support.

Additional resources for national systems can often be obtained through membership in research networks. These are usually for specific purposes but if they coincide with local objectives leverage in terms of results can be substantial.

Exploiting opportunities can be facilitated through regular communication between participants. Unrecognized opportunities are often identified through better conceptualization of research problems facilitated by a broader set of contacts.

Synergistic effects are expected to result from all research networks at the level of individual participants as well as at the institutional level. This comes not only from increased communication and sharing of ideas but also from the demonstration effect of observing different ways of carrying out and managing research, modes and practices.

Catalytic impact can also be achieved through networking by display of scientific and technological potential constrained by institutional or environmental restrictions in other countries or regions. This recognition of opportunities may arouse the interest of sponsors, policy-makers and end users with respect to research results.

Global Networks and Networking, a voice for the Grassroots

In almost direct apposition to the highly organized and institutionally determined networks typified above in the types of networks which have been found to be useful for agricultural research, and indeed for any type of formal institution dominated activity, one can discover a whole range of much less organized arrangements. This is especially true of NGO and voluntary organizations in the non-profit sector, pressure groups and community development oriented groups. These networks tend to be much less formalized and structured allowing for a great deal of individual expression outside the constraints of what may be politically correct or accepted practice at a particular point in time by different governments, organizations and cultures. They help form what has been referred to as the civil society, a term used frequently in literature discussing the present state and future potential of electronic communication based networks. In general, as Hall indicates, the term refers to " the totality of institutions and human arrangements such as associations, clubs, family structures, cultural organizations which operate with some degree of autonomy independently of the state." Some specific examples are cooperatives, women's groups, mutual aid groups, craft and housing associations and private self-help groups.

There are many types of global networks a few of the defining dimensions of which, as set out by Hall, are as follows:

Geographicdimensioned networks are based on a country or region, an area defined by boundaries. There are also inter-regional networks with members from

several regions or global networks with a very broad coverage of members. South-South, South-North, North-South or North-North networks have geographic dimensions.

Membership dimension networks are characterized by the nature of their participants: individuals, organizations, people working directly in communities, researchers, agency heads, professionals, volunteers, etc.

Functional dimension networks are characterized by activities such as mobilization for transformative action, lobbying national or international governments and organizations, promotion of new ideas or areas of action and gaining visibility, dissemination of information and exchange of research findings.

Networks have ***Ownership*** dimensions in the sense that they may be the property of, or controlled by a large agency such as the UN or part of an externally funded research project. They may be part of a donor agency or shared by several organizations, the result of collaboration between several smaller organizations, or ad hoc and free standing,

Coordination dimensions of networks relate to how they are managed or facilitated. They may have a full-time coordinator, or several with specific responsibility areas. There may be shared coordination, an advisory or managing committed, rotating coordination between members or little coordination at all beyond membership agreement on purpose basic communication rules.

Combinations of these and other dimensions will define the form and functionality of a network. It will be noted that these are also dimensions of many of the characterizations of structured networks in section V above . As voluntary networks grow, take on more functions and establish wider contacts and linkages, they perforce become more structured and organized in order to cope with the added burden of administration and demands.

Network Participation

Networks are by definition participatory and, depending on their purpose, how they are organized, their origin, control and evolution exhibit characteristics which can be used to typify them. This participation may range from simple communication or receipt of information to full-fledged interaction and input to all aspects of network activities with strong influence on outcomes. Maclure has pointed out some ways of characterizing networks on the basis of the quality, kind, quantity and intensity of member participation.

Provoked-planned participation networks usually evolve out of existing institutions and programmes and correspond to the structured types of networks.

Spontaneous participation networks spring from the grassroots and are likely to be characterized by the coming together of a number of individuals or groups with a specific message, issue or problem they share and wish to promote, explore or resolve. These kinds of networks are most often associated with action groups but scientists have long developed their own spontaneous informal networks for synergistic interaction.

Core-periphery participation characteristics often evolve as networks grow and where capabilities and interest varies between members. Invariably there is a dynamic core which provides the leadership and control of the network and as a network grows, this core takes on a more central role while more passive members assume a position on the periphery.

Commentary groups or networks emerge from voluntary initiatives of interest groups looking for personal interchange of information and ideas on specific topics. These groups are likely to remain small and depend heavily on regular exchanges among members. Much scientific exchange between researchers takes place in this fashion, especially among scientists from the North and those in well-funded Southern institutions who are able to attend professional meetings on a regular basis.

Documentalist networks are built on the need for collation and dissemination of knowledge and are usually generated by formal institutions to serve their policy and information needs. Such a network is generally more formal and involves less exchange among individual members.

Social Networks

The ideas in this section are drawn principally from a paper by M. Diambomba on the evaluation of a West Africa research training network. Elements of social network theory are used in the analysis and have interesting implications for broader application to understanding the functioning of networks from a social interaction or communication perspective. The author refers to a network as some definite range of relationships an individual may have or to some type of connecting grid among a number of individuals, families, groups of organizations or other social units. Networks can be classified by characteristics of the relations or interactions involved between individuals and groups and how these affect behaviour and organization.

Structuralist frameworks have been developed mainly by anthropologists to analyse kinship patterns of people, role systems and other structural relations in order to show network obligations and expectations inherent in the varying levels of traditional social organizations. This approach has been applied in formal

analyses of extended families in traditional societies. Interestingly, the typologies of structured, institution based networks bear some affinity to this approach.

Sociometric studies of small groups look at interpersonal alliances and the dynamics of the interactions in these alliances. They provide a clear description of the links which bind individuals together in complex networks of communications.

Process studies of social change, such as urbanization, and the effects of continuing traditional links and networks have been done extensively in Africa and illustrate the need to be cognisant of existing patterns of communication and loyalties before defining, designing and imposing new forms of linkages based on foreign criteria to the traditional ones. These studies integrate analysis from both the structuralist and sociometric approaches by combining larger scale structural regularities of social and cultural experiences with the micro-dynamics of small group behaviour.

Properties of Social Networks

Analysis of social objectives and the means through which they are realized can be accomplished through a focus on properties of individual and group relationships. Still drawing on the ideas summarized and applied by Diambomba, the analysis may consist of two levels based first on the ***meaning and content*** of relationships between network members and second, on the multiple ***sets of relationships*** or links which appear in different structural patterns. A number of component elements can be used to describe each level. These are as follows:

First level, meaning and content of relationships or links within networks can be defined by:

Source - the social context from which the link emerged.
Frequency - the number of times contacts are made within the network.
Duration - the length of time the network has existed.
Symmetry - the balance of power across the network (who controls).
Intensity - the degree of commitment of network members.
Intimacy - the degree of closeness of network members.
Multiplicity - the number of roles, activities, exchanges, dependencies, etc.

Second level, sets of relationships which define network structure may be composed of the following elements:

Reachability - average number of links needed to connect actors by shortest route.
Density - a measure of connectedness or interrelatedness, ease of contact.
Range - the number of actors in the network.

Homogeneity - similarity of actors in terms of a relevant set of characteristics.
Clustering - the extent to which distinct cliques or clusters form within a network.
Dispersion - the range of source social contexts from which the links are established.

An interesting aspect of this approach to describing network relationships and structures is the possibility for modelling or quantifying the relationships, qualities and flows throughout the network using concepts and approaches of the mathematics sub-discipline of topology. Caution is needed in such quantification of interaction, however, to be sure the most important and crucial elements are being measured and that they are adequately represented. In fact, in many cases quantification will not be necessary or feasible. Diambomba used the first level set to evaluate a West African network on training research in a descriptive non-quantified way to arrive at an insightful assessment of problems in the program which kept it from developing as intended by the designers and funding agency.

While I will not attempt to do so here, these same sets of criteria could be applied to assessing or evaluating more formalized networks such as those involved in scientific research in health, agriculture, engineering, etc. Some modification in definitions might be necessary but the same concepts would seem to apply if one accepts the view expressed in the introduction that networks are about communication, idea-sharing and human interaction. This holds true in networks based on exchange of materials or prototypes as well since the physical artifacts involved embody a package of accumulated knowledge which, in order to be useful, needs testing in other environments than where they were originally developed and thereby the addition of further ideas and knowledge to the package.

NETWORK ORGANIZATION AND MANAGEMENT

The success of networks in achieving their objectives depends very much on the quality and appropriateness of their organization, leadership and management. This is particularly true for research networks but applies to other types as well including voluntary and action groups. Without leadership and clear purpose, it is unlikely that a network will develop an adequate organization and management structure to keep it on track, utilize available resources (human, physical, financial and information) efficiently and facilitate activities effectively. However, because no two networks are alike, there is no set pattern to follow aside from applying good organizational and management principles generally accepted in both the private and public sectors. It should also be noted that requirements will change as a network evolves over time so that systems and structures should be kept flexible.

Network Formation: Whose Interests?

Particularly in the case of research, decisions regarding the formation of networks have mostly been taken by individual donors or leading research institutions and then promoted by them. This has at times led to later difficulties when the purpose and objectives are not fully shared and supported by the participating members. It is essential from the beginning, no matter who or what organization takes the initiative to promote the development of a network, that it be responsive to the expressed interests of the developing country partner institutions. It must also be clear that the representatives involved in such discussions are in a position to speak for the interests of their institution and have influence to assure that resources are available to support the proposed endeavor. If the objectives of a partner don't coincide clearly with those of the network, it is unlikely that institution will be a fully active member of the network to the detriment of other members.

A Well-defined Problem and Strategy

The starting point for organizing a research network is a clear and well-defined problem and a strategy to harmonize the various elements of the proposed collaboration. The way in which the problem is defined is also critical to the success of the network. While network project identification meetings may be called by donor countries and organizations, much preparatory work is needed to assure that the research needs have been identified by scientists from the invited participating institutions and respond to constraints or problems of recognized concern in their countries. Where scientists from industrialized countries are involved in the process, they can best serve in a supportive role leaving the main debate and decisions to the developing country scientists. This process is eased and accelerated if a series of projects on the topic of interest are already operating in the potential partner institutions.

The need for a clear set of objectives and purpose for a network, understood and accepted by all its members, cannot be over-emphasized. It is around this understanding that the rest of the network structure, whether simple or complex, will be built and resources allocated. If the set of activities and objectives is too broad, coordination will be more difficult and distinguishing between national programs and network activities less clear.

Shared Values and Basic Ideas

Plucknett et al stress the importance of guiding values or principles and basic ideas which should be shared by members of the network. For example, degree of client orientation, degree of autonomy of network members in the way they pursue their research, attention to research quality standards, team spirit, encouragement of innovation and means of resolving political or scientific discord among members and with the lead institution. While each participating institution will have its own subculture, it is likely that the value norms, operational style and

procedures will be heavily influenced by the coordinating body. Guiding values may change as the network evolves and matures. Part of the role of a network coordinator is to promote and ensure faithful adherence to the guiding values agreed to at the outset and monitor the need for change as the collaboration advances.

Management Flexibility and Independence

Networks normally require some sort of secretariat to plan and coordinate activities, manage resources, distribute information and facilitate communication between members. The role and functions played by a secretariat vary widely depending on the size, complexity and objectives of the organization. National research institutions should preferably take on this role but often have difficulty doing so within the confines of their domestic economic and employment systems. For coordination to be effective, the host institution must be able to provide flexible access to international telephone, FAX, email and other rapid communication media. In some countries, these are expensive, if available at all, and closely controlled. Ease of travel in and out of the country is also important as is access to a foreign exchange account for managing advances to the various partners for activities such as workshops, meetings and travel, training and purchases of journals, books and equipment. If some secretariat staff are hired from another participating country, not an unreasonable expectation, immigration, residency, salary and benefits, taxation and externalization of funds become important issues. Many developing country institutions have difficulty setting up systems able to handle these requirements and while the particular institution or ministry may wish collaboration and give it high priority, this attitude may not be shared by other ministries such as finance, immigration and the civil service administration which control important aspects of these arrangements.

I am reminded of a network with which I was involved in Southern Africa where the host country, designated officially as convenor by the other members of SADCC, subjected operation of the network secretariat strictly to domestic and civil service rules. The result was too much time spent on pushing the system and finding ways around the rules and frustration on the part of the secretariat professionals who could not focus fully on the technical leadership functions of their jobs. In the end, the network was folded because of the lack of independence and flexibility on the part of the administrative system. This is one of the reasons why international and regional organizations such as the International Agricultural Research Centres or NGOs are often turned to for assistance in providing an adequately flexible administrative structure. Without this flexibility, resources are wasted and the purpose of a network can be seriously compromised.

Leadership and Coordination

Effective leadership and guidance is essential for a network to survive and reach the objectives set by its partners. While they may be guided by an Advisory Committee or Board, operational management requires the day to day input and leadership of an active coordinator and, if the

network is large and/or complex, specialized support team. Whatever the nature and composition of this core unit, it must have the confidence of the network participants. It is the management group that oversees the setting and reviewing of network priorities and the conception, planning, implementation, facilitation, and evaluation of network activities. Martinez Nogueira has identified various ***core functions***:

- Initiate and convene
- Structure and lead tasks
- Provide technical support for participants
- Manage program resources
- Be the hub of a communications network
- Coordinate actions
- Supervise actions
- Evaluate actions

The coordination unit or secretariat usually responds to a steering group, advisory committee or other oversight committee composed of representatives from the various partners. This group is accountable to the network creating membership in some way, whether elected, appointed or composed of specific interest sub-groups, etc. The network coordinator is normally a member of this committee and in some cases, donors and major international technical institutions may also be represented or have observer status. To function best, the committee members should be senior members of , and able to speak for and influence, the organizations they represent. They should have a technical background in the specialized area addressed by the network as well as administrative experience. In practice, this mix of qualifications is often hard to meet, particularly with less well endowed institutions and poorer countries. Political appointment of inappropriate representatives to these positions as well as in the selection of secretariat staff can have negative effects on the functionality and effectiveness of the network in meeting its objectives.

Principles for Effective Network Management

A number of principles for effective management of networks have been distilled by Plucknett in his review of network planning and management practices:

- Widely shared values
- Effective governance and policy-making structure
- Effective coordinator/leader
- Clear, well-focused strategy
- Decentralized coordination and communication
- Sound, pragmatic workplans
- Effective review mechanisms
- Appropriate work processes
- Good system for recruiting and keeping network staff

- Stable and adequate funding
- Adequate physical resources
- Effective information management and sharing
- Good linkages with clients
- Productive dialogue with donors
- Healthy relationships with host institutions
- Effective ties with other networks and institutions
- Skilled research managers at the network nodes
- Effective teamwork among participants

POSITIVE AND NEGATIVE ASPECTS OF NETWORKS

Positive and negative aspects of networks can be interpreted in many ways depending on the purpose, organization, management, structure, relationship dynamics and communications of a particular network or set of networks. It also depends on the perspective of the evaluator and his purpose. For example, a well-focused, tightly organized and productive network of agricultural scientists working on chemical pest control for an international company or agricultural research centre might be highly successful in meeting their goals and their collaboration be considered advantageous by their sponsor. Environmentalists might find such a network disadvantageous because of the way the research problem was defined and the network organized from above. It would be much too complex to analyze these kinds of contradictions in all their ramifications so suffice it to note here a number of the main advantages and disadvantages of networks which have been noted by practitioners and evaluators from experience in the past.

Advantages or Positive Aspects of Networks

Efficiency.

Networking can boost the cost/effectiveness of R&D investments of donor and developing country institutions. Theorstically it enables each participant to bring to bear his comparative advantage in a common effort and coordinated approach. Duplication and overlap can be avoided, or reduced, through exchange of information and use of common methodologies. This is of particular interest to donors who view an internationally structured and managed programme as more effective and less costly than supporting individual projects independantly through bilateral assistance.

Generally, developing countries lack sufficient scientific and technical skills, facilities and infrastructure to mount a full scale scientific and technological attack on the various pressing problems they face. this often leads to low effectiveness as scarce resources are spread too thinly over too many problem areas. Networking offers the possibility of focussed R&D efforts, more rapid implementation of research plans and effective attraction of outside resources to augment local investment and technical capacity. Interaction and communication through network

facilitated meetings, reports, workshops, and other communication can provide more immediate and interactive access to a much broader current knowledge of relevant scientific literature and research undeway internationally and at partner institutions in the region.

Synergistic Effects

Networking institutionalises a dialogue among scientists from different developing countries resulting in a better definition of research problems and objectives, better research plans, more effective research protocols and methodologies and concerted action. The positive pshychological effects of these interactions can boost morale, provide encouragement to young researchers, and increase commitment. Through these interactions and network training programmes, scientific and technological disparities among scientists from various countries can be reduced. A commonly agreed research plan for attacking a widely experienced problem that reflects the thinking and commitment of research scientists and institutions from several countries can attract support from donor countries and organizations by offering greater assurance of concrete results with wider application. It is often possible to introduce and test new ideas and approaches which would otherwise be rejected by the institutional status quo without the international critical mass provided by network association for innovative researchers, especially those who are relatively young.

Strengthening National Research Capabilities

Research networks help to identify scientific leaders and provide opportunities for them to visit other countries and attend international seminars and workshops in both developing and industrialized countries. They provide opportunities for training and upgrade capabilities of personnel involved in joint research by being challenged to meet higher standards engendered by network coordinators and professional competition. It also encourages and enables developing coountry researchers to engage in interdisciplinary research that would be impossible or very difficult to initiate in a national program due to lack of research capability in relevant disciplines and lack of budget.

Program Flexibility and Independence

The associations created by networks can often result in greater freedom from internal political influences and burdensome regulations that afflict many research activities in developing countries. Within the context of the defined purpose of the network, it is possible to have more flexibility in deciding on research priorities and modifications as things progress if the work is part of an internationally agrred and monitored project or programme.

Association with other developing countries and participation in steering committees can reduce the influence of donor countries toward problems of less interest or significance for the recipients where these may be a condition of assistance including participatiion of donor country institutions with their own research agenda. It can also insulate the research activity somewhat from domestic funding restrictions by exerting pressure on gavvernments to maintain international commitments. None of this is guaranteed of course and these pressures can be applied in ways that have negative impact as well.

Technology Transfer

Networks can facilitate the transfer and application of research results across a wider area through the more systematic and regular communication channels they engender. This can have productive results at various levels of research, but particularly at the application level when emphasis is given in the network to testing and dissemination of technology and ideas resulting from considerable prior research. This dissemination/action aspect of networks also allows for feedback on the acceptability and functionality of the solutions introduced and allows for more precise follow-up research or shift to another aspect or set of problems with wider implications.

Opportunity to Work on Larger Context Problems

There are many problems which require a more global perspective and integration of ideas than can be achieved at the national level. Of particular note are environmental, political, population growth impact, poverty and health issues. Networks allow for regional and global contextual views linked to input from domestic perspectives.

Networks of voluntary groups and organizations can create opportunities to influence status quo thinking of entrenched power structures by joining forces to research their concerns in a systematic and solid way and present cohesive cogent arguments to influence policies and programmes. An example of such action is the NGO parallel environmental congress in Brasil.

This aspect of networking is growing rapidly and will continue to expand as the immensity of global problems impact on industrialized as well as developing country societies. The potential exists for using electronic communication means to rapidly form new international networks to deal with major problems and issues as they spring from misplaced technology drive, economic greed or environmental disasters, but this capability is still only in its infancy. Various aspects of this potential will be discusssed in more detail in the sections dealing with electronic communication and layered networks.

Reduce the Isolation of Researchers and Groups

In developing countries, many researchers are isolated having limited contact with other people working on similar problems and with access to wider sources of information. By facilitating contact, exchange of ideas and challenging younger workers in particular to develop their professional capabilities and raise their standards, networks can fulfill an important developmental role.

Disadvantages or Negative Aspects of Networks Assumptions

Despite the many positive advantages which can be achieved through networks, difficulties and disadvantages are frequently encountered when network objectives are not clearly defined and institutional purposes are not adequately aligned. Effective network functioning and output depend on good organization, clear leadership and transparent communication. Some or all of the following difficulties or disadvantages are likely to be experienced when this is not the case.

Effects on National Programmes

Research priorities of network programmes may differ from those envisioned from a national perspective since network projects usually seek to meet a cross-section of participant needs. This then can fail to take into account national peculiarities and differences. External funding can be a liability if gaps in continuity occur due to donor or network decisions about availability of funds and technical personnel and applicability to specific topics of interest to a national programme. National programmes may also be burdened with nework-generated demands for staff time and inputs beyond their capability to respond.

Distortion of National R&D Effects

Although many donors try to ensure that new networks respond to developing country priorities and become "responsive networks", it is often hard to draw the line with donors on judgements of where to invest their funds. These ideas are often formed by industrialized country researchers based on interaction with developing country scientists in specific disciplines. "Suggestive networks" driven by "experts" reflecting a narrow set of interests not shared or understood by potential partners, but entered into for sake of available financing or prestige association, are likely to fail for lack of commitment and support from domestic programmes.

Neglect of Lesser Developed Country Institutions and Researchers

Good research depends on the quality of researchers and research institutions. In a network, where success depends on coordination and interdependance, differences in capability can lead to discrimination against partners from less capable or endowed countries. Small numbers of trained scientists, limited research facilities, weak administration and inadequate communication infrastructure can restrict institutions to marginal roles or small sub-projects. More capable participants may object to slowing their own progress in order to mentor and assist weaker partners. A focus by donor agencies on stronger institutions, better able to collaborate with their own advanced research institutions and to show more rapid scientific results, can lead to further marginalization of weaker countries and institutions unless concerted efforts are made to improve their capabilities.

Research Management Problems Affect Research

Bureaucratic and administrative structures can slow and block research progress and effective participation in networks. Networks should not be defined by bureaucratic structure as much as by their purpose. If they are not kept administratively simple and focused, facilitating communication and exchange, research and new ideas will be curtailed. This is of particular concern with institutions controlled by governments insisting on internal controls by various ministries on clearances for flow of materials, information, researchers, and currencies.

Fragmentation of Research by Discipline or Sector

Fragmentation of research requiring a multi-disciplinary approach is not unique to networks but can be exagerated with specialist oriented definition of problems to be investigated. The problem rests in the way universities and research organizations reward research output and the way much scientific research is published. In this case, networking can equally serve to overcome the

problem, as well as to exacerbate it, depending on the focus and orientation of network leadership.

Distortion of National Programs and Misplaced Priorities

Where substantial outside funds are available for participation in network research and opportunities are created for qualified national researchers to work with internationally known and published investigators, they can often be enticed to work on problems of personal interest rather than in key areas defined and prioritized in national programmes. The benefits of research money, easier administration, travel, more frequent contact with disciplinary specialists and more opportunities to publish can be very attractive to isolated national researchers who have trained in an industrialized country and see the research paradigms and focii of those countries as being in the lead. Such people may have strong influence over their own institutions' research and, in addition to seeking benefits for their own research, allow the outside attraction to influence the advice they give to administrators and policy-makers on national R&D priorities. In some cases, just the fact that money may be available has led administrators who control scarce budgets to accept participation in activities their institutions cannot adequately undertake. In some cases, potential donors may buy the services of researchers to achieve objectives of their own institutional agenda.

Do They Create a New Elite?

In some networks with international funding, the access to better equipment, communication, participation in international meetings and greater funding can leave researchers and programmes not favoured by international networking interests with a sense of being left aside. If this kind of situation is not carefully managed, and overall programming is left fragmented, it can lead to internal conflict and a sense of a double-class system.

Potential for Undue Influence by Donors or Leading Institutions

Unless international donors and leading researchers are extremely sensitive to the strong influence their control of resources and powerful presentations exert, the potential is substantial that programmes designed in detail by outsiders will determine how national resources are applied and priorities set. Of course this is equally as true for bilateral programmes as for networks. The weakest countries and programmes are most vulnerable to this kind of pressure. When donors lead too quickly and strongly, consultation is minimized and mismatches are likely to occur.

Cost of Research Networks

Networks can demand a heavy coordination workload on the part of both the coordinating institution and the various partners. Organization of meetings, workshops, reporting in different formats, keeping separate books, etc., can be a heavy load for an otherwise weak institution with limited research and administrative staff. Opportunity costs of network activities need to be taken into consideration in deciding whether to participate or not. In some cases, the coordination and administrative functions of a network may be contracted out to an IARC or a private

organization. Such contracting can have the effect of losing cumulative experience at the end of the contract period.

Faris notes that a benefit to one party in a network may well be a cost to another. Looking at a reseach network's objectives can put its costs and benefits into perspective and any network activity that does not strengthen national programmes or institutions can be considered a cost. The proliferation of networks and participation of individual researchers and institutions in several at the same time can add administrative load and draw heavily on scarce researcher time.

Poor Communications Limit Synergistic Interaction

Communications within a network are influenced by several factors. In poorer countries, the basic infrastructure for adequate communication may not be available or be too expensive for frequent interchange. This problem is rapidly being overcome, but is still an issue of concern. Differences in competence and experience of researchers can limit free and open communication as can language differences in regions where multiple tongues are common and researchers are not fluent in expressing their ideas in one of the commonly used international languages such as English, French or Spanish.

Networks Can Become Isolated and Take on a Life of Their Own

Where funding is assured and not linked to national support systems and interests, networks can take on a life of their own to the detriment of national programmes. Successful networks often have a tendency to grow, attract more participants and pressure builds to include a wider variety of subject matter. Such dispersion can be costly and deflect the purpose for which the network was created in the first place. If initial problems have been resolved, it is important to reassess the need for the network and, if necessary, realign its purpose and objectives. All networks should be assessed critically in terms of accomplishments and operations on a regular basis to keep them sharp and connected to the needs of their base clientelle.

The more structured networks tend toward institutionalization, such as some examples from the international agricultural reasearch field, and require close monitoring. The same may be true for UN Agency sponsored and led networks and those of other large donors. It is questionable whether an association which begins as a collaborative network and gradually takes on the characteristics of an institution in its own right is any longer a network.

THE WORLD OF ELECTRONIC NETWORKING

The rapid development and evolution of computer mediated communications (CMC) and other electronically facilitated means of communication over the past 15 years has opened up a whole range of new possibilities for networking on both an institutional and individual basis. The implications of these new modes of sharing ideas, knowledge and perceptions are far-reaching and likely to challenge existing bureaucratic institutional control of information and power. They are opening opportunities to create networks of individuals and small groups for more

democratic and widely influenced problem definition and decision-making world wide. While this may be a somewhat utopian view, certainly not without constraints, it is worth considering the potentials and implications of its development.

This section will present some of the possibilities suggested by current authors and thinkers on the topic along with potential limitations and dangers. Since much of this is relatively new and not related specifically to R&D the discussion takes a broader view than that related to the structured and institution oriented networks discussed above.

The Internet

The Internet, or more informally, The Net, is a loosely interconnected web of computer networks that use CMC technology to link people around the world in discussion, research, lobbying, knowledge exchange and interaction. There are no central control or monitoring stations but messages and information can flow anywhere the existing telephone based communication system reaches through both hard wired and radio telemetry systems. It can do this much more economically than telephone or even FAX connections because of the efficient compacted digital means used to forward electronic signals through various gateways from one network to the next.

In his book, *The Virtual Community,* Howard Rheingold claims that this technology "has the potential to bring enormous leverage to ordinary citizens at relatively little cost - intellectual leverage, social leverage, commercial leverage, and most important, political leverage." He speaks of the "wildly varied assortment of new cultures that have evolved in the world's computer networks over the past ten years" and how "profoundly the social, political, and scientific experiments under way today via computer networks could change all our lives in the near future."

The CMC networks which join together thousands of smaller networks and span continents are a spinoff of American military research from the late 1960s and early 1970s. The first computer network, called ARPANET, was created by the US Department of Defense for data exchange between researchers on defense research contracts. ARPANET, in turn, was based on an earlier scheme for a military communication, command and control network that would have no central control location and thus be able to survive nuclear attack. If one or two nodes were taken out, messages could be rerouted automatically via other links to whichever node hosted the central decision-making group. This basic system has proved very flexible and has been adapted in many ways not visualized by its early designers.

Rheingold points out that a continuing theme in the history of CMC has been the adaptation of technologies designed for one purpose to a variety of others as individuals perceived new needs and possibilities. He notes, "the most profound technological changes have come from the fringes and subcultures, not the orthodoxy of the computer industry or academic computer science" and

"whenever CMC technology becomes available to people anywhere, they inevitably build virtual communities with it, just as microorganisms inevitably create colonies." Computer conferencing grew out of the need for dispersed decision making and dissemination of up-to-date information

from a large number of dispersed sources. Once demonstrated, computer conferencing was quickly adapted to commercial, scientific, and social discourse.

At present, the Net is anarchic and widespread because of the way it evolved in the 1980s through the convergence of a variety of independent and unrelated developments and experiments with computer-mediated networking. These efforts used different technologies and involved a variety of participant populations but the ARPANET technology was able to link these diverse initiatives into a comprehensible set of channels that has rapidly grown to the point where no one knows exactly how many networks and network users are actually interconnected. Estimates range from 12 to 15 million users and up in at least 60 different countries. With a growth rate of 15 percent per month it has been impossible to maintain a useful directory. One has to jump in and explore to discover what is there. At the same time it is possible to communicate with specific individuals through email. A guide to the world's computer networks referred to by various authors is called *The Matrix.* Author John Quarterman estimates there are nine hundred different networks worldwide today in addition to the ten thousand networks already linked by the Internet. The closest analogies used to describe this wildly growing and interconnecting mass are biological where exponential growth is common.

The Virtual Community

The grassroots part of the Internet springs from home-grown computer bulletin-board systems or BBSs spawned initially by computer enthusiasts but today accommodating hundreds of thousands of people in distance communication on any topic that interests them. Each BBS hosts anywhere from a dozen to several hundred or thousands of individual participants and started out as a small community of a few people who wanted to exchange views on a particular topic. The first network of private BBSs worldwide, called FidoNet, is now linked into the Internet. Technical bridges thus connect these grassroots groups with the more formal parts of the network inhabited by the programmers who built the Net, scholars, scientists, information specialists and commercial/industrial entities. Each of these groups is a community of its own with accepted norms of interaction and sometimes intense personal relationships between participants. When connected into the larger networks they become subcultures within a larger growing and evolving CMC culture observed by a variety of futurists and writers concerned with the implications of "the information age".

Virtual communities are described by Rheingold as "social aggregations that emerge from the Net when enough people carry on those public discussions long enough, with sufficient human feeling, to form webs of personal relationships in cyberspace." He goes on to define *cyberspace* as "the name some people use for the conceptual space where words, human relationships, data,

wealth, and power are manifested by people using CMC technology." While technology and the investment of billions of dollars has made these new communities and communication across national and cultural boundaries possible, it is not the technology itself which will resolve social problems but rather what humans and their communities do with it. The cyberspace of the Net is a social phenomenon where people meet to gather information, debate and share, "one to one" or "many to many", analogous of the market place of traditional societies. This has strong implications for the evolution of global civil society and as Kealey quotes Quarterman, "One reason for the popularity of computer-mediated communications is that it can be used to reach people directly without going through established bureaucratic hierarchies."

The Internet versus the Information Highway

A great deal is written and said currently about the development of new sources of information and entertainment, the term *infotainment* has been coined to describe the product, and how they can be accessed readily by ordinary people through their television, telephone or TV cable. In fact, the huge companies that control these services are locked in fierce battle to determine which of them will tap what they perceive to be an incredible new source of cash flow and profits through "pay per view" or "pay per data bit" charges. This perspective views information and knowledge along with entertainment as commodities to be packaged and sold in a capitalistic marketplace. The main focus in this view of communication is centralized broadcasting, "one to many", within a controlled bureaucratic structure.

By contrast, the Internet is about relationships, as Gillis suggests, about interaction, social construction of meaning, and the proliferation of social space. It has the potential to open channels for new ways of accumulating and creating knowledge across cultures and existing institutional control structures. In this context, the significance of the ARPANET technology which easily bypasses central control points becomes apparent. Rheingold maintains that the approach of the communications companies is unlikely to be successful for the simple reason that people like to interact with each other and will do so when given the opportunity. Interaction and selection from a controlled information source is not nearly as interesting or creative and, even if many channels and a broad database are available, most people stick within a narrow range of choices.

As an example of this phenomenon, Rheingold compares network experiments in Britain and in France. In the early 1970s, British telecommunications companies initiated an experiment to sell videotext information services via television screens using telephone touchpads as a control mechanism. The effort failed miserably, as have other similar experiments, demonstrating that people aren't that interested in information alone on screens unless they are also offered a means of interaction with one another. By the mid-1970s, the French Direction Generale des Telecommunications (DGT) began modernization of their telephone system including consideration of "the computerization of society." The system called Telematique was born and put into experimental operation in several municipalities. One of these localities was monitored

to determine whether professional associations and institutions would use data banks. Few users called the service and most encountered difficulties. In an effort to assist new users cope with confusing commands, a system was designed to communicate with trial users and coach them in learning the system. When one of these users cracked this communication system and used it to connect and talk with friends, the system administrators improved on this part of the service and made it a legitimate activity. Six months later, the system was logging 700 hours of connection time per day compared to 100 to 300 hours in another community where people had access to information but not to person-to-person communications. What contributed to the rapid growth and eventual success of this "messageries" or "chat" service was the free distribution of small terminals which included a tiny screen, small keyboard and a telecommunications connection. The giant distributed database was sold as a communications system.

The Electronic University

It has become fairly common to view the changes currently taking place in society as a major shift in organization and ideas. Rossman, along with others, compares the end of the twentieth century with the beginnings of the Renaissance in terms of the potential magnitude of change and shifts in thinking. Higher education and related research is an important foundation and instigator of this change to an emerging information and knowledge based society. It is analogous to the early use of the word "university" to refer to guilds of students and scholars who came to study and discourse with various known intellectuals and to participate in the vigorous intellectual life which grew up around them. Originally, universities grew out of these informal associations, had very little organization and were international in scope. Students often wandered from country to country in search of the course or knowledge they wanted much as modern day knowledge seekers explore the offerings of, and add their ideas to, the worldwide electronic network of individuals and databases.

Presently, large numbers of people are participating in distance education, open universities, and other electronic learning networks. With the demand for continuous life-long learning in the evolving knowledge economy, these kinds of programs are growing into worldwide networks. However, universities are slow in facing up to the emerging global society and the need to adopt wider and freer networking with the implications for replacing cumbersome, bureaucratic institutions with flexible networks through which scholars can communicate on a global basis and students can take courses from various universities in different countries without leaving their home base. Rossman states that ".... this emerging international electronic university consists of all electronic cooperation and exchange among students, faculty, and researchers." In this way, education can be offered to the world and smaller, more remote colleges can enlarge and enrich their offerings by linking to larger and more specialized institutions through electronic networks. Instead of a global university with a large, centralized administration, what is likely to evolve is a network of "hubs" coordinating or offering courses from various sources including universities, government agencies, and business.

In his 1938 book, *World Brain,* H.G. Wells expressed concern over the outmoded styles of university education and called for coordinated research and a less parochial university that could deal more adequately with large-scale global problems. Today's electronic interconnections are beginning to make that vision a reality. Rossman states that, as a fundamental educational principle, "every person and every culture, as well as every country's educational institutions, have much to teach and much to learn. All peoples need to share what they have on a two-way basis, as equals - facts, science, knowledge, research methods, wisdom - so that ordinary people as well as scholars and political leaders everywhere can decide for themselves how to develop themselves and their communities for the good of all." The old style of organizing by self-contained departments and specializations is no longer as functional as it once was. Universities must now exist in a global context experimenting and improvising with joint projects and consortia, building bridges to industry, government agencies, research institutions and community groups in their own and other countries. These networks could well emerge as the twenty-first century form of institution.

In this context, it is important to define networks on the basis of what they do, on the purpose they serve, rather than on their boundaries and structure. Starting from core ideas, and a clear definition of purpose and function, greater opportunities will be available to expand to new ideas and problems beyond restrictive, inflexible discipline or institutional boundary limits. Universities can become networks of interdependence for both teaching and research.

The Global Paradox

Business gurus Peter Drucker and Tom Peters make much the same point about business. Bigger is no longer better. Virtual corporations composed of many small independent units forming alliances for specific objectives, internally and externally to the parent company, and then realigning for further projects when objectives are met, are characteristic of many of today's most dynamic companies. On an international scale, futurist John Naisbitt titled his latest book, "Global Paradox: The bigger the world economy, the more powerful its smallest players". He boldly claims that "the more universal we become, the more tribal we act" and that this tribalism will bring hundreds of new countries into being and empower thousands of diverse, tribally affiliated groups. In the same way, the virtual corporation reflects a dismantling of bureaucracy for survival and economies of scale giving way to *economies of scope* for synergy, market flexibility and speed. Big companies are decentralizing to become *networks* of entrepreneurs in confederations of small autonomous companies. Multinationals won't dominate world business because bigger is inefficient, wasteful, bureaucratic, costly and inflexible. The bigger and more open the world economy becomes, the more small and medium-sized companies will dominate. Not everyone will agree with this point of view but things are changing so rapidly, and electronic networking is making old loci of power so vulnerable, that it is not implausible

Research Teamwork

Research has always involved teamwork, communication between scholars and scientists in networks. Through professional associations, international scholarly journals, and conferences, researchers were already part of an invisible worldwide university before the advent of electronic communication. It is not surprising therefore that electronic and research networks grew together. Computer networks and global cooperative laboratories mobilize and join many minds to facilitate a collective intelligence and empower researchers to work internationally in science, medicine, space exploration, weather and earthquake prediction, and world economy simulation. Research in the humanities as well as science is benefitting from this new interconnectedness.

Probably the greatest potential for use of this rapidly evolving technology for communication is in "grand research designs" focused on solving many of the serious global scale problems the world faces today. These are problems which cross national boundaries and ignore disciplinary divisions of knowledge. Obvious examples are pollution, the greenhouse effect, deforestation, soil degradation and acid rain. Linked to these environmental problems, often in causal ways, are social problems of poverty, equity, health, conflict and peace. All need international, multidisciplinary research attention which can only be achieved through interaction, information sharing and cooperation on the broad scale made possible by electronic networking. In fact, the most important aspect of networking is the greater precision and understanding which can be brought to the identification and definition of problems, issues and alternative perspectives.

In discussing the above issues and the role of research institutions as currently constituted, Rossman makes the following observation: "It is paradoxical that so much scholarly work fails to be global because nationalism has a firm grip on universities. Faculty members so often forget that they are members of a cosmopolitan community. If universities are not to be intellectual ghettos, then the worldwide exchange of ideas and research is a necessity." It is essential to entertain more holistic views and explore scenarios that can only be put together by scholars from many cultures and backgrounds if global social problems are to be solved. All kinds of combinations of institutional, social and economic interfaces can be explored through computer simulations. Without teamwork and networking, the comprehensive data, information bases and perspectives needed for such work are impossible or won't be adequately brought to bear on relevant problems or lead to appropriate decisions.

The real point here is not that computer technology and electronic communication will do the thinking for scientists, politicians and ordinary people in the street. Far from it. The focus must be on using these tools to magnify and achieve a "collective intelligence" by bringing together many minds in collaborative research, to create a network fusing many kinds of expertise where no one specialist can deal with the whole problem. Openness, flexibility, imagination and creativity need to be encouraged in place of competition and possessiveness.

The Global Encyclopedia and World Brain

Another aspect of benefiting from networks is the comprehensive availability of knowledge from both the past and from the present as it evolves. The core of the Global Encyclopedia and World Brain concepts was probably born with early initiatives to establish libraries of manuscripts for their conservation. With the interactive nature of electronic storage, classification and search systems, the idea becomes more alive and dynamic, linking existing minds more fully to those of the past. H.G. Well's "World Brain" idea encompasses the comprehensive organization and coordination of all knowledge in a way that would be "alive and growing, changing continually", "much more than an assembly of fact" and, as Rossman adds, "an instrument for synthesis, a filter, a place to coordinate all research, a global network of intelligent workers and researchers, in other words, a super-university." He continues to summarize a literature spun off from these ideas, demonstrates the power of network linkages and relationships, and notes how "technocrats and scholars are now at work on bits and pieces of what may become the most important research project in history." "This massive scholarly project, underway but not yet systematized or coordinated, can provide one of the most important foundations for a new and more adequate system of global scholarship, research and higher education." To moderate the rapidly expanding mass of published documentation, such a system could eliminate duplication of effort and therefore waste of scarce resources.

The process of gathering and integrating all this knowledge is taking place in dispersed data bases and computers, cross-indexed and interconnected, with much greater potential than could be imagined by early scholars or even the visionary Wells. Eventually, it is possible that these initiatives will begin to bring down national and other boundaries between universities, scholarly disciplines, scientist/scholars and average educated persons, and simultaneously value the unique contribution of each culture, nation and discipline. It can go beyond the current boundaries of academia to encompass traditional community knowledge, oral traditions, business knowledge, market research, government and governance practices and a host of other categories at all scales of human association and endeavour.

The Razor's Edge of Electronic Media and Networks

As.with every social experiment and technological innovation, there are negative as well as positive implications and results. Not everyone interprets the potential benefits and risks in the same way or from the same perspectives. It is worth, then, outlining some of the concerns expressed by critics of the unabashed acceptance of CMC and other electronic communication media in interconnected networks.

A major question is, who will own the information highway and control access? There is a definite threat of monopoly control as the shift quickens from publicly funded, educational and non-profit networks to regulated, commercial networks privately built and managed for profit. To what extent will universal access be available at affordable prices under this regime? What

degree of censorship will be imposed and will information be further packaged according to the objectives and views of controlling interests in league with governing bodies?

Rheingold points out several social criticisms worth considering. One focuses on "the way electronic communications media already have preempted public discussions by turning more and more of the content of the media into advertisements for various commodities", including the political process and what has been termed "the commodification of the public sphere." CMC activists see unfettered online networking as "a way of revitalizing the open and widespread discussions among citizens that feed the roots of democratic societies." A second criticism is that, with the proliferation of interactive networks, it becomes easier and quicker to follow personal information trails as a means of surveillance, control and disinformation by government and private interests much as anticipated by George Orwell. The tools now being developed called "intelligent user agents" or "knowbots", to assist the average person sort through the masses of files and databases available online, will be equally as effective at ferreting out comprehensive personal information. A third line of criticism, the hyper-realist school, claims that perceptions of reality have been changed through carefully constructed simulations which mimic the real world but are designed to extract money from unsuspecting consumers. The tools of this web of illusion include television, movie stars, theme parks, marketing, etc. Neil Postman portrays this view at length in his book titled, *Amusing Ourselves to Death,* in which he claims that it is not Orwell's "Big Brother" which is to be feared but rather Aldous Huxley's *Brave New World* where culture becomes a burlesque, society a spectacle and social customs are changed accordingly. People are controlled by pleasure, unconsciously, and are willing to pay for the privilege. Concern is expressed that CMC will quickly become just another conduit for this "disinfotainment". Information exchanged in research networks could be manipulated as well to justify certain views or results.

An article in The New Scientist presents a pessimistic view about the way the Internet and other communication technologies are developing and who has access in the "Global Village." The author, M. Holderness, states that "to make the most of the information age, you need to be male, speak English and live in an industrialised country." More than half the people in the world have no access to the telephone network through which much of the new information and communication exchange takes place and large numbers are also illiterate. How can these people access the potential benefits promised by the electronic world? Even while great advances are being made for many communities, global division is being accelerated between the information-rich and the information-poor, between the North and the South, urban and rural, male and female, educated and uneducated, between all the already advantaged and disadvantaged groups.

There are those who worry about scientific division when more research is published in electronic journals and readers are charged for each article consulted in a privately controlled "transaction-based service" and when printed publication is curtailed. Although on-line access is potentially cheaper, and could be made more accessible in remote institutions and developing countries, this won't happen automatically unless policies and resources are aimed at making that possible.

Other barriers to wider access include language and computer literacy. Neither of these is insurmountable but at the moment both still cause problems. Most software for communication programs is written in English and Roman script. Use of systems like the Internet is often difficult because of arcane, difficult to remember commands and unhelpful technical error messages. While these are major concerns, technical solutions are reportedly on the way. A standard is being devised for consistent and compact encoding of many scripts in computer files. User interface programs to display the many characters and typefaces, as well as edit text, and language translation software are on the horizon while simpler communication and information search programs are appearing. Still, to be used effectively, even user friendly software demands a level of technical sophistication, acculturation, literacy and skill. Access to physical facilities, education and exposure to the technology, as well as ability to pay for the services, are key factors in expanding the networks and exploiting their potential.

In his book, *Technopoly*, Postman points out that the benefits and deficits of new technologies are not distributed equally; there are winners and losers. Knowledge monopolies are created by important technologies and some of these may come in the form of networks. Those who have control over the workings of a particular technology accumulate power and inevitably form a conspiracy against those who have no access to the specialized knowledge made available by the technology. This is particularly true of computer technology which is indispensable to most researchers for analysis and communication and has increased the power of large scale organizations. Winners will encourage losers to be enthusiastic about computer technology but refuse to say from whose point of view the expected efficiencies are warranted or at what cost. It is not always clear in the early stages of a technology's intrusion into a culture who will gain or lose most. The questions must be asked: To whom will the technology give greater power and freedom? Whose power and freedom will be reduced by it? How will this come about? Who owns or controls the sponsoring network?

The Future Electronic Network

The world of electronic networking and its potential permutations is currently in its infancy. Even though much has already been accomplished, the limits of existing technology have not been reached to say nothing of new advances on the near horizon. The topics covered here have ranged from brief notations on current Internet and other networking experiences to speculative, imaginative possibilities for much more ambitious endeavours. The technology itself will not solve problems, however, and may create new ones. It depends on human imagination, integrity, and ingenuity to reach its best potential. Not everything that can be done should be done and so the importance of choice. One thing is clear, without the collaboration and communication engendered in networks, the utopian potential only glimpsed above is completely impossible. With a multitude of well chosen networks at every level, however, almost anything can be achieved. For now, our operational objectives need to be of more modest scale, albeit oriented within a more grandiose vision of what might be. The electronic tools available make it possible for ordinary people, scientists, concerned citizens, educators, almost anyone, to network with

others of common interest in providing services, confronting problems and accessing information.

LAYERED NETWORKS, MATCHING NEEDS

Many networks are needed, both specific and general. A present difficulty with many research networks is trying to do too much with any one set of associations. An ideal of networking expressed in almost all reviews is that of democratic process. This is difficult if the various partners are not coming in as equals in knowledge, capability, shared interests etc. In organizing and coordinating networks a useful concept to be developed might be that of layering according to a hierarchy of identified needs and capabilities. One of the weaknesses of existing research networks noted above has been that of weak members holding stronger and more advanced members back. This can be the result of inadequate scientific capability and resources but these institutions might thrive in a different kind of network focused on applied parts of local problems. They could tap into more advanced networks for access to information, training and technology without having to participate in all activities. At another level, groups of much more sophisticated and advanced researchers, with access to specialized facilities and worldwide information sources, could work on components of wider problems.

Today's world is exceedingly complex and issues more global and interrelated. Where in the past individuals and small groups acted in isolation to solve problems and create opportunities within their own communities, such initiatives, while still essential, now face many more outside influences. On the other hand, they can also draw on a much larger pool of information and technology than was ever conceived of earlier, even in remote villages, isolated research institutions or NGOs provided they have established connections outside their immediate groups and linked in with a larger network of associations. In this context, one could think of networks of networks. The number of layers and their configuration is innumerable, each serving to provide useful interaction, information and appropriately packaged technology to members of other layers in the overall global system.

The permutations of groupings, organizations, issues, technologies, sciences, interests, demographics, industry and geographic locality to name only a few qualifiers is infinite. Networking within this plethora of possibilities demands some way of structuring the many possibilities conceptually if not organizationally. The building blocks are small groups of linked individuals with a common need or objective and islands of such groupings which can be interconnected through networks. Internally these groups or "horizontal networks" are integrated around fairly specific problem and information needs. Externally, or vertically, they can be viewed as layered in relation to the other input and environment components or their contextual reality.

For networks to be effective, they must share a definable **community of interest** (COI) on the basis of which to interact. Examples of such COIs might be health issues, research in specific

disciplines, manufacturing, business, municipal, regional or state government, NGOs, or international donors. These can be sectionalized by size, type of organization, whether private or public, by industry, cultural affinity and language, common problems or issues and by services such as medicine, legal, financial, credit/banking, basic services/shelter, transport, education, information, etc. Each COI is a layer in responding to the needs of individuals and their communities which can be defined and sorted on the basis of identifiable characteristics and used to focus the purpose and objectives of the networks related to those needs.

In addition to the core purpose, initiative and need, the COI of a network, its effectiveness depends on how it is initiated and develops. Experience indicates that networks function best when they are begun from a small core of shared interests and needs then allowed to spread out autonomously in search of necessary information, support and multi-way interaction. In other words, let the structure evolve as needed and is found effective, developing by exploration rather than by prior design. Of course there needs to be an agreed on set of rules to keep the interaction and expansion focused and on track. At times it may be necessary to spin off new groups, eliminate activities that have reached their goal or to declare a sunset for the whole endeavour. In many ways this is in antithesis to the way donor defined networks have been organized and promoted. The emphasis needs to be on interaction and constant attention to the needs and perspectives of final and intermediate beneficiaries of network objectives and donor support.

GENDER ISSUES AND NETWORKS

Given the biases inherent in the way problems are defined and solutions evolve, it is essential to include a special section on how gender issues are dealt with in networks. What is the potential for new networking technologies and channels to be used for promotion of special interests and to integrate seemingly divergent and antagonistic perspectives?

Women in developing country societies need outlets to express, share and communicate their feelings, perspective and aspirations and these could be provided through organized groups and networks relevant to their needs. Equally, channels could be opened for male discussion of gender issues in the context of more equitable relationships and organization of society. Such network discussions would necessarily deal with culture and the meaning of relationships and could lead to cross cultural comparisons and interaction.

Communication between women's groups and networks can be facilitated by the new, rapidly developing, electronic network facilities and Internet. This would help alleviate some of the isolation experienced by many women and provide them with a stronger collective voice on their concerns, perspectives, contributions and role in their own communities and global society. This obviously has a close link with participatory research networks and global civil society concepts and initiatives.

NETWORK EVALUATION

As with any other kind of program or project, ongoing monitoring and periodic evaluations should be key components of network management and development. Although seldom considered until later in the game, when donors get anxious and seek an accounting of what has been accomplished or funding gets tight, evaluation plans and schedules are best prepared as an integral part of initial network design. This *ex ante* evaluation planning process assists in assuring that clear objectives and expected means of reaching them are set out and agreed upon by all participants. Contributions and roles of partners, whether national or regional research institution, voluntary organization or international donor are delimited and anticipated outputs are defined. A time frame may be set for reaching the expected delineated goals and guidelines set for the adherence of further partners and associates as things develop. With an explicit outline and timetable set, it is not only easier to evaluate what has been accomplished but also to effectively manage and guide network activities and evolution.

This ideal scenario is rarely considered with the initial enthusiasm or urgency to begin work on specific themes which loom large in the minds of committed initiators. In general, networks have been developed in a fairly ad hoc way or been designed by one or two network members who continue to lead and define activities. Not too much thought has gone into measuring the performance of networks per se. Most of the evaluation efforts have focused on organization, management structure and operations, little on outputs. Plucknett et al. 1991 point out that any organization has three main ingredients to its activities: inputs; internal processes and procedures; and outputs. Referring to earlier network assessments, they admit to a focus on structures, operational procedures and principles for success. Some problems with networks in agricultural research were also identified and most of these have been set out in the first sections of this paper. These efforts dealt almost exclusively with inputs and internal processes practically ignoring outputs and impact. Perhaps this is not too surprising because separating the accomplishments of a network from what might have been achieved alone by individual research institutions with the same resources is a complex task and the methodology for attributing benefits in such cases is not well defined.

Research outputs from network nodes, and networks as a whole, could be defined on the basis of products, services and utility to the end beneficiary. The latter is the most difficult to measure and define precisely. Research output can be isolated in terms of new knowledge, new methods or systems, new material objects, including intermediate products used by others to create final user products, and final products for dissemination. No single network is likely to deliver all three of these outputs in equal measure as the range of activities would be too broad, unwieldy and expensive. Outputs of creative networks are likely to have impact on science through new ideas, methodologies and knowledge and in another facet, impact on institutions. The latter is more difficult to define including as it does a mixture of influence on individuals, institutional organization and concepts, national policies, and interaction at the international level.

Despite the difficulties, it would seem networks and their output can be evaluated using the same

methodologies applied to complex institutions. If the goals and objectives of a network are clearly and relatively narrowly defined, they can be assessed on the basis of mission and scope of activities and on the collective institutional environment of the network. In addition, network organization, leadership and management are important as is performance in terms of effectiveness in achieving network goals and mission efficiently by providing value for resources invested. Much more could be done in adapting existing evaluation methods to networks both *ex ante* and *ex post.*

NETWORKS AND APPLICATION OF RESEARCH RESULTS

The application and use of research results is a complex and far from straightforward process. Much discussion on the topic, and many projects, assume a fairly linear progression from science and technology research to promotion of a final product the user is expected to purchase or adopt. Similarly, social science and policy research results are published and circulated but mostly among the research community. In recent years, greater attention has been given to user or client needs and perspectives, however, even here most research is still limited to specific disciplines, topics and researcher agendas. Although one can argue that all well focused research adds to the available pool of knowledge from which innovations arise, only a very small portion of research results are directly linked to specific technological, organizational, political or educational research outputs. In today's interrelated world, applied results are built on a combination of skills, knowledge and experience of which research findings presented in traditional forms are only one component. A successful product or policy is likely to result from the combination of many individual ideas focused toward a defined need and objective.

The exploitation of new knowledge and technology depends on a multiplicity of links between economy, society, science and technology within the context of what more and more is characterized as networking. This theme is developed by Dr. V.V. Krishna based on a review of science and technology policy literature and on the ideas and model of M. Callon. What follows is summarized from Krishna's paper. A key element to this perspective on networking is that innovation should not be limited to science and technology elements with inward looking strategies. Success rests on a wide range of actors, institutions and strategies including political, legal, banking and credit systems, industry, markets, technical and scientific skills, design, consumer choice, etc. The economic realities of the 1990's demand more than looking solely at self-reliance in S&T and include questions of market, competition and trade. This perspective applies at the regional and community levels as well as the national and international.

The application of research results thus nests within the context of a national innovation strategy where R&D is only one of the important elements. Networking is proposed by Krishna as a relevant innovation strategy noting that there has been a "rapid narrowing of gap between the contextual extremities of 'market pull', 'science push' 'technological push' theories; and that there is a growing realization of (quoting Callon, 1990) 'general consensus that innovation is born of a narrow coupling between science and technology on the one side and the market on the other'.

Whilst these interconnections are considered as central to the innovation process, there are various 'intermediates' or S&T policy intraventions underpinning the innovation system". Networking serves as a useful conceptual model for pulling together the various disparate threads of the research to utilization process into a cohesive whole.

Callon et al. (1990 & 1991) proposed a model called Techno-Economic Networks (TENS) defined as a "coordinated set of heterogeneous actors, laboratories, technical research centres, financial organisations, users, and public authorities which participates actively in the development and diffusion of innovations, and which via numerous interactions organizes the relationships between scientific-technical research and marketplace". TENS is intended to map the way in which actors and agencies comprising a network, both social and technical, "define and distribute roles, and mobilize or invent others to play these roles". Within TENS, the role of intermediaries is emphasized for facilitating transfer and interpretation between actors and agencies of the three recognized poles of **science, technics and market**. Figure 1. illustrates the structure of this model the relationships and functions of which are described below.

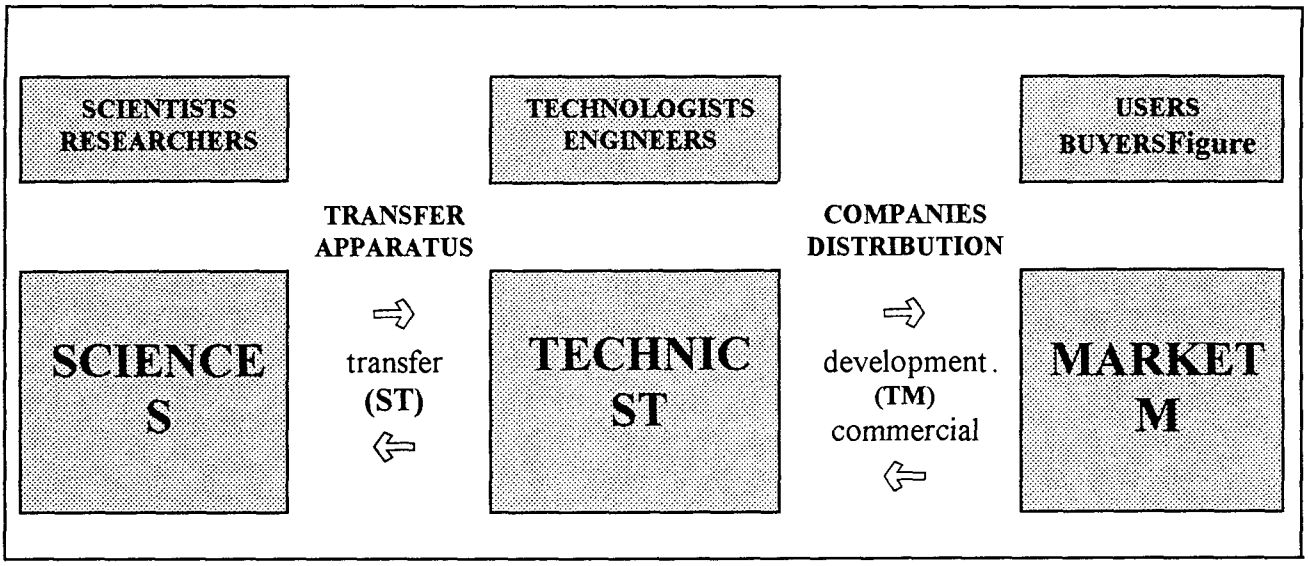
The Scientific Pole (S) - deals with science and research related to advancement of scientific knowledge. It includes the systematic identification and incorporation of knowledge from various sources into this pole and is characterized by activities of generation, absorption, theoretical application and extension of scientific knowledge.

The Technical Pole (T) - includes the conception, development and testing of specific objects, tools and techniques such as software, molecules used in pharmaceuticals, equipment and manufacturing technology. Models, patents, prototypes, test sites, designs, norms, trials and state of the art methods underpin the development of technical objects. The activities of this pole play a key role in the innovation process which results in useful products.

The Market Pole (M) - encompasses the state of demand, consumer characteristics, the nature of their needs and preferences, socio-economic levels of consumers, class and social organization, tastes, design styles and modes of living. Financial resources come into play as a means of end and intermediate users fulfilling their needs and signalling their demands along distribution and marketing channels. The market is a mode of organization and coordination for integrating demand for and production/supply of goods.

Traditional dissemination of innovation models assumed a linear flow from S to T to M and much S&T policy was based on that and related assumptions. In fact, the process is much more complex as reflected by the inclusion of two further intermediatory poles in the TENS model. These links between the S-T-M poles give rise to a much more flexible view of actors and transactions in the research results application arena. It is here that the idea of networks, dynamic and flexible, comes most actively into play.

Figure 1. Techno-Economic Network



The Transfer Pole (ST) - nurtures activities in both S and T poles and successive iterations in sharing of knowledge and contact between them. This often requires special interpretation and use of scientific and technological knowledge and perspectives not shared by core actors of the first two groups. The result is a process of transformation of objects in the scientific realm into technical objects such as patents, processes and equipment which lead to user defined products. A large number of institutional mechanisms, organizations, actors and agencies are brought into play to facilitate connectivity between S and T.

The Development Pole (TM) - is concerned with the production, distribution and marketing of products derived from S&T interaction and modified to satisfy specific user or consumer needs and demands. Much of the "value-added" activity and innovation takes place in this sphere.

This is, of course, a gross simplification of the overall R&D situation in practice and some degree of overlap exists between the S, T and M poles. Scientists can be associated with companies or become entrepreneurs, technologists may set up production facilities in scientific labs and a marketing company can be involved in science and technology. What should become clear is that many alliances are formed to achieve a variety of specific objectives and that these form and reform in a dynamic process of networks involving actors from across the spectrum of STM interests. The model stresses interconnectivity between the different actors and agencies involved in innovation and the unlikelihood of any one focus achieving "impact" in a user or market sense.

Although the TENS model was developed within an industrialized, capitalist economy and society, it can, with modifications be used as an outline for defining the linkages and processes of knowledge development and application in other contexts. I have not attempted such

applications specifically, but conceivably it could be applied to other cultures, ethnic groups, communities and production to consumption networks. By modifying the terms and defining the intermediary relationships that satisfy needs and make improved living standards and progress possible in each context, local, national or international, the model can be used as a conceptual tool in understanding a multitude of situations and how research-based knowledge can be effectively introduced. Too often in the past, emphasis has been placed on the role or product of one or two institutions and actors in competition with, or ignorance of, other complementary actors which should be partners in networks facilitating economic and social betterment. Nodes, linkages, flows and actors need to replace the more fixed ideas of compartmentalized disciplines, institutions, functions and roles.

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