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ABSTRACT

Organizational alternatives for a Pacific educational computer-communications network are studied through the examples provided by other networks. A survey of networks is provided with a discussion of the history and development of networks and the distinctions in network technology and applications. Nine specific networks are described. Libraries and education offer complementary network applications. An analysis of network applications follows in which summaries of advantages and disadvantages are given with an analysis of selected networks. The context of international development is examined from basic assumptions and a Pacific Rim network survey reveals that the conditions which promulgate computer network development are present. In the final section the actual organizational requirements, issues, and alternatives for development are addressed. This all includes the organizational requirements for project development, the determinations of participants, and policy-making, administrative, and operational structure, and a development model. (WH)

ORGANIZATIONAL ALTERNATIVES FOR
A PACIFIC EDUCATIONAL COMPUTER-COMMUNICATIONS NETWORK

BY

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Table of Contents

Page

PREFACE

The purpose of this paper is to provide a general background for the development of computer-communication networks for the non-technical reader. The specific focus is on establishing a foundation for considering the organizational problems of educational computer-communications network development in the Pacific Rim.

To provide some background for the consideration of networks, several networks concentrating on network technology as well as several concentrating on network applications are discussed. Important points of network development and operating organization are analyzed.

Background for international development is then discussed to enlarge the focus from U.S. experiences to the international environment. In this regard, some basic assumptions on the international environment and the results of an interest and capabilities survey for such a network within the Pacific Rim are discussed.

Finally, the requirements, issues, and alternatives involved in international network development are covered. Though the focus is on the Pacific Educational Computer Network, many of the points are universally applicable to network administrative development.

Other studies in this series cover the technical, economic, political, and sociological issues of Pacific Educational Computer Network development.

1. SURVEY OF NETWORKS

1.1. CONCEPTS AND CLASSIFICATIONS

1.1.1. HISTORY AND DEVELOPMENT

In the most general sense, computer-communications networks can be defined as arrangements of computers and terminal equipment devices interconnected by various means of telecommunications and appropriate interfaces. Though the concept of computer networking has been under serious consideration since the early 1960's [Baran], it was not until late in that decade that technological developments provided a concrete basis for actual network planning and design for widespread non-military use. Since then, research, development, and implementation of computer-communications networks have sprung up in commercial, governmental, and educational fields at continually increasing rates.

Historically, networks developed for data traffic were originally designed for military command-and-control systems where the emphasis was on the reliability and security of the communications lines, switching mechanisms, and computers to send, receive, and process data. Because the security of the nation was at stake, economic considerations were not a prime focus of these networks. The command-and-control networks prompted the study of alternative network configurations, many of which are in use today. These configurations borrow heavily from counterparts in electrical systems but until recently have been hampered in their development by the lack of functional components.

The first non-military application which contained the elements of computer-communications networks was Sabre, the American Airlines Reservations System. In light of today's state-of-the-art, Sabre's single computer supporting a host of terminals was a rudimentary network but nevertheless a lone successful large undertaking in the early years of terminal-oriented systems. Again, the reason for development was primarily efficiency in the handling of airline reservations rather than economics, a motive on which later systems were predicated.

Terminal-oriented timesharing systems continued to appear on general purpose medium-and large-scale computers in the 1960's but they suffered from ineffective implementation. The real cause was inappropriate hardware and software to support timesharing applications.

Timesharing was found to be more effective on dedicated systems and minicomputers. The low data rates used in terminal-computer communications made the terminal network a fairly successful, though somewhat limited, application. Actual computer utilization in the man-machine mode was very low because of the low speed at which man generates computer-readable data compared to the speed with which the computer can process it. A single computer,

properly mutiplexed, could accommodate a number of terminals, giving each the illusion of having the machine's total resources for a portion of the expense.

In the late 60's and early 70's, the large computers with telecommunications software appeared on the market. Single-computer networks with all terminals drawing from a single-source were the first step in the network development. Multiple-computer networks depending on dial-up connectability and no apparent hardware integration between the nodes were next to appear.

So far, network access and connectability was by agreement and standard telephone and hardwire hookups. The next phase was the multiple-computer arrangement with integration between the host computers. This required much more planning and technical development by the network designers.

Currently underway is the formation of a network of networks concept, using interest groups of computer users as the unifying device. This and the other development phases are described in more detail in the following sections.

The concept of effectively extending the use of expensive resources to those with a limited amount of funding was realized with the first timesharing minicomputers. This concept was easily extendable to sharing large, powerful computers as well as to specialized computer-based resources such as programs, data bases, and software. Sharing held promise because there tended to be a concentration of resources at institutions with higher levels of financial backing. The demand for use of these resources was widely distributed, sometimes not even within reasonable physical proximity of the computer.

It became apparent that if reliable communications could be established between the various types of equipment being operated by network computer centers, increased service levels and revenues could be attained on one hand, and a more wide-spread distribution of the resource could be effected on the other.

Resource-sharing, therefore, has been a major thrust behind many of the educational network developments. Reductions in the amount of subsidization received by academic computer centers has also given impetus to this effort in the United States.

1.1.2. DISTINCTIONS

Network terminology has borrowed heavily from mathematics and electrical engineering. In the process of adapting these technical terms to a new area, the various groups involved in network development have attached different shades of meaning to common terms. Two concepts in particular deserve clarification. These are: (1) the distinction between the resource-sharing network and the special purpose network; and (2) the division of network development into technical and applications areas.

In this study, the focus is on resource-sharing networks. The history of networks is replete with specific and limited interest developments. Airlines reservations networks, for example, service airlines. Academically-oriented networks have computing resources specifically established to handle scientific computation. Commercial networks offer business-oriented services. These networks were formed to service a particular clientele and to a large degree are tailored to meet the needs of that clientele.

The concept of resource-sharing implies a widening of scope in network development. Both the security and the status networks are specialized applications, with highly prescribed updating, inquiry, and procedures for usage. Resource-sharing networks, on the other hand, are conceived to be generalized and service a diverse clientele with an equally diverse set of resources.

The implications of resource-sharing are pervasive. The larger the range of services offered, the larger the network clientele has to be in order to support the communications, computation, and support service overhead attached to such a system. The critical mass necessary to support the network without governmental subsidies and the optimal mass are important considerations in the system design. Generalized resource-sharing will require solving compatibility problems between the various hardware devices in the network as well as providing direction in policy and coordination among the users. The resource-sharing network, therefore, implies a high overhead for connectability and effective utilization.

Developments in computer-communications networks fall into two major classes: network technology and network applications. In studying and planning network developments, it was useful to separate these two areas of activity. There was little overlap in the functions of each area and a review of existing networks suggests that more interaction and coordination during the systems design and development may have been beneficial.

Network technology covers the hardware and software associated with the development and operation of the physical network. This would include the computers, the communications, and the terminals in the network. Primarily, network technology is concerned with the means by which work gets done. People interested in this area generally have an engineering or technical background.

Network application, on the other hand, is the actual implementation of work using the network. This would include not only the utilization of the network itself, but also the coordination and administrative efforts necessary to make the network function effectively and economically. People interested in this facet of networking come from a variety of backgrounds and so far have tended to be more than casual computer users.

1.1.3. NETWORK SYSTEMS HIERARCHY

In perspective, the resource-sharing network concept is a logical extension of time-sharing systems. The historical development of computer systems illustrates how the resource-sharing network concept compares to other applications of computer and computer-communications systems. The general progression includes stand-alone batch computing, timesharing, primary resource networks, multi-resource networks, and networks of networks.

The most elementary level of the computer systems hierarchy is the stand-alone batch computer. Characteristics of this type of installation are self-contained equipment, software, and data with no telecommunications capability or hardware sharing. Theoretically, software can be shared, but only in the sense that it is somewhat transferable to hardware of a similar configuration. The only practical relationship to the resource-sharing concept, however, is the transferability of the data files.

Because single-partitioned and multi-programmed batch computers are essentially the same insofar as resource-sharing networking is concerned, no distinction is being made between them in this communications-oriented hierarchy. The IBM 1401 and the IBM 360/50 operating in a non-timeshared environment, therefore, would both fall into the same category.

It is interesting to note that, with some difficulty, an inexpensive manual method of resource-sharing can be achieved, though the interconnective property of networks is significantly missing. The Quantum Chemistry Program Exchange (QCPE) has collected and duplicated upon demand programs used in chemical research. The collection, duplication, and distribution processes of the QCPE have been carried out at Indiana University, but the service is tenuous because of the voluntary nature of the submissions and the lack of continuous funding for services. This operation more closely resembles a centralized clearinghouse rather than a network. It does, however, approach the problem of software sharing on a relatively inexpensive basis.

One step above the stand-alone batch computer is the single mainframe with timesharing capability which becomes the repository for campus or institutional computing resources. Typically this is a main university campus computing center which services terminals, remote job entry units, and other computers in addition to the normal central facility workload. There is no on-line sharing of the resources between the remote users, since all derive their computing resources from limited local capabilities and the one powerful central resource. This type of installation has, in some cases, been referred to as a network. Its classification as simply a timesharing system may be more appropriate, since it is primarily the facilities at the central resource that are being shared, not a system in which there is the interactive sharing of resources between the many users.

This type of timesharing system is distinguished from the resource-sharing network concept by administrative structure more so than by the technology linking the terminals and computers. A single administrative entity is involved when the resources of a central facility are being shared by the sub-units of the institution.

When several administrative jurisdictions combine their funds to centralize their computing resources, the concept of resource-sharing networks comes into play. Examples of this are TUCC, the Triangle Universities Computing Center in North Carolina, and the composite center proposal to serve the University of Southern California, California Institute of Technology, and University of California at Los Angeles. In these situations, the computing centers are servicing more than one administrative entity and the organizational and financial concerns become important. Essentially, the computing hardware funding for the major participants has been pooled to obtain a very large computer. This pooling makes the computing dollar extremely cost-effective because by economies of scale, the amount of computing power available from a larger machine exceeds what the individual groups could have obtained with their proportionate shares of the total budget.

This arrangement allows for each participant to maintain a certain amount of computing power at the local site and use both the local and the central computing resource, as they are most efficient for the particular application.

One level above the single resource center form is the small resource-sharing network. An example of this type of development is the MERIT Computer Network which links the computing centers of the University of Michigan, Michigan State University, and Wayne State University. The purpose is for these three universities to share and extend their computing resources. This network organization involves three separate self-sufficient computing centers and four administrative entities. It is a prototype for enlarged resource-sharing network development.

The critical factor in delineating the hierarchical levels thus far has been the degree to which computer resource-sharing is accomplished through telecommunications. By resource-sharing, not only computing power but the programs, the data files, and the associated human expertise are also shared. The OCTOPUS Network, developed at the Lawrence Radiation Laboratory, is a small-scale example of this concept.

The ARPANET development, linking dissimilar equipment of over 30 institutions spanning the United States, is the largest project in the computer-communications networking area. However, in its current state, it may more appropriately be considered as a means of telecommunications. The distinction is that the ARPANET provides the transmission means that make resource-sharing possible but it does not integrate the nodes of the network, e.g., the institutions and their specific resources, tightly into the

organization of the network. The subtle distinction between members of the network and the underlying transmission medium is foreseen to play a significant role in later organizational questions.

Progressing from the small resource-sharing network typified by MERIT alone, the evolution to larger regional groups seems natural. There are no specific larger general purpose regional developments underway in the United States at this time though there are studies for special interest nets. The National Science Foundation is sponsoring this type of research, as are the National Institute of Health and several subgroups in chemistry and education.

Assuming that larger regional organizations and geographically dispersed special interest networks evolve, a proliferation of resource-sharing networks with different organizational structures and practices may emerge. The resources available through linking the various networks are worth consideration

We approach the problem, then, of the organization of a meta-system which would encompass the various special and regional networks. The goal is to provide a basis for the voluntary integration of a number of different entities. Before examining the objectives and problems of such a supra-organization, a brief description of several kinds of networks will be covered.

1.1.4. DISTINCTIONS IN NETWORK TECHNOLOGY

Network activity has previously been separated into Network Technology and Network Applications. Figure 1.1 shows the components of each area.

Network technology is concerned with the design and development of the hardware and the software for network operations. Further references to the categories summarized here can be found in the bibliography.

Network hardware includes the computers, the communications system, and the terminals. In a network configuration, the computers are classified as either resource computers or remote job entry computers. Resource computers are those which have specialized processing capabilities or large computing capacities which can be made available to other users through the network.

As illustrated under shared computing arrangements, the availability of large computing resources reduces the need of the individual campus centers to have large processing facilities. Instead, remote job entry sites may be an adequate complementary configuration. Remote job entry stations, minicomputers, or scaled-down larger computers with limited local capability are examples of complementary computer-class hardware in the network environment.

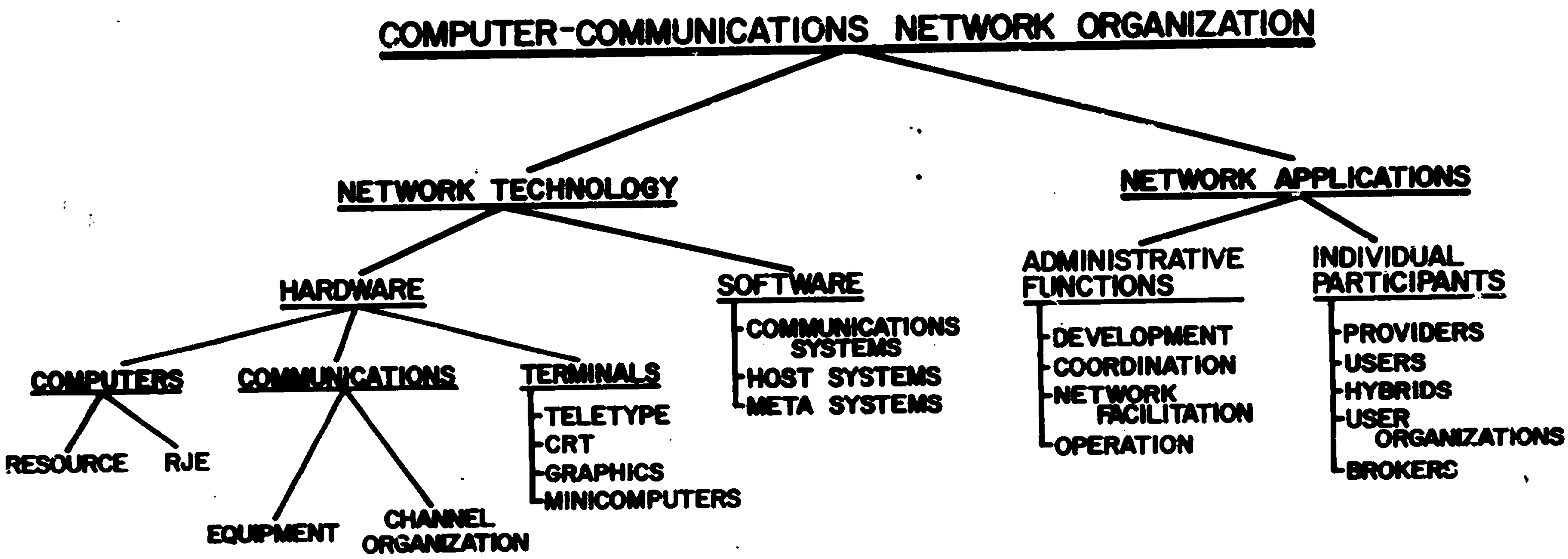

COMPUTER-COMMUNICATIONS NETWORK ORGANIZATION
NETWORK TECHNOLOGY
NETWORK APPLICATIONS
HARDWARE
SOFTWARE
ADMINISTRATIVE FUNCTIONS
INDIVIDUAL PARTICIPANTS
COMPUTERS
COMMUNICATIONS
TERMINALS
RESOURCE
RJE
EQUIPMENT
CHANNEL ORGANIZATION
TELETYPE
CRT
GRAPHICS
MINICOMPUTERS
COMMUNICATIONS SYSTEMS
HOST SYSTEMS
META SYSTEMS
DEVELOPMENT
COORDINATION
NETWORK FACILITATION
OPERATION
PROVIDERS
USERS
HYBRIDS
USER ORGANIZATIONS
BROKERS

Figure 1.1

The communications hardware would involve the equipment required to send, receive, and transmit the data. Initially dependent on the telephone land line system, data transmission is now being carried out using microwave or radio channels as the medium. Satellites are also being used, but not currently in a way particularly advantageous for data transmission. Research necessary in the satellite transmission area covers new methods of using transponder equipment and organizing the transmission channels to more effectively handle data traffic.

The communications system would include everything not belonging specifically to the host computers or to the user sites for local operation. This would, therefore, include the interface mechanisms for connecting the users and hosts to the network, the transmission channels, the transmission devices, whether they be conventional store-and-forward nodes or satellites, and the data distribution/collection mechanisms, e.g., the ground stations.

Classified under terminals would be the conventional teletypes, the cathode ray tubes, graphic plotters, and minicomputers. Though minicomputers operate well as input devices and in the communications systems as the multiplexors and signal generators, they can also be well adapted to the terminal context as installation-operated data concentrators. The development of new types of terminals, such as hand-held sets are also included here.

Network software includes development of the nodal, network, and meta-network levels. At the nodal level, each host installation is assumed to have its own conventions for operations. Each node, then, has to resolve the conflicts with network level operations before it can function as a part of the network. One method for accomplishing this is by the development of interfaces, which translate network transmissions into a form that can be used by the host computer and vice versa. A similar operation has to be performed at the user sites. In the present state of the art, separate programs for each type of connection equipment have to be written.

At the network level, two types of software appear to be necessary. One is the internal language by which the technical personnel of the network communicate. Embedded within this internal language would be the standards for communication in the network. In addition, a higher level language which gives users a simple mechanism for accessing the network facilities is required.

In addition to the nodal and network software, it is conceivable that interconnections to other networks may exist, in which case a software system which performs this interface may be necessary. This type of connection has been tried on a limited basis, but for extended applications, more effort would be required for smooth and consistent internetworks operations.

1.1.5. DISTINCTIONS IN NETWORK APPLICATIONS

Network utilization involves two classes of application. One is the network administration, which is concerned with the development, coordination, facilitation, and operation of the network. The other is the group of individual participants, the suppliers and the users of the available resources.

Network administration is separate from the technical operation of the network. It is primarily involved in organizing the users and suppliers in such a manner that utilization of the network is effective. In order to do this, some direction and assistance in the use of the network must be available and coordinated among the many participants. Further, the ground rules for network usage must be established and administered--protocols, accounting, and priorities fall into this area. The interface with technical network operation is also highly important.

The individual participants can be users, providers, or both. As individuals, they are considered separate administrative entities in the network. However, groupings which overlap the basic entities will tend to emerge. For example, a National Center for Theoretical Chemistry has been proposed. This center would be a national computing resource for theoretical chemists. To adequately service the clientele of this resource, the traditional administrative entity would be a poor target group and focusing on the special interest group would be more appropriate.

Groups of special interest groups can provide an articulation of the concerns of the users of the networks. These meta-organizations may provide another form of clientele within the network that should be recognized.

The providers of services also have options for hierarchical organization within a network. The distinction between supplying raw computing power and being the broker for this power has emerged in some jurisdictions. In some cases, the distribution and sale of excess capacity for several installations is handled by a separate organization, which also provides user services.

Because of the many options available for both hierarchical and network organization in the context of resource-sharing networks, it is difficult to assign a strict hierarchy to network applications.

1.2. NETWORKS

1.2.1. OVERVIEW

Local and regional networks have had the longest history of operation, thereby providing a good basis for retrospect and analysis. The several networks being examined here were selected because of their development patterns, organizational strategies and resulting degree of success in operation. The target of the survey is to identify those factors of network development which contribute significantly to the success of a smoothly running operation and to detect those weaknesses which have caused others to only marginally achieve their objectives.

The networks which were surveyed were the Dartmouth Time Sharing System, the New England Regional Computer Program, Chi Corporation, the ARPA Network, the Canadian University Computer Network, the Triangle Universities Computation Center, MERIT, UNI-COLL, and the Japanese University Computer Network.

All of the networks surveyed are in operation or are being planned. The network development strategies are well-represented, as are the organizational concepts of centralization and decentralization.

In general, the networks offer the computation and user services and the specialized common carriers offer the data transmission capability. This is often transparent to the user. Though the separation of data transmission from other network activities currently exists in the local and regional networks, the distinction has become blurred in national networks. This occurs because of the fragmented approach to computer communications systems generally adapted in smaller implementations.

The survey of networks which follows focuses on the development patterns of the selected networks. These networks were selected because of the significance of their concepts and organizational development patterns. Enough network research is being conducted today that the results of other studies were used in addition to interviews with the selected network administrators.

1.2.2. DARTMOUTH TIME SHARING SYSTEM

The Dartmouth Time Sharing System (DTSS) is particularly interesting because it was one of the first educational timesharing

systems developed in the United States. As the forerunner in educational computing, Dartmouth devoted much attention to the philosophy and approach of systems implementation.

The Dartmouth Time Sharing System was initiated in 1964 with 3 users. By 1971, it was the largest educational timesharing system in actual operation, capable of servicing 160 simultaneous users at Dartmouth College and other institutions in the New England states.

Behind the development of DTSS was the philosophy that understanding the capabilities and limitations of computers was an important part of the education of a college student and a valuable asset in his later life. Therefore, the decision to provide free availability to the computer was made and computing became a standard part of the education of the Dartmouth student.

The decision was not trivial in terms of effort. The primary focus was on the student. The system development therefore had the requirement of facilitating the use of the computer for the non-engineering student. The BASIC language was developed for this purpose.

Systems design and implementation were not without financial constraints. The decision was made to use conventional hardware, communications, and terminals, leaving only the software system to be developed. The Dartmouth undergraduate students did most of the software development of the initial system. In later versions of DTSS, a team of engineers from General Electric designed and programmed a timesharing system with the aid of Dartmouth students. This development was commercially marketed as the GE MARK II Time Sharing Service.

The significance of this phase of development was that the student and his acceptance of the use of the computer were primary goals of this project. The concentration on satisfactory software to achieve this end was reflected in the attitude of the developers: simplifying the user interface by using standard equipment; making the learning process easier by developing a new language, BASIC; and making access to computer terminals free and convenient. Once the major problem of recruitment of users was solved, the technical developments received more attention.

Networking was begun with the support of National Science Foundation grants. Sporadic use had been made of Dartmouth facilities by other schools and colleges until NSF grants helped finance staff and curriculum development materials that would make the system attractive to other schools and colleges. A study demonstrating the effectiveness of the networking idea concluded that: 1) distributed timesharing services were economically acceptable to schools operating on modest budgets; 2) the startups of systems were discouraging but there were no serious technical problems; 3) communications technology and pricing, based on the

telephone system, did not impose economic problems on a network of DTSS's geographic size; and 4) non-availability of an adequate supply of curriculum materials prevented teachers from using the network in their courses extensively.

In addition to computational resources, DTSS also provides user services, data bases, and a software library for its use.

Administratively, the Dartmouth Time Sharing System is an incorporated entity. Incorporation has given it the freedom to pursue network and computer developments which are not always administratively feasible under the college institutional structure. The subject of incorporation is discussed more fully in the section on the Triangle Universities Computation Center.

An interesting administrative arrangement for networking is the relationship that DTSS has with the New England Regional Computing Program (NERComP). DTSS is a network in itself, servicing a clientele in the New England area. NERComP is a broker and coordinator of computing power usage, also operating in New England. DTSS is a supplier of NERComP computing power. In essence, the arrangement is that of a network within a network.

Because of the use of conventional communications equipment the internetwork connections present no substantial technical problems. The financial arrangements are also clean, with DTSS billing NERComP for services rendered to any of NERComP's clientele and billing any of its own clientele individually.

The significance of this relationship is that the seeming inflexibility that some institutions have toward inter-organizational arrangements has been overcome by administrative arrangements and positive attitudes toward the sharing of resources.

Of some interest is the data bases which are available for use by all DTSS users. IMPRESS, a social science data base system, gives its users access to 40 different files through an interactive approach. The user is prompted for responses, which make the material he needs available to him. Again, the philosophy of servicing the user is the intent --- provided with the data is a series of standard analysis routines, giving the student the capability to develop and test his own hypotheses without extensive programming.

In addition to student services, which are usually for small jobs requiring rapid responses, DTSS also provides research services, data base services, administrative services, text editing, and canned program library.

In summary, DTSS is a simple teletype-oriented network with one server providing resources for many users. Its interesting characteristics are (1) initial user orientation philosophy; (2) grant-supported development pattern; (3) distribution of services to a regional base; (4) emphasis on reliability and transferability as means of network extension; (5) technology-imposed geographic constraints; (6) technology-imposed resource-sharing limitations--terminal-oriented; (7) open-minded attitudes toward expansion of services; and (8) ability to respond or pioneer enhanced by incorporated status.

1.2.3. NEW ENGLAND REGIONAL COMPUTING PROGRAM

The New England Regional Computing Program (NERComP) is a not-for-profit organization which promotes communal use of computer hardware, software, and personnel for better utilization of regional computing facilities among the institutions of higher learning in the New England area.

Historically, the network began as an independent project establishing the New England Regional Computer Center at the Massachusetts Institute of Technology in 1965. It was continued as a regional computing facility until 1968, when the NERComP project was undertaken. Since 1970, it has existed as NERComP, Inc., a nonprofit organization which gets services from suppliers and distributes them to users.

The user clientele of NERComP is made up of 42 colleges and universities which contract for computer services offered by six major university-based computing centers. These resource centers offer a wide range of computing power and capability.

The resources include a Hewlett-Packard 2000A at Babson College, a PDP-10 at Bowdoin, a CDC 3600 and a CDC 3800 at the University of Massachusetts, a GE-635 at Dartmouth, and an IBM 360/67 at Brown, and the dual GE-635 MULTICS system at the Massachusetts Institute of Technology.

In addition to hardware sharing, software and data bases are also available to members of the network. For example, IMPRESS, the large social science data base at Dartmouth College, is available to users of the Dartmouth System.

The NERComP network concept was aimed at providing computational capability to smaller colleges whose needs could not justify the establishment of individual computing centers. Until the inception of NERComP, the alternatives available to these limited computer users were: (1) linking to computers of larger universities and incurring substantial communications charges; (2) using commercial timesharing services, which were not particularly oriented toward educational problems; or (3) using the facilities of a national project, incurring turnaround time running into weeks.

The NERComP experience has highlighted several things in the administrative and organizational development of networks. These are: (1) the relationships between users and suppliers; (2) the function of the network; (3) the development and maintenance of the critical mass of participants; and (4) a cost structure which is based on operational rather than experimental usage.

As the intermediary between the users and the suppliers, NERComP functions as a facilitator of services and as the mechanism for settling financial accounts. The services of the resource computers are made available through a circuit-switched network which offers toll-free connections between the users and the computers. Further, NERComP has developed a series of learning materials through which network users can learn to use the facilities. These include terminal-based tutorial on NERComP equipment; a set of manuals which introduce the user to the methods and procedures utilized at each of the resource centers; and a series of seminars on both applications and programming.

As the network administrator, NERComP maintains the accounting between the various network participants, collecting from the users and reimbursing the suppliers. NERComP itself receives funding support from the National Science Foundation.

In addition to brokerage and facilitation activities, NERComP is also planning hardware facilitation by network and host computer accessibility through any type of terminal and through a single telephone number.

In terms of relationships between the users, suppliers, and among themselves, the existence of the network is considered to be a short-term solution to the fulfillment of the needs of the have-nots. Because no long-term commitment is entered into by either the supplier or the user, the rate of computer usage becomes a tenuous figure. Some implications of this arrangement is that the regional network may not be the ultimately efficient or effective resource for the users. With increasing experience, they may establish local service or utilize mini-computers.

Even among themselves, and with the different computing capabilities at different rates, there has been little in the NERComP experience to encourage sharing among the suppliers. NERComP is a terminal-oriented network and the communications charges may still encourage timesharing on the local campus if any alternatives for sharing exist.

The functions of the network have turned out to be executed largely independent of the participants. As such, the suppliers have not been deeply involved in providing technical and consultative services. From the viewpoint of the suppliers, the resource centers have not been encouraged to cooperate rather than compete.

The development and maintenance of a critical mass of participants is related to the question of financial structure. The network is almost self-sufficient, with an annual dues income of

$18,000 and a monthly gross revenue of $7,000-$8,000, which is below critical mass stage.

The critical mass depends highly on recruiting the requisite number of participants to make the network a self-sufficient operation. The deficiency in the process appears to be in the marketing of services to prospective users. It does not appear to have worked when done by an organization which is external to the sellers of the services themselves or when economic incentive is lacking. It has been suggested that either the marketing responsibility revert to the local networks or be injected with commissions to build the network to the point of economic viability.

The cost structure, while not exceedingly sophisticated, offers an example of network accounting, an aspect of administration not well worked out in other networks. The simplicity of the structure may account for part of its understandability.

Essentially, any four-year accredited college or university in the New England area with at least 500 students can apply for membership in NERComP. Membership dues range from $200 to $800 per year, depending on the number of full-time faculty members. With membership, the users are entitled to choose a leval of computing services and this agreement is formalized in a contract. The level one contract allows users access to the centers using mini-computers; a level two contract covers access to the level one computers as well as the medium-sized computers. Level three contracts allow access to all six computers. For most users, the number of hours used on these computers is not restricted throughout the length of the contract, which may range from one to twelve months.

The expenses accruing to the prospective user include the membership fee, the contract fee, terminal rental at approximately $65.00 per month apiece from a commercial vendor, the installation of a business telephone, and a minimal line sharing charge at the maximum of $2.00 per month.

As with other applications which are implemented on a regional basis, NERComP experiences are somewhat limited by geographic considerations. The level of services exchanged, as indicated by the monthly and annual gross figures, is not particularly high. The most interesting feature may be the flexibility it allows its participants in being one of the alternatives using standard interfaces, not trying to be the only alternative available.

1.2.4. CHI CORPORATION

The Chi Corporation was formed as a solution to funding problems for computing at Case Western University. Chi is a profit-making organization which services both educational and commercial users and governmental users. Chi purchased a UNIVAC 1108 and contracted with Case Western to provide its computing needs for four years. In addition, a large research contract with an industrial

organization for three years gave the new corporation a financial base that allowed it to borrow the money to purchase its equipment.

Chi has a Board of Directors which is made up of industrialists and persons connected to the University. The staff of hardware and software specialists came from the University's computing center, and the know-how in sales and management of a profit-making organization had to be recruited. The clientele that made up Chi's customer base was diverse--the usual university demands coupled with a wide range of industrial customers.

The computing center at the university was revamped to cater to research needs and these activities were removed from the general purpose Univac and placed on a larger PDP-10. The Director of this campus center also is responsible for the University's relations with Chi, including maintenance and educational policy questions.

It took Chi three years to reach a break-even point on its equipment. As a corporation, it has been quite successful, having built its base to 150 customers and $2 million in operations. The operation has achieved many of its objectives but the task was more difficult than anticipated.

The interesting aspect of Chi's development is that the profit-making motive and recruited business experience worked toward providing educational requirements in a self-sufficient manner, whereas other institutions have banked on the non-profit organization form. Diminishing educational discounts for computing equipment may influence the establishment of more profit-oriented operations.

No data was available on the degree of academic satisfaction with Chi's services.

1.2.5. TRIANGLE UNIVERSITIES COMPUTATION CENTER

The Triangle Universities Computation Center is located at Research Triangle Park, North Carolina. It provides Duke University, North Carolina State University, and the University of North Carolina with information processing services for education, research, and administrative activities.

TUCC was established as a joint computing resource of the three North Carolina universities when their projections showed increasing computing requirements and a corresponding inability to meet the increased costs. By combining their requirements, they were able to take advantage of economies of scale which accrue to the lease or purchase of large equipment configurations.

The TUCC network was developed to: (1) provide each of the institutions with adequate computation facilities as economically as possible; (2) to minimize the number of systems programming personnel needed; and (3) to foster cooperation in exchanging software and ideas

among the three universities. In addition to providing services to the three universities, TUCC also sells computing power to the North Carolina Educational Computing Service (NCECS), which in turn sells computing capacity and user services to other private and public institutions of higher education in North Carolina.

Administratively, the Triangle Universities Computation Center Corporation is a non-profit organization owned by Duke University at Durham, North Carolina State University at Raleigh, and the University of North Carolina at Chapel Hill.

It is governed by a nine-man Board of Directors which is composed of administrative officials, fiscal officers, and computer center personnel from each of the three universities. The Board meets once a month to determine matters of general policy. The Director of TUCC, the Associate Director, and the Systems Manager are included at these meetings. The computer center directors of the universities and the Director of NCECS are also invited.

In addition to policy level meetings, Campus Center Directors' Meetings and Campus Systems Programmers' Meetings are also held on a monthly basis. These insure communication and coordination between the operations and software personnel of the centers.

The TUCC staff itself is divided into Systems Programming, Operations, and Information Services. Systems Programming is responsible for the installation and maintenance of operating systems. Operations is responsible for the continuous operation of the machine room and building security. Information Services is responsible for the collection and dissemination of important information to users, campus center directors, and the Board of Directors on a timely basis. Formal documentation for all TUCC users is edited and distributed by Information Services.

The center of the TUCC hardware configuration is an IBM 370/165. The three universities operate IBM 360/40, 360/40, and 360/75 as primary job entry nodes. The job entry nodes also serve local telecommunications requirements. Approximately 200 terminals and numerous secondary RJE points are also attached to the network.

TUCC is located at Research Triangle Park, geographically situated between the sponsoring universities, which are between 10 and 15 miles away. The university computers are connected through Telpak-A lines. Fifty other educational institutions serviced through NCECS are connected through a variety of equipment and arrangements.

With regard to financial arrangements, TUCC was initially funded by grants from the National Science Foundation and the North Carolina Board of Science and Technology and from the funds of the three sponsoring universities.

Its present income is derived from the wholesale distribution of computing power to the computing centers of the three universities and to NCECS. These organizations perform the billing

and accounting for all services they distribute. At the current time, each of the three universities and NCECS each pay 25% of the TUCC budget. Every two years, this figure is renegotiated between the three universities. A computer algorithm maintains statistics on usage by each of the participants and perform priority leveling in accordance with the amount of service already rendered. Because their funding is guaranteed, the three universities receive their services at a rate which is lower than that of NCECS.

The interesting factors of TUCC development are: (1) a relatively successful network operation based on strong central technical services and decentralized user services; (2) a strong user services component developed independently by NCECS, who retails computer and user services to all non-TUCC members; (3) the transition from separate centers to network development and full self-sufficiency in two years; (4) the very close relationship between the participants in the policy-making and administrative structure; (5) the stress on interpersonal communications; and (6) a geographically separate location, deliberately chosen to be independent from each of the participants.

1.2.6. MERIT

The Michigan Educational Research and Information Triad (MERIT) is a network formed for the purpose of prototype resource-sharing in Michigan. Three universities, University of Michigan, Michigan State University, and Wayne State University, are cooperating in this experimental effort to determine the feasibility of sharing.

Funds for the development of MERIT were provided by the State of Michigan and the National Science Foundation. The objective of the MERIT research is to gain knowledge about the possible solutions to the problems of network operation in an established educational environment. Specific benefits of the concept include the augmentation of computing resources of each institution with those available elsewhere in the network; the sharing of human achievements of each of the institutions through the network, including software, data bases, and special programs; and the joint-development of computer-aided instruction programs.

The project has been successful in setting up a communications sub-network for the transmission of data traffic between the schools and is attempting to define and work out solutions to the administrative and financial problems which have emerged in the development.

The policy-making and administrative machinery of MERIT is somewhat complicated. The policy-making structure is composed of three entities--the Michigan Interuniversity Committee on Information Systems (MICIS); MERIT, Inc.; and the Joint Executive Committee.

MICIS is composed of representatives from Michigan State University, the University of Michigan, and Wayne State University who banded together to facilitate maximum interaction and effectively and significantly relate the efforts of the three universities in the broad area of information processing and exchange by computer and other electronic media. One of the specific objectives was the development of a prototype statewide computing network to determine the contribution of such a network toward improvements in learning and teaching in higher education.

MICIS serves as an unofficial Board of Directors for MERIT. Though MICIS has no real power, its membership is made up of vice-presidents of the three universities, computer center directors, and senior professors. Membership from each university is limited to four. The MERIT Director is an ex-officio member.

The Michigan Educational Research Information Triad, Incorporated (MERIT, Inc.) is a purely administrative mechanism for channeling non-state funds into the organization for network development. Its make-up is identical to the Joint Executive Committee.

The Joint Executive Committee was formed to seek and receive state funds for the network on behalf of the universities. It is composed of vice-presidents of each of the universities.

Administratively, the components are the MERIT Computer Network Project and the Fiscal Agent.

The MERIT Computer Network Project was formed to develop a prototype network to share and extend the educational and research facilities of the participating schools. The Fiscal Agent receives and disburses all funds at the request of the MERIT Project Director and subject to the approval of MERIT, Inc. and Joint Executive Committee.

Essentially, MICIS recommends action to MERIT, Inc./Joint Executive Committee, which then enables the action by securing the necessary funds. The work is done by the MERIT project.

The MERIT Project organization is constructed to service three major functions: (1) educational and promotional; (2) research and technical development; and (3) financial administration. Educational and promotional activities are carried out by three Associate Directors, who are located at the three campuses. These Associate Directors have the responsibility of encouraging and promoting network usage at their campuses; they also assure that network implementation and performance are satisfactory on their campuses. There is no formal relationship between the MERIT Associate Directors and the campus computing center directors.

Research and technical development activities are carried out by four groups - the Network Central Staff and network staffs at each of the net sites. These groups are collectively responsible for the integration of the network's technical components and for the programming subsequently involved.

Financial administration is carried out by Wayne State University. The multi-institutional project requires continuous attention to the problems of the receipt and distribution of network funds.

Network computing resources include a CDC 6500 at Michigan State University, an IBM 360/67 at the University of Michigan, and another IBM 360/67 at Wayne State University. Telecommunications capacity is currently 2000 bits per second on voice grade lines. The interface equipment can handle 50 Kbps. Automatic dial-up procedures are being used rather than dedicated lines but the change to point-to-point transmission is imminent.

MERIT's administrative arrangements have some interesting premises. First of all, the autonomy of the local computer center is regarded as extremely important. In preserving this philosophy, the administrative structure of the MERIT network gives the computer center director the decision-making power to determine whether a job is to be sent out to the other network nodes for processing or not. The wholesale-retail concept is embodied in this. The local center is envisioned as a wholesaler, in that it has computing capacity to sell, and as a retailer, in that it has to distribute the capacity to its users. It can assign different rates to these external services if it is appropriate.

The second premise is that "the success of the network is directly proportional to the volume of the exchange resources." In other words, high transmission of data between sites is the measure of success. This measure of success compliments the ability of the technical transmission network but does not necessarily indicate that the quality of the resource exchanges is good or cost-effective.

At this point in the MERIT development, the project personnel see their role as the technical developers of the network. The hardware development for interfacing telecommunications equipment was contracted but project personnel did all software development.

The interesting observations about the MERIT network are: (1) that the three universities joined in an effort to share their resources, which were different enough to offer the use of more effective equipment and systems; (2) that, having gone operational in the summer of 1972, MERIT has still not reached maturity. Its development pattern indicated that the incentive for sharing was not present because funding was extremely tight in each of the local centers; (3) that the potential for sharing was present, but there appeared to be a rivalry between the centers and close cooperation between them was elicited only through previous personal contact; and (4) that MERIT is seeking smaller college entry into the network to create increased needs on the assumption that this would alleviate the apprehension caused by the possible net loss of funds under the three university structure.

1.2.7. UNI-COLL

The information that was received about UNI-COLL was incomplete but it is being discussed because its development pattern offers some unique experiences. UNI-COLL was formed to provide computing services to the institutions of higher learning in the Delaware Valley. Its principal customer is the University of Pennsylvania, which disbanded its own computing facility to take advantage of possible economies offered by the consolidation of resources of many smaller institutions.

The University of Pennsylvania provided the funding base necessary to establish UNI-COLL operations and an IBM 370/155 was secured as the central processing computer. Policy-making was the responsibility of a Board of Directors made up of representatives from participating schools. UNI-COLL was administered as a non-profit corporation consisting of a group of technical specialists who were physically and organizationally distinct from the participating institutions.

The particularly interesting factor in UNI-COLL development is that emphasis was placed on operating an educationally-oriented installation in a self-sufficient manner. The philosophy of financing the operation maintained the rate of charges at pre-network levels until such time as revenues warranted their reduction. This policy had two important ramifications: (1) that the principal funding institution received no benefits from having entered into a network arrangement; and (2) other schools, because of the relatively high charges for computer usage, were discouraged from commiting their resources to UNI-COLL. The result was that the machine capacity was grossly under-utilized.

Conclusions about UNI-COLL experience are that (1) even when a relatively "captive" clientele exists, the mechanism of the market place is prevalent and that (2) unless network services are made reasonable and truly cost-effective, they may never achieve their potential cost-saving capabilities.

1.2.8. ARPA NETWORK

The ARPA Network is a project sponsored by the United States Advanced Research Projects Agency. Its main purpose was to determine the feasibility and characteristics of packet-switched networks and multiple computer resource-sharing.

The ARPAnet is nation-wide in implementation. Linkages have also been established to Europe and to Hawaii via satellite. Over 40 computers at 30 different sites are linked by the network, with connectability provided by a common transmission network and interface computers, which translate the local site coding conventions into network standards. Both computers and terminals can be connected to the network through devices called Interface

Message Processors (IMPs) and Terminal Interface Message Processors (TIPs).

Administratively, the ARPA network was developed under the direct supervision of the Advanced Research Projects Agency. Since ARPA is primarily a funding agency and not a project development agency, the development was contracted out. Bolt Beranek and Newman was the primary contractor in technical network development. It continues in the role of the technical manager of the network, even though many of the precise administrative relationships have not been spelled out.

Operations management for the ARPA communications network has been turned over to the USAF Range Management Laboratory at Patrick Air Force Base. Other administrative groups active in the network are the Network Control Center (NCC) operated by Bolt Beranek and Newman for network monitoring; the Network Measurement Center (NMC) at UCLA, which analyzes the performance of the network; and the Network Information Center (NIC) at Stanford Research Institute, which provides information and reference data to network users.

There are also a host of user groups which meet periodically to facilitate the use of the network. Among these groups are the Computer Based Instruction Group, the File Transfer Protocol Interest Group, the International Packet Network Working Group, the Information Center Network Liaison Group, and the Speech Understanding Research Group.

Computer hardware available in the network is diverse, since part of the ARPA goal was to link dissimilar equipment. Some of the computers available through the network are MULTICS at the Massachusetts Institute of Technology, the IBM 360/91 at UCLA, the Burroughs 6700 at the University of California at San Diego, and a group of PDP-10 configurations supporting TENEX, a Bolt Beranek and Newman software system. File transfer experiments and other time-resource-sharing applications are being tested on TENEX.

Communications capability is provided through the Defense Commercial Communications Office (DECCO), which is the administrative mechanism for dealing with the common carriers. Technical connectability is coordinated through the technical network manager, Bolt Beranek and Newman.

Of particular interest in the ARPA network development is the scope of the project. Its objective was to create a nationwide network of data transmission facilities and to link into this network many types of dissimilar equipment, thereby providing the vehicle for widespread resource-sharing. It has succeeded in establishing the technical network which supports these objectives.

Unlike regional projects, however, it did not suffer from funding and provincial constraints. Because of its internal agency support, it had the resources necessary to fully develop and test the network design and performance. It also had the necessary

funding to support levels of testing necessary to initiate network transferability and voluntary resource-sharing, a characteristic which was force-fed in most regional developments.

In the context of this study, the ARPA network was considered an exception to the rule because of highly subsidized development. The administrative aspects of the project were not the subject of much attention, though the technical development was highly significant.

1.2.9. CANUNET

Now under study in Canada is the Canadian University Computer Network (CANUNET). Among the technical points considered are the possible use of ANIK, the Canadian satellite, as a transmission medium; standard message lengths to enable future interconnection with the ARPA network; and fixed paths rather than the alternate routing scheme developed for ARPA.

CANUNET is expected to link provincial universities from the east coast to the west coast of Canada. Partipant universities were preliminarily selected on the bases of number of full-time students of institutions which had expressed interest.

Because of the recent nature of CANUNET developments, only preliminary report data was available during this study.

1.2.10. JAPANESE UNIVERSITY COMPUTER NETWORK

Japanese activity in academic computer networking began in 1965 when a large regional computing center was established at the University of Tokyo. Today, there are 78 national universities, 32 public universities, and 294 private universities located in 7 regions in Japan. In each region, a large university computer center has been established to service the academic and research needs of the faculty, graduate students, and engineering students of the universities in the area. Both time-sharing and remote job entry services are available.

The development of the large central academic processing centers was supported by the Ministry of Education on the advice of the Japanese Science Council. Six other district centers were established between 1968 and 1971. Future plans call for the linking of these centers and the sharing of processing capability and data bases.

Telecommunications transmission speeds range from 50 to 2400 bps, depending on the application. Terminal-oriented transmission goes up to 1200 bps to accommodate CRT displays; remote job entry units use 1200 to 2400 bps. All telecommunications capability is furnished by Nippon Telephone and Telegraph.

Japan plans to complete the interconnection of all of its academic centers by 1975. All of the computers being used are of Japanese manufacture but use standard programming languages such as FORTRAN, COBOL, PL/1, and ALGOL. Tohoku University has worked with the University of Hawaii to produce the capability to link the two using a combination of the ATS-1 satellite and Telex connections. The Japanese universities appear enthusiastic about international networking possibilities.

Academic networking in Japan is highly influenced by the government. The centralized nature of the government and its power to set policy enhance the ability of Japan to establish the networks, whereas in the United States, the mechanism for networking is largely one of gaining concensus among the many involved parties.

1.2.11. SUMMARY

Network development, both in the United States and in other nations, has concentrated on the provision of the technical system necessary for concentration of computing power and its distribution through communications lines. Except for the ARPA network, most of the implementations have had financial constraints which have strongly influenced their patterns of development. Though the potential benefit of networking can be substantial, experiences have shown that the results do not always live up to expectations. Additional comments on the networks are presented in Part 3.

Whereas network development is heavily concerned with technology of networks, the next section examines uses of networks.

2. COMPLEMENTARY APPLICATIONS

2.1. OVERVIEW

The development of computer-communication networks offers opportunities for exploitation of not only computation-oriented applications but for other large systems of data usage as well. Systems supportive to knowledge-based processes have been implemented to a considerable extent and illustrate the possibilities for computer-based services within a network. The fields in which these supportive applications are most advanced are library search and cataloging assistance, computer-aided instruction, computation, and biomedical literature searching.

Computer-communications networks have also been incorporated in the concepts and implementation of resource-sharing systems in specialized disciplines such as physics, chemistry, engineering, and economics.

Whether the networks are a resource of the applications or whether the applications are a resource of the networks depends on the provider of the services. The relationship, however, appears to be extremely symbiotic and cooperative development can lead to the mutual benefit of both interests.

2.2. LIBRARIES

2.2.1. OVERVIEW

In their role as the prime repository of information on university campuses, the ability of libraries to service the academic community is critical. The libraries are currently facing increasing expenditures due to expansion in their scope of services and in increased operational costs.

Librarians have reexamined the mission of libraries in a rapidly changing society and an evolution of attitudes is in evidence. As society becomes more complex, an increased reliance is placed on the dissemination of information. As the function of information dissemination mechanism becomes increasingly important, in the view of the librarians, so does the function of the libraries. The attitude of the libraries has therefore shifted from being the passive keepers of information to being active participants in the user's need for information by anticipating, locating, and retrieving.

In addition to philosophical changes in the function of the library in society, the costs of providing services have risen. The generation of materials brought on by the information explosion and rising personnel costs in this labor intensive operation contributes to the problem.

Using present techniques of processing library materials and rendering service, the costs of continued operation increase at an unacceptably high rate. A radical change in the methods of library operation, taking into account new technologies, is considered to be essential to the survival of some libraries.

Several library networking projects are examined, including the New England Library Information Network, the Ohio College Library Center, and BALLOTS, a project which is being conducted at Stanford University.

2.2.2. NEW ENGLAND LIBRARY INFORMATION NETWORK

The New England Library Information Network (NELINET) was conceived in 1965, during a period of accelerated physical growth for New England universities. To meet the demands placed upon the university libraries by growth, program expansion, and a quest for quality, growth rates exceeding 20% per year in some cases were projected for the libraries. There was serious doubt as to whether the processing of library materials could keep up with this growth.

The six New England state universities decided on a cooperative approach toward meeting regional needs and simultaneously solving their individual growth problems. The NELINET concept was developed to provide a regional computation and communications system to assist in technical library processing. This includes most of the activities involved from the time the decision to acquire a book is made to the time it is placed on the shelf for use.

It was in the area of increased technical processing that the libraries expected the greatest workload. Systems studies indicated that the libraries had common goals and similar collections. Forty percent of the holdings were duplicated, indicating that regional sharing was feasible and economical.

The services provided by NELINET to the individual libraries include the creation and maintenance of a machine-readable catalog; the production of catalog cards, book pockets, and book labels; catalog searching; and order processing. NELINET was designed for input-output compatibility with the Library of Congress Machine Readable Catalog (MARC) thereby providing a machine-readable source for its own data base.

Organizationally, NELINET is administered by the New England Board of Higher Education. Its development was sponsored by the Council of Library Resources and technical development was contracted.

The geographic proximity of the participating libraries was considered important because of the leased communications lines. The processing center was established at Cambridge and all users were located within a 150-mile radius.

The key point in the NELINET development was its recognition that regional resource sharing makes it possible to undertake projects which will enable new techniques to be utilized but which are too expensive for any institution to implement alone. The sharing of overhead enables the participants to capitalize on duplication, overall reduced costs, and increased capability.

2.2.3. OHIO COLLEGE LIBRARY CENTER

The Ohio College Library Center (OCLC) concept is another step in the direction of sharing resources. Where the focus of the NELINET concept was to share the facilities of the production of catalogued material, OCLC was developed to make all the resources of all Ohio academic libraries available to each other. In doing this, computerization was required and the joint cataloging effort is but one part of the total system. A primary goal is to provide a more efficient search and retrieval system for library books and journals.

Inherent in the overall goal is the utilization of the computer to aid in the process of searching for materials, to eliminate duplication in high cost of technical processing, and to reduce the rate of increase of per-student cost. In the future, this system will replace the card catalog, utilizing the computer terminal as the location and search mechanism.

Services which will be provided through the Ohio College Library Center system are shared cataloging, in which all members of the system have access to the cataloging effort performed by any of the other members; a union catalog, giving the locations of all member libraries which have the desired material; a communications mechanism for interlibrary loans; serials control for periodical holdings; technical processing systems, which will assist in the entry of information into the catalog and produce catalog cards; remote interrogation of the catalog file from sites external to the library, a feature expected to cut the costs of the user; and a bibliographic retrieval system, which can search the catalog by author, title, or subject.

The OCLC system is designed to be a regional library system that can serve as a prototype for other computerized library centers. Its development can hopefully be duplicated to form a network of library centers.

Approximately fifty libraries are on-line to OCLC. These libraries catalog over 10,000 books per week and only by sharing this laborious cataloging effort can they hope to keep up with manual technical processing operations. Without labor-sharing, the rising costs would have disastrous effects on their budgets.

However, because of data in the system produced by the Library of Congress or other member libraries, the cataloger need only enter the Library of Congress number to retrieve the data that the system has stored. If the data exists, only the editing

required to make it conform to local requirements is necessary. A "Produce" button on the special OCLC terminal will cause the catalog cards to be printed by the system that evening and mailed to the specific library the next day.

It is interesting to note that NELINET looked into adapting the OCLC system to its needs in 1972. The feasibility study produced favorable results.

OCLC hardware consists of a Xerox Data Systems Sigma 5 computer linked to 80 specially-adapted CRT terminals in the participating libraries by a multi-line, multi-party synchronous transmission telephone network. The Sigma 5 has 64K and a large capacity disk storage system. According to simulations run by Comress, a firm specializing in the simulation of computer systems, the OCLC system has the capacity to expand to 5 times the number of libraries it now services with the current configuration.

Organizationally, the Ohio College Library Center is a non-profit corporation organized to establish and operate a computerized, regional network to serve academic institutions in the State of Ohio. A Board of Trustees, originally formed as a constitutional board, has become increasingly involved in the decision-making of OCLC and has evolved to be more of a consultative board, with its make-up being deliberately selected to encompass a variety of disciplines.

The OCLC system is far more flexible in implementation than NELINET and is certainly more expansive in scope. Adherence to national standards makes it a system which has the capability for nationwide implementation.

2.2.4. BALLOTS

BALLOTS (Bibliographic Automation of Large Library Operations using a Time-Sharing System) has been partially implemented at Stanford University. In terms of service offerings, it is quite similar to the Ohio College Library Center. At the present time, BALLOTS supports the Main Library staff in the technical processing area by producing purchase orders, receiving books, producing cards for catalogs in the several campus libraries, producing book labels, and updating catalog records. Future capabilities are expected to include the ability to catalog books which are not in the MARC file and the searching of the reference data in the main and the several branch libraries on campus with CRT terminals.

Though the end products are somewhat similar, there are significant differences between the hardware, software, and project intent of the OCLC efforts and the BALLOTS. OCLC was primarily designed to be a library center node in a possible national network. As such, its services were designed primarily to relieve workload in the subscriber libraries and to make the reference material available to all users in a particular region. The BALLOTS implementation, on the other hand, was designed as a test case for

SPIRES (Stanford Public Information Retrieval System), one of several information system projects sponsored by the National Science Foundation.

BALLOTS is currently operational on an IBM 360/67, using SPIRES-developed searching and file management software. The technical processing is done by the library staff on remotely-located programmable Sanders CRT terminals. Hard copy system outputs are produced in the batch mode at night.

Much less attention has been given to the data base development than in the OCLC project. MARC records are currently the sole source of input into the data base.

The BALLOTS system, in its current stage of development, is limited to individual institution implementation. Its prime objective is not so much the sharing of resources as it is to provide retrieval searching from data bases to an academically-oriented public. The system's virtues, however, are that it appears to be somewhat more transferable than the OCLC implementation, which operated on a dedicated system premise. The library data base, an applications subset under SPIRES, would be one of several data bases which could be queried by a terminal user.

2.2.5. CONCLUSIONS

As network resources, library systems have several possible contributions to offer. The NELINET implementation took place when regional resources were somewhat constrained by the availability of appropriate equipment and communications expenditures which were directly related to distance from the central computer facility. Clusters of this type of facility may be apropos for groups with special language problems or with special geographic constraints.

The OCLC example offers a developed system with the ability to duplicate the central processing facility as well as the highly important data base resource, enabling new systems users to begin operation with the cataloging efforts of others as a bonus.

The BALLOTS/SPIRES system offers multi-data base retrieval capability, though the implementation has not yet focused on transferable data base mechanisms.

These different approaches to computer-assisted library systems development are a resource capable of being distributed through a computer-communications network. Levels of sophistication and a range of capabilities can be selected by the implementing institution without having to duplicate the entire systems development process.

2.3. EDUCATION

2.3.1. OVERVIEW

Higher education has adapted the computer to support its functions in a variety of ways. For Dartmouth College, a pioneer in the use of computers in higher education, the exposure of its students to the capabilities of the computer as an influential mechanism on society and decision-making in their later lives was important. For others involved in the educational process, the enhancement of the learning process by the use of the computer to drill students, to augment laboratory processes, to assist in interactive learning, and to perform computations were foremost. For educational administrators, the possibility of a reduction in costs by transfering some of the teaching processes to the computer was attractive, as was the use of the computer for administrative record-keeping and other business-oriented functions. For the researcher, the sharing of resources--data, programs, and possibly human expertise--was attractive.

Within the academic disciplines themselves, the use of computers is extensive. The following list provides some indication of the types of computer usage being carried out by the various disciplines:

Biology	Ecosystem simulation
Business	Accounting, simulation, planning, control
Chemistry	Computer-aided instruction, research
Economics	Games, simulation models in microeconomics
Education	Computer-aided instruction for teaching, evaluation, drilling, and learning
Engineering	Simulation, computation, analysis, numerical control, optimization
Geography	Modeling, statistics
Languages	Drilling
Art	Graphics
Mathematics	Analysis, computer-aided instruction
Physics	Statistics, laboratory augmentation, graphics

History	Computer-aided instruction
Political Science	Data analysis
Social Science	Data base exchange, analysis

The areas most amenable to network application are those which at the present time are terminal-oriented or adaptable to terminal processing. Computer-aided instruction is a prime candidate.

The term "computer-aided instruction" (CAI) has been used to encompass an array of efforts applying the computer to the process of education. These efforts are economically motivated --more than $50 billion is spent annually in the United States on formal education with per-student costs rising rapidly. Many institutions have been investigating the use of computer-based technology to (1) reduce the per-student cost of education and to generally increase educational productivity; and (2) to enrich the instructional process by using more effective teaching techniques and evaluating both the student and instructor more efficiently.

The use of the computer in the instructional process has been criticized for: (1) imposing regimented and de-personalized teaching on students; (2) standardization of education; (3) limiting education to simple-minded course materials because of the limitations in technology and difficulty in using computers; and (4) forcing the loss of individuality and human freedom in society.

Suppes, in his research at Stanford, dispelled these fears with the results of earlier CAI efforts. In essence, the use of CAI increased the capability for flexibility and individualized instruction. Rather than lecture sections of 200 students, CAI provided optional paths for learning material in different manners and at different speeds. This method is also considered to be a more flexible means of teaching than using textbooks, which could hardly be classified as non-standard education. Advances in software and other research projects have somewhat eliminated or at least reduced the charge that only simple-minded course materials can emerge from CAI developments. Playing chess with the computer is pointed out as an example that simple-mindedness is a shortcoming of the human being and not of the computer. The experiences with CAI and the favorable reception by students and instructors indicate that the threat to individuality and human freedom has not materialized.

In general, the results of CAI projects have been substantively gratifying but have not proved to be particularly cost-effective. At the University of Texas at Austin, a CAI program developed for teaching an Arabic course cost $13,000. Some current research efforts, TICCIT at the University of Texas and the PLATO project at the University of Illinois are now concentrating on the development of cost-effective systems, after having proven that system software and hardware can effectively augment teaching.

The areas in which CAI can be most effectively utilized are in the undergraduate level of colleges and universities, and in community colleges. The community college level is considered to be a prime recipient of CAI benefits because (1) there is a shortage of qualified instructors, and (2) there are many transfer students from other institutions who may need introduction and review to course materials that cannot be accommodated otherwise.

In the universities, the prime application area is in the large introductory courses, where per-student costs can be reduced because of the distribution over a large population. These large lecture courses, however, are where many graduate students are employed, and the universities will face the dilemma of reducing the per-student undergraduate course cost or removing the opportunity for teaching experience from the graduate student.

The need exists and the problem of the cost-effective implementation of CAI systems has been addressed, indicating the imminent availability of a potentially important educational resource capable of being distributed through computer-communications networks.

2.3.2. EDUCATIONAL NETWORKS

The primary benefit of educational networks is resource-sharing. The best work and resources of all other network members are theoretically available. Non-local facilities which could be utilized through networking are: other computers, which allow the user to select the hardware best suited to his task; data bases, developed and maintained by others; and special programs or general purpose software not locally available. One facet which has not yet been extensively explored is the use of the network for communications between researchers in the development of new ideas and concepts.

With the benefits of resource-sharing networks come some disadvantages, largely connected to the decreasing ability to control the factors associated with doing work. The aspect of unreliable response from a remote installation is even harder to cope with than the failure of the local installation. Further, because of the overlaying of the network on the computer use structure, the sources of operational problems are increased. Other problems which have been experienced in network usage are pecularities of the originating installation or problems in the transferability of concepts, pedagogy, philosophy, and documentation.

To illustrate the potential, several networks specifically oriented toward the process of education, as opposed to supporting educational endeavors, are being described. These are: PLATO, TICCIT, CONDUIT, NCECS, and EDUNET. In several cases, the philosophy of computer-aided instruction is as relevant as the use of the computer network itself.

Two different approaches toward the implementation of cost-effective computer-aided instruction are being undertaken by PLATO project at the University of Illinois and by the TICCIT project at the University of Texas. PLATO is attempting to establish economic viability through the use of a large integrated system with project-developed terminals and software. TICCIT is employing the services of the MITRE Corporation to help establish a mini-computer-based CAI system developed with off-the-shelf components.

2.3.2.1. PLATO

PLATO (Programmed Logic for Automatic Teaching Operation) has a 13-year history of CAI development. PLATO I was developed in 1960 with one terminal. Its programs were then used for drill and practice routines in elementary mathematics and languages. PLATO II appeared the following year with two terminals and expanded tutorial capability. Remote terminals and college credit for PLATO-developed courses were established in 1961 and 1962. The experiences of PLATO I and PLATO II led to additional research and development in the field of CAI, still heavily funded by the federal government. PLATO III appeared in 1966 with 20 terminals and a special language for course authors called TUTOR. New teaching strategies were developed in this stage and capabilities far beyond the role of drill and practice applications were developed for widespread use.

Built into the system are statistical routines which capture all data relative to student reponses to the CAI course. The instructor can monitor this material, either after the fact or from a separate terminal during the student's session to assist in the instructional process or to determine the effectiveness of course development. This built-in feedback and evaluation mechanism produces statistics which help the instructor either give individualized instruction or indicate where the course material can be improved. In this way, the student, the computer, and the instructor are interactive partners in the process of CAI.

The effectiveness of CAI in theory-oriented courses is encouraging, though the samples collected so far are not enough to be conclusive. A course in medical science was taught entirely via PLATO and the students compared favorably with one-third to one-half as many hours of instructional contact as those who had received their instruction in the conventional classroom.

Perhaps PLATO IV is the most interesting since it is a large scale system being specifically designed to be economically viable. PLATO IV terminals went into operation in 1972 and there are currently 250 such terminals in existence at 40 different locations in the United States.

The equipment includes a plasma terminal which can be used to display both computer-generated data as well as computer-selected slides. Optional equipment, also under computer control,

include a touch panel and a random access audio system which can hold 4000 messages totalling 21 minutes of sounds. These are useful in teaching with non-reading materials.

The design guidelines for PLATO IV assign it a properly supportive role in education, insuring that its design will enhance its ability to be effectively used in a teaching environment. The PLATO development philosophy is that the computer should be used only when it is the best method of presentation. Reliance should be on cheaper methods when they are more appropriate--films, programmed texts, and other audio-visual media means are among the alternative means.

Flexibility, adaptability, and teaching methods which do not resemble flipping pages in a book are required, as well as cost-effectiveness in terms of initial capital investment and continuing per-student cost. The system, when introduced into a school, can be used for incremental terminal cost, instead of requiring a large investment for system implementation or duplication on another system. The target cost per terminal hour per student is 25¢ - 30¢. If the costs of computer-aided instruction can be effectively lowered to offer a viable alternative to conventional methods in terms of both pedagogy and economics, the distribution of CAI through computer-communications networks can be a distinct benefit to network participants.

2.3.2.2. TICCIT

TICCIT (Timeshared Interactive Computer-Controlled Information Television) is an experiment in cost-effective computer-aided instruction being carried out at the University of Texas CAI Laboratory. The hardware and software development was contracted to the MITRE Corporation.

The system development philosophy is to make maximum use of existing, off-the-shelf technology while capitalizing on advances in relevant technology. To this end, a small inexpensive system which an individual school could buy or lease is being designed and developed. The breakeven point for these systems is about 100 terminals.

System hardware consists of a mini-computer for terminal processing and a medium computer as the main processor. Data General NOVA 800 and SUPERNOVA were used for these functions, respectively. The main processor is supplemented by slow, low cost peripherals, two moving head disks for data, and two fixed head disks which act as virtual memory. Telecommunications capability is provided by wideband coaxial cable.

Software consists of a special user language which allows the course author to be creative and at the same be efficient on the computer.

Previous CAI research at the University of Texas indicated that: (1) the junior and community college setting is the most fertile ground for CAI growth; and (2) the cost of producing course material as CAI programs was excessive. Their current research reflects both these observations.

While the TICCIT project results in a self-contained network, it withdraws from the widespread resource-sharing concept prevalent in other developments. On such a limited basis, the degree of commitment gives the implementer a chance to withdraw if the development did not materialize as planned.

2.3.2.3. CONDUIT

CONDUIT (Computers at Oregon State, North Carolina Educational Computing Service, the University of Iowa, and Texas) is a project established to examine the feasibility of exchanging educational materials between institutions. Its practices are not necessarily oriented toward network implementation but its concerns are highly applicable.

A basic problem area of any type of resource-sharing has been defined as transportability of the resource, especially as applied to the exchange of programs. There is generally an absence of program documentation, and when there is documentation, it is non-standard. In addition to informational shortcomings, program exchanges also experience technical problems in machine differences, language translation, file organization, and storage capacities. Serious questions have been raised on whether it is not more practical to write original programs to accomplish a specific task rather than attempting to adapt the work of others to the problem.

The real value of computer-based education was identified as pedagogy, philosophy, and substance of the package, as opposed to its ability to be transmitted through a network. The question is whether these qualities can successfully be transmitted. Current practices indicate that technical capability outstrips the capability to make effective use of the available resource. CONDUIT is composed of schools which are not particularly in the mainstream of current developments and they are especially aware of the problems of the effective transfer of network resources.

2.3.2.4. NCECS

NCECS, the North Carolina Educational Computing Service, was previously discussed within the context of the Triangle Universities Computing Center. As a user services organization, it is significant in its own right.

NCECS, funded by the North Carolina Board of Higher Education, buys computing power from TUCC and distributes it to other institutions of higher education in North Carolina on a retail basis. In addition to the resale of computer resources NCECS provides its users with documentation and consultation services normally associated with campus computing centers. Each of the other universities in TUCC provides user services to its own campus while NCECS services over 50 other geographically dispersed institutions. This is done by a staff of "circuit riders" who periodically visit each client institution.

Through this medium of facilitation, the users are kept constantly aware of hardware and software availability and are given training in basic computer programming, conventions in TUCC usage, and other pertinent network information. In effect, NCECS has functioned as a broker of computing capacity and has concentrated on making TUCC an effectively used network.

In concept, NCECS is similar to NERComP, except that its concentration is totally on user services; NERComP has to some extent, become involved in the technical design of communications.

The data is insufficient to determine whether the user services component has any significant effect on the relative success of the TUCC network; it is significant, however, that NCECS has been able to aggregate enough demand from the smaller institutions in North Carolina to make up 25% of the TUCC annual budget.

2.3.2.5. EDUNET

EDUNET is a conceptual network for sharing educational resources in the United States. It was the product of a study done in the summer of 1966 sponsored by EDUCOM, the Interuniversity Communications Council. 180 individuals from education, government, and industrial organizations met to assess the desirability of a nation-wide educational computer network aimed at making the nation's information resources available to all.

Though the results of the study provided no answer to many of the questions of network development, substantial attention is devoted to technical, administrative, and organizational issues. Advances in technology have obviated many of the technical issues but the administrative and organizational issues are highly relevant to any network development. The results of the study are published in <u>EDUNET</u> by George Brown, James Miller, and Thomas Keenan.

The methodology of developing the body of information needed to consider the value of such a network was of particular interest. The participants in the study were from widely diverse backgrounds and they brought with them the ability to quickly assimilate a body of relevant information for consideration in network development.

Among the topics covered in the EDUNET study were a survey of current network configurations and resources; the identification of needs from various academic sectors; network applications; organizational consideration; network design; and a proposal for a nation-wide interuniversity network. EDUNET was used as a normative model for the development of a network which had the characteristics deemed desirable by the study group. It was more of a proposal for additional work on the concept rather than for the development of any specific network since many of the issues required further study with hard data.

EDUNET's idealistic all-inclusive network concept was not funded or otherwise formally furthered. Several factors may account for this. One is that the group which produced the report had no particular continuing affiliation. In order to maintain interest in such a wide-ranging concept, continuous attention must be given to the interest articulation function and without a group dedicated to the function, the process is difficult. Secondly, the scope may have been too wide for effective planning and design. The study itself was a compilation of various reports, working papers, and viewpoints without any particular attention to the integration of the information.

2.3.3. CONCLUSIONS

The networks described above represent a range of different concepts in educational networking. In general, their orientations have included the effective use of a network to a much more substantial degree than have the technically-oriented developers. Though not explicit in the descriptions, the focus of these educational networks was not strictly limited to computer applications. PLATO, TICCIT, CONDUIT, and EDUNET all envisioned computers to be the primary focus in the network but that other means of audio-visual transmission would also exist.

The significant contribution of the educationally-oriented networks is that their concern for the quality of the educational product has given technical networking a perspective that has been previously lacking.

3. ANALYSIS OF NETWORK APPLICATIONS

3.1. INTRODUCTION

From the results described, it is evident that networking has its share of advantages and disadvantages. Some of these are explicit in the description of experiences and others are not. This section summarizes the advantages and disadvantages of resource-sharing networks, analyzes the developmental and operational patterns of selected examples, and draws some conclusions on computer-communications networking in general.

3.2. SUMMARY OF ADVANTAGES

The advantages of computer-communications networking can be aggregated into three different categories: (1) cost reduction; (2) resource-sharing; and (3) interactive group developments. These classifications are not mutually exclusive.

Cost reduction is most typically exemplified by the computer utility, where the aggregation of demand can be used to bring the per unit cost of computing down substantially. The economies of scale which accrue to the purchase or lease of large-scale computer configurations and the reduction of the computer center operations overhead are the primary contributing factors to cost reduction.

Resource-sharing is concerned with the availability of an expanded set of resources, including hardware, software, data bases, and human expertise. Network participation affords benefits for both the users and suppliers of these resources.

For the user, all of the above resources within the network are theoretically available. That means that the user does not have to outlay his own resources to gain access to the services available at other sites. The availability of resources reflects the number and kind of suppliers in the network.

One example of hardware sharing is the remote use of computers with large core availability for running mathematical problems unable to fit the local equipment. Another example of hardware sharing is the shifting of work from one computer to another in the case of overloads. Networks which span wide geographic ranges have the built-in advantage of time zone differences, which allow peak processing periods to be distributed in such a way that the slack period of other network machines can be used to handle excess demand.

Software sharing is exemplified by the use of specialized simulation packages or computer models at other sites with the results being transmitted to the user's home facility or terminal.

Data base sharing has the advantages of making large amounts of information constantly available, with centralized maintenance and decentralized utilization. The Ohio College Library System is an excellent example of a shared data base with distributed use.

The area of computer-communications least explored at the present time is the use of the network to provide and facilitate human interaction in the development of plans and the solution of problems. In much the same way that the most powerful computer hardware is concentrated at certain sites in a region, the distribution of scholars with distinguished achievement follows a similar pattern.

System Development Corporation studies in online planning have used real time systems to coordinate the development of new plans and concepts between experts in the fields and their associates. An experimental system, Gaku, has been developed to provide the coordination of ideas, details, and alternatives in the process of planning and problem-solving. The SDC studies have pointed toward the ARPANET as a possible medium for widespread interactive development of ideas. Through the network, it is possible not only for persons at the local site to participate but also experts located elsewhere and technical personnel whose detailed knowledge is required to produce feasible solutions.

The suppliers of resources can also benefit from network participation. Equipment is always purchased with growth potential, with the understanding that there will be underutilization in the beginning. This excess capacity can be marketed through the network to others who need the particular resource and who are willing to pay for its use. In addition, where utilization is not a particular issue, additional revenues may be forthcoming if the use of software and data bases is extended to other network members.

Summarizing the advantages, cost sharing is primarily achieved by the sharing of the computer power source; resource-sharing makes available a wider range of hardware, software, data bases, and human expertise; and interactive group development is a more organized form of resource-sharing. In addition to the relatively unorganized array of resources, interactive group development has a more purposeful aim: to direct the resources toward a common objective.

3.3. SUMMARY OF DISADVANTAGES

Examining some of the disadvantages of networking, it appears that they fall into three major classes: (1) loss of control; (2) questions of effectiveness; and (3) the question of feasibility.

Loss of control can apply to users, suppliers, or both. In the case of both the suppliers and users of resources, the

participants are likely to be subjected to another level of operational bureaucracy, this one imposed by the network. The degree of imposition remains a question of policy for the network implementers.

Network users face a possible loss of control over processing. It is difficult enough to get work done at the local installation. Remote access would make it even more difficult. Another apprehension of network participation is that the users of the campus computing center may prefer to go elsewhere for processing, resulting in a loss of operating revenues for the local installation. If the loss is critical enough, it may lead to the extinction of the local installation.

Suppliers of the network, in addition to facing procedural and protocol requirements of the network, may be faced with a situation of undeterminable demand, which may have a detrimental effect on their ability to serve their own clientele.

Regarding the effectiveness of the network, the possible disadvantages are phrased in terms of questions directed toward the validity of the basic reasons for networking. Among the questions asked--and for which no satisfactory results have yet been produced--are: Is networking really the best way of doing things or are there other alternatives? What beneficial results can networking truly provide? How transferable are resources really? Is networking the most appropriate method of resource sharing?

The questions of cost-benefit are paramount in network development because the expense of establishing a network is extremely high. Further, though benefits have been demonstrated by the regional networks and the ARPANET, the question of whether alternative means, e.g., on-site minicomputers, would have been better still remains.

The question of the real transferability of resources has been raised by network users. On the assumption that pedagogy, philosophy, and program development are important in the development of educational resources, are they capable of successfully being transmitted through a computer-communications network? Serious doubt on the part of the more educationally-oriented community exists on this point. In addition, theoretic availability does not necessarily mean practical availability, as has been the experience in some networks and time-sharing systems.

Whether computer-communications networking is the most appropriate means of resource-sharing is another question which is often asked. Alternate means, e.g., manual clearinghouse methods for the collection and dissemination of materials may be more appropriate because very little in the academic environment has to be completed immediately.

The third class of networking disadvantages is also phrased as an unanswered question: Is the scope of educational computer-communications networking too broad and too heavy for

development and implementation in an institutional setting? Many ambitious undertakings have met the fate of not progressing past the proposal stage for the reason implied above.

These disadvant. _ s or negative observations become highly important in setting up the design for network policies and organizational structures.

3.4. ANALYSIS OF SELECTED NETWORKS

Network development in the United States offers numerous opportunities to view alternatives in network scope and development. Information on actual development in other nations is sparse and, when available, is heavily oriented toward the technical aspects of networking. The analysis which follows concentrates on networking experiences which emphasize developmental problems, organizational techniques, financial arrangements, and operating efficiency, particularly insofar as it is related to the cost-effectiveness of the total network. These networks are not particularly comparable in their characteristics and information available or stressed did not always provide data for rigid comparisons. Rather, each network has its unique points, as is illustrated by Primary Motivations listed in Table 3.1.

None of the networks surveyed possessed the total range of characteristics which would be present in Pacific Educational Computer Network development. A composite set of characteristics has been developed from five representative ne. orks currently in operation in the United States. While the international Pacific environment will be quite different, the points made in the context of the analysis are generally applicable.

The networks being compared have all been described earlier. They are DTSS, NERComP, TUCC, MERIT, and UNI-COLL. The specific attributes being observed are DTSS's philosophy of taking responsibility for the provision of services and facilities for its users; NERComP's concept of distributing resources from the "haves" to the "have-nots"; TUCC's administrative structure; MERIT's concept of sharing dissimilar resources to the benefit of all; and UNI-COLL's attempt to employ commercial philosophies to the operation of a regional educationally-oriented computer utility.

The specific development characteristics that were reviewed were Primary Motivation, Development Support, Development Philosophy for Hardware, Development Philosophy for Organization, Types of Sharing, User-Supplier Relationships, Development Organization, Development Problems, Operational Organization, Organizational Funding, and Relative Degree of Success.

The ARPA Network provides the lone nationwide example of educational and research-oriented networking. Comments and analysis of the ARPANET are discussed separately because its

intent, funding pattern, and technical development are substantially different from the more limited regional applications.

3.4.1. NETWORK DEVELOPMENT

The following comments on network development relate to Table 3.1, Network Development Foundations, and Table 3.2, Network Development Patterns.

Primary Motivations. The motivation of MERIT is perhaps the most sophisticated and theoretical of the networks surveyed. The nodes of the MERIT network offer distinctive resources, each sufficiently different that cost-effective use could be made of them by other members of the network by not duplicating already existing applications and equipment. There is for example, a CDC 6600 for efficient numerical processing at one node. Another node provides good general purpose computational power. The third node specializes in administrative processing.

The purpose of MERIT was to determine whether this arrangement was workable as a resource-sharing regional network. Initial emphasis was given to providing the means to make the resource transfers possible. This type of sharing represents not so much the distribution of resources but the trading of specialties among already sophisticated users.

Examining the motivation issue from another standpoint, its disadvantages would discourage participation if economics or prestige did not provide an attractive form of compensation. Network developments have been difficult and in general, have not emerged with glowing successes, thereby diminishing the prestige factor as overridingly important. The subjugation of network participants to network protocols and administration and the possible threat to campus computing installations was a problem. The more recent networking projects, therefore, concentrate on distributing the available resources to a wide population. NERComP acts as the intermediary by providing users for the excess of capacity of its suppliers and providing hardware capability for its clientele without incurring the costs of establishing additional computing centers. The result is the better economic utilization of existing facilities.

TUCC and UNI-COLL both created computer utility facilities by employing the economies of scale to regional network development. The centralization of the massive computing resource and the subsequent distribution of this power to their clientele theoretically produces economic advantages not available to the users individually. The cooperative arrangement allows for the acquisition of computing equipmen. which increases processing capacity many times for each computing dollar spent. For cost-effective operation, however, the base of funding and the amount of use has to be increased, leading to increased efforts to distribute the resources more widely.

Table 3.1. NETWORK DEVELOPMENT FOUNDATIONS

Network	*Primary Motivation*	*Development Support*	*Development Philosophy-Hardware*	*Development Philosophy-Organizational*
DTSS	Educational; to introduce students to concepts and capabilities of computers; to encourage use of computers by students.	Dartmouth College National Science Foundation	Use existing technology for computers, communications and terminals; develop own software.	To understand the impact of computers takes experience; experience is gained through access and availability. It is the responsibility of DTSS to provide the access and availability.
NERComP	Broker of computing power from institutions with computers to those who do not.	NERComP, Inc. National Science Foundation	Computing capacity of a variety of types and sizes of computers are made available to members through terminal-oriented time-sharing.	By coordinating the resources and needs for computing services within a region, better utilization of existing facilities is attained and a better range of services is available to the user.
TUCC	Economic consolidation of the massive computing power required by the three members universities.	University of North Carolina Duke University North Carolina State University National Science Foundation N.C. State Board of Science and Technology	Consolidation of the primary computing power and limited local capability was only way the increasing demand for computer services for the three schools could be met.	TUCC exists primarily to service its three sponsoring universities, which annually pledge the funds needed for its support. Excess capacity is sold to other North Carolina educational institutions.
MERIT	Experiment in network behavior under resource-sharing philosophy.	National Science Foundation State of Michigan Michigan State University University of Michigan Wayne State University	Network equipment was dissimilar enough for effective interchange of services to the place; concentration on providing communications and interfaces.	Originally, the three universities planned the flow of computing resources between institutions, controlled by the individual campus computing centers. Current plans are to include smaller colleges and high schools
UNI-COLL	Distribution of computing power to schools in the Delaware Valley region.	University of Pennsylvania (no other information available)	Centrally operated computer utility providing time-sharing and data processing services. (no other information available)	Administratively separate organization operating the computer facility for clientele of Delaware Valley institutions on non-profit basis.

Table 3.2. NETWORK DEVELOPMENT PATTERNS

Network	*Type of Sharing*	*User-Supplier Relationships*	*Development Organization*	*Development Problems*
DTSS	Timesharing Data Bases Computer Hardware	1 supplier, many users	Dartmouth project team originated DTSS; upgraded by GE project team with Dartmouth students.	Early lack of software to easily extend computation facilities to non-programmers.
NERComP	Timesharing Data Bases	6 suppliers, 40 users	MIT experiment; project was incorporated as an entity after several years.	Unable to establish fully self-sufficient base; good interaction between users and suppliers has not been encouraged.
TUCC	Computer Hardware Software Data Bases	1 central computer, 3 primary distribution nodes, many users	Project located away from all participating institutions with administratively separate staff.	Establishment of self-financing base once federal funding was cut off.
MERIT	Computer Hardware	3 cooperative centers distributing to many users	Small development staff recruited from participating institutions; housed at the host institution.	Unable to establish good flow of resource exchange between the participating centers; reasons are economic.
UNI-COLL	Computer Hardware	1 supplier, 1 primary user, many smaller users	Administratively separate staff handled all organizational details.	Unable to attract sufficient clientele to make operation self-sufficient and cost-effective to users.

Though the primary motivations for network development have been stated in numerous ways in official statements of purpose, the underlying reason is always a matter of economics. The lone exception is the DTSS, which was premised on educational purposes.

The historical development of networks supports the shift from educational to economic purposes. The Dartmouth system was one of the earliest educational network projects and funding to support its development was readily available. As additional networks became established, the concept lost its originality and emphasis was shifted to making networks self-sufficient as soon as practicable.

Concurrently, there were changes in the funding patterns of computers in higher education. Two occurrences which had significant impact were: (1) the drastic reduction of the level of federal support to university computing centers; and (2) the diminishing of educational discounts for university computers by the equipment manufacturers.

The imposition of these reductions in operating revenues caused the computer center administrators to develop new means of coping with the problems of inadequate or marginal funding support. Sharing of resources through reductions in local operations is one reason why networks are not universally welcomed as an answer to the economic difficulties in higher education computing. Nevertheless, the substantial attention being given to resource-sharing networks indicates that the potential economics are well worth the disadvantages.

Development Support. It is significant to note that all of the networks for which there was information had outside funding assistance to help finance their initial development. The National Science Foundation has been a consistent source of these supporting revenues. State and institutional sources have provided other funds necessary to build the networks.

The availability of funds appears to have a significant impact on the ability of the network to prosper. While the network activity in the educational environment is non-profit, it should not be synonomous to operating at a loss. Yet, most of the networks have had difficulty reaching economical self-sufficiency.

The development patterns show that the initial concentration is usually placed on hardware development, leaving the development of the critical mass of users necessary to support the network until later. Given the funding patterns for computer developments in the United States now, a different set of priorities in the development schedule may be in order, that is, more attention will have to be given to the concurrent effort of creating a user base and maintaining it.

Other developments, such as TUCC, were given a limited time period to make themselves economically viable. With a sure funding base TUCC managed to achieve economic viability in a short period of time. MERIT is having difficulty because the computing dollar is a precious commodity in Michigan and without infusion of funds from outside the computer center budgets, the local computer centers are reluctant to transfer their dollars elsewhere for fear of ending the year in the red themselves.

There are other factors which may be constraining the MERIT development but the scarcity of funding resources for experimental exchanges of cost-effective computing is certainly a critical issue that strikes at the heart of the resource-sharing problem.

When the length of funding is too short for adequate network development and experimentation, or when the amount of funding is too small, the success of the network is endangered.

Hardware Development Philosophy. Regarding the economies of scale relative to hardware which can be realized by network arrangements, it was shown that unless adequate administrative support and technical planning were in evidence, the actual achievements did not meet the expectations. The hardware development philosophies of the various networks tend to bear this out.

TUCC, MERIT, and UNI-COLL all experienced problems related to this aspect of network development. In the case of TUCC, the positive attributes of administrative and technical preparation can be emphasized. The tri-university computer center was established when funding was decreasing and demands were increasing. The administrative personnel of each of the participating colleges were vitally interested in the successful implementation of TUCC and the position of the TUCC director is highly dependent on his ability to satisfy the members of the Board of Directors, who represent the administrative, fiscal, and computer processing interests of the participating universities. Technical planning concentrated on the provision of adequate service to all clients, not the central computing resource.

MERIT, on the other hand, was composed of three self-sufficient computer centers. The incentive for optimization of processing using the varied capabilities of the three network machines was somewhat defeated by the pressure to maintain the economic viability of each, rather than maximizing the effectiveness of the total network. With each computer center director responsible for adhering to his individual budget and with his authority to direct or not direct work elsewhere, the network failed to achieve the degree of sharing that was possible. The ultra-conservatism was promulgated by the lack of adequate

funding for experimentation without penalty to the operations of the particular center.

The technical planning of MERIT concentrated heavily on the development of the communications system, to the detriment of the possibilities for sharing under the concept of the sharing of specialized equipment and applications.

UNI-COLL also banked heavily on technical achievement but failed to support the development with administrative effort necessary to attract additional customers beyond the University of Pennsylvania, its primary client. As a result, the UNI-COLL equipment was highly underutilized and its prime client received none of the benefits possible through economies of scale.

The Dartmouth System started with the philosophy of using standard hardware, conventional communications, and custom-developed software. With a lack of trained personnel to develop a user-oriented system, software was the area in which there was the greatest amount of raw talent on the Dartmouth campus. Contributed hardware solved the equipment problem and conventional communications, i.e., standard telephone lines, made the communications interface easy to deal with when implementing new user sites.

Since software to support the philosophy of student education was non-existent, the logical course was self-development, resulting in the BASIC language.

NERComP's philosophy was to utilize the hardware of existing universities by providing the mechanism to extend their usage to the smaller users who could not afford their own installations. Six resource computers offered a wide range of computing power and capability. The user could select services which ranged from minicomputer resources to MULTICS, a very large computer resource at the Massachusetts Institute of Technology. In this manner, they could choose the resource most suitable to the problem, a feature which is not necessarily present in the other networks, even though it would seem that an economically motivated network would take this into consideration. Perhaps it is indicative of the fact that except for NERComP, which is essentially a facilitating and not a technical network, the network development projects have emphasized technical hardware development without much inclusion of the ultimate users of the system.

Organizational Patterns. In reviewing the patterns of organizational philosophy of the five networks, no particular pattern of success was discernible. However, those whose orientation was geared more to servicing their clientele in a satisfactory manner appeared to be more successful than those without this orientation.

DTSS and TUCC had somewhat similar user-oriented development philosophies -- DTSS because as an experimental system, it had to attract and maintain a group of student users; and TUCC,

because its livelihood and funding depended on its ability to render satisfactory service to its funding institutions. In neither case were the clientele 'captive', i.e., without alternatives if the processing proved to be less than satisfactory.

NERComP's development collected 6 suppliers and 40 users, with NERComP itself taking the responsibility of furnishing the materials necessary for systems utilization. The user manuals for the using institutions are prepared not by the supplying center but by the NERComP staff. The administrative coordination, which includes the inter-institution billing and arrangements for processing is also taken care of by NERComP. In the development, however, the mass of users may be more impressive than the amount of processing being shared.

Type of Sharing. The concept of sharing has several dimensions which happen to be well-illustrated by the networks surveyed. Resources had been previously defined as hardware, software, data bases, and associated human expertise. The difference between a timesharing network and a true resource-sharing network is the flow of resources. In the timesharing network, it is primarily, though not limited to, the sharing of computer hardware and operating system software through a flow from the central computing resource to its users. Under a resource sharing concept, the flow of resources would be a two-way affair, with each resource node being able to provide services as well as to use them from other machines if it should so prove to be advantageous.

Most of the networks surveyed are timesharing networks. The distinction is made because the later analysis of networks in which each node may be both an input and output is extremely more difficult to plan for and administer than those networks which are either input or output. For this reason, MERIT is an extremely interesting experimental network.

User-Supplier Relationships. In at least the DTSS and NERComP implementations, the user-supplier relationships proved capable of being assimilated into networks and metanetworks. Metanetworks are defined as "networks of networks". In the DTSS-NERComP case, DTSS constitutes a network within itself and when it functions as a participant of the NERComP net, it creates the metanetwork effect.

The significance of this is that the physical network can be transparent to the user while the logical network can be as multi-leveled or laterally connected as desired.

One other aspect of the user-supplier relationship is that the NERComP broker role illustrates that the owner of the services need not be the seller of the services. The separation between the ownership of the resource and administration of the network can be made somewhat transparent to the supplier in the

same manner that it is to the user.

Thus far, however, there has not been a substantial effort undertaken to provide the intermediary services necessary to develop a truly operative and effective network. The NERComP effort can be considered an ad hoc type of arrangement especially as it affects the suppliers.

Development Organization. The organizational structures which developed the networks were generally small project groups which gathered personnel from the host institutions. For administrative purposes, the project was usually incorporated as a separate entity from the participant institutions during the process of network development.

When the participating institutions have relatively equal strength, geographically separate network headquarters appeared to reduce the potential conflict between the participants.

Developmental Problems. The major problems faced in the development of the networks centered around economic self-sufficiency. Only in the early Dartmouth development was funding not a particular problem.

The initial concentration on technical development has evidently produced working technical systems which are fundamentally administratively and financially vulnerable.

NERComP, for example, has still not been able to establish a fully self-sufficient funding base. MERIT was not able to encourage a good flow in the exhange of resources between institutions and UNI-COLL faces a critical problem in not being able to attract additional clientele to make its operations cost-effective to its current users. These problems appear to be related to the orientation of the network toward its participants. In the case of TUCC, the Director's job is directly related to his ability to perform satisfactorily. In the case of MERIT, the network, for all of its benefits, could be considered an ad hoc arrangement to the current capabilities of the campus centers. It is too early to predict the fate of UNI-COLL, but its major client was less than satisfied with its early efforts to capitalize on the opportunity for cost reductions provided by the large computer environment.

3.4.2. NETWORK OPERATIONS: ORGANIZATION AND FINANCING

General conclusions reached on network organization and financing, as documented in Table 3.3, are:

1. That in the development of multi-organization networks, the establishment of separate organizational entities to handle their collective business was universally adopted.

Table 3.3. NETWORK OPERATING PATTERNS

Network	*Organizational Structure*	*Operating Organization*	*Financing*	*Degree of Success*
DTSS	Incorporated entity of Board of Directors Organizational affiliation with Dartmouth College	Dartmouth Time Sharing System, Inc., a non-profit organization	DTSS receives basic financing from Dartmouth College; other users are billed for services.	Based on its philosophy of reliable systems development on proven technology, DTSS has been fairly successful.
NERComP	Incorporated entity No organizational affiliation	NERComP, Inc., a non-profit organization	NERComP administration is supported by NSF; NERComP bills users for services from suppliers and pays suppliers for resources used by its members.	Magnitude of sharing has been relatively small; has been in operation since 1968 and is still not self-sufficient.
TUCC	Incorporated entity Board of Directors from three sponsoring universities Physically distinct from sponsors	TUCC Corporation, a non-profit organization	TUCC receives pledged funds from the three sponsoring universities for its operations; excess capacity is sold to NCESS, which acts as a brokerage to other users.	In terms of meeting, its expectations and objectives, TUCC has been fairly successful.
MERIT	Incorporated entity Board of Directors from three participating universities Physically merged with sponsors	MERIT, Inc. is the central fund repository MERIT Project is the group operating the network Both are non-profit organizations	MERIT is an overlaid communications network which receives its funding primarily from external grants. Member schools do not contribute much to its support.	MERIT has not yet achieved the level of resource-sharing that is possible under the network concept.
UNI-COLL	Incorporated entity Board of Directors No organizational affiliation	UNI-COLL, a non-profit organization (no other data available)	UNI-COLL receives most of its income from the major client, the University of Pennsylvania. It is attempting to attract other users to increase its funding base.	UNI-COLL is experiencing difficulty in developing the user base necessary to support a central computing facility.

2. That the personalities of the participants more so than the organizational structure is responsible for the success of network operations.

3. That the behavior of the marketplace is a stark reality in the provision and sale of computer services.

4. That it is possible for networks to become self-sufficient but not without substantial attention to network economics, marketing, and research and development.

5. That success has been an elusive quality in network development.

The form of the non-profit corporation was the most widely used administrative device in establishing the operations of a multi-jurisdictional computing facility. Generally, the participants with high vested interests in the facility maintained a degree of control through membership on the Board of Directors.

The non-profit corporation provided the computing facility with the organizational mechanism to escape the bureaucratic red tape that it would encounter in a purely institutional setting. As a semi-independent organization, it was able to respond faster to changing requirements and to execute agreements to facilitate the operation on a network. The characteristics of institutional inertia on some matters of this type can stymie networking efforts indefinitely. If agreements and approvals between a group of institutions are necessary, the probability of success is somewhat more diminished, given the drawn out nature of the agreement-approval process.

Hence, the separate non-profit corporation provides an excellent vehicle for the coordination and execution of networking efforts between institutions. It does, in essence, provide the necessary administrative interface between the participating institutions.

The organizational structures of most of the networks were variations of the form where policy-making is carried out by the Board of Directors and policy-execution and operations are carried out by the staff of the non-profit organization. The similarity in basic structure suggests that no particular variation was overwhelmingly better than the other. Rather, it appeared that the attitudes of the Board, the network director, and the participants made the basic difference between the networks which are operating 'successfully' and those which are operating marginally.

The degree of success at this point can only be measured by the degree to which they have reached their stated or implied objectives. For the newer networks, this is somewhat a function

of time, but their basic philosophy of development, the milestones which they have reached, and the type of problems encountered somewhat indicate the degree of success they have achieved.

For the development of future networks, the experience has shown that the development of networks was universally a harder task than originally conceived. The motivation for success was highly dependent on the people involved in its development. The key personality is the director of the network and where he has been able to achieve good working relationships with the Board of Directors and the clientele, the degree of success is higher.

There has been a question as to whether the economic characteristics of the marketplace would be applicable to academic networking. There have been two different attitudes on this issue: (1) that the academic environment is somewhat insulated against the economic behavior of the real world and this insulation will apply also to networking; and (2) that the only rational way to operate a network is to let the behavior of the marketplace prevail.

The insulation attitude can be extended to create an artificial environment for networking, where subsidies create the illusion of equality for all participants. An actual example of an insulated network is the Arpanet, where many of the services and some of the facilities at certain sites are, for all practical purposes, free to the participants. This situation does not distinguish between users with bona fide funding and those without. Since ARPANET is an experimental network, this equality among users is not consequential.

However, in attempting to establish an operational network when there is dependence on operating revenues, the issue of the marketplace emerges. In the academic environment, the sharing of resources appears to be an ideal situation for many. The 'have-nots' are afforded access to resources that they could in no way obtain independently. The question is, what is the structure of charges for the use of these resources, if any? The resources would include computation power, software, data bases, consultation, and data transmission.

Can the network devise an equitable structure for all parties theoretically involved? Some network researchers think that this is possible.

Others believe that the administrative problems involved with trying to devise a workable structure for equitable networking, i.e., provide the little institution with as much potential capability as the better endowed institutions, prevent the networking concept from ever reaching fruition. The need for funding to get the network established is acknowledged but the suggestion that the behavior of the hosts and users be regulated to any degree by the administration of the network is rejected. Instead, the group supporting the viewpoint of independent behavior of participants, e.g., a laissez faire model, would have the functioning of

the network regulated by the economics of the marketplace. For example, where the prices of computation are high, the demand for services is low; where prices are low, the demand is higher. The price would be controlled by the director of the installation selling the computer time. The ability to work out individual agreements between users and sellers for more reliable service than provided on a casual basis is assumed.

In the networks surveyed, it was evident that the pricing structures attached by the computation facilities strongly influenced the level of services they were able to sell. Users were also influenced by the comparative prices they have to pay for processing. The problem emerged in the MERIT network where computation unit prices at other installations in the network were marked up, making local processing much more attractive. Pricing is therefore used as a competitive device or one which can be used to turn away excessive demand.

The implications of the insulated behavior model and the laissez faire model are far-reaching in the actual development of a network administrative mechanism.

4. CONTEXT FOR INTERNATIONAL DEVELOPMENT

4.1. BASIC ASSUMPTIONS

In the preliminary stages of project development, very little information was available on the context for developing international computer-communications systems. Experiences in the U.S. and Europe do not provide particularly relevant data on dealing with the problems of widely varying levels of technical expertise, diverse cultures, and different legal systems for communications that are present in the Pacific Rim community. Certain assumptions which have been implicit throughout the development of the Pacific network concept are therefore being explicitly stated to set the guidelines for interest, contributions, and further participation in future experimentation and development. As additional discussions take place, these assumptions may be altered and certainly will be added to. Initially, however, they are:

1. That the basic means of telecommunications will be satellite transmission.

   This assumption is made because of the widely dispersed geographic area which is included in the Pacific Rim and because with satellites, transmission cost is relatively insensitive to distance.

2. That the basic language in the development effort will be English.

   This assumption is made because in most technical applications English is almost a universal language. In addition, almost all the programming languages used in the Pacific Rim are English-based.

3. That the project will concentrate on developing an experimental network for academic and research use.

   The primary focus of the network is to distribute relevant educational resources to other users in the Pacific. This type of service is not now offered by the common carriers but to avoid aspects of competition later, the development of a plan to phase out of experimental networking will be included within the general plan.

4. That before the network can be implemented in countries within the Pacific Rim, an assessment of the individual country's ability to absorb and use the technology should be carried out to determine the positive and negative effects of the network.

5. That the political environment will be international in nature.

   The network participants will come from all countries capable of technically supporting ground stations for data transmission.

6. That the user population will have a wide range of computer-communications ability and a variety of telecommunications capability.

   There is a diverse array of computing equipment in the Pacific, as well as supporting telecommunications systems of varying reliability. All of these have to be taken into account in the Pacific Network development.

7. That a complex funding situation for both development and operations is likely.

   The exchange rates for various currencies fluctuates and where an exchange of funds is necessary between institutions, the financial arrangements will be complex. If operational status is planned, an accounting system for the purpose of equitable payment for resources used will have to be designed well in advance of implementation.

8. That international network interconnection will produce problems in network connectivity that are administratively difficult to solve and that these administrative problems may preclude or delay the implementation of certain technologically desirable alternatives.

This list by no means covers the entire scope of assumptions taken into consideration in the Pacific Network development but they set the stage for further discussion and the development of alternatives.

4.2. PACIFIC RIM NETWORK SURVEY

A survey of selected educational institutions within the Pacific Rim was taken to determine the degree of interest and the level of expertise available for an international experiment in networking.

4.2.1. INTRODUCTION

Briefly, educational networking is receiving considerable attention in the academic environment for several reasons: (1) educational costs are rising; (2) the distribution of educational

resources is such that there are concentrations of high quality talent and facilities at the same time that there is need without sufficient resources; (3) computing as a resource can be extremely cost-effective by applying economies of scale; and (4) computer-communications networks offer a viable solution for providing the necessary mass to effect economies of scale and for distributing the available resources in an effective manner.

Educational computing in the Pacific includes a diversity of capability, ranging from initial attempts to sophisticated multiprocessor operations. A study of educationally-oriented computing capability in the Pacific Rim nations was expected to indicate the interest and capability existing for further study on a computer-communications development. The ultimate objective was the sharing of educational resources among institutions in the Pacific region.

Experiments in Canada, Japan, and the United States indicate that the potential of computer-communications networks are well worth the investment of planning and implementation. Canada is developing CANUNET, Japan is liking its regional university computers, and the United States has been experimenting with the ARPANET. In all cases, the primary motivation has been to reduce overall expenditures by the sharing of resources through communications channels.

Similarly, international regional networking is also a concept which merits further examination. The international context illuminates the more general benefits of computers and networking. For example, increasing man's ability to deal with this environment is cited by the United Nations reports as a prime reason for encouraging the inclusion of computers into the development plans of emerging nations. Use in statistics generation, economic modeling, and planning greatly enhances the value of these processes in national planning and development.

Reducing the scope to aspects of international educational resource-sharing, specific applications which could be available through networking would be general computational capability, computer-aided instruction, regional library sharing, and specialized discipline developments, e.g., chemistry program exchanges or data banks for physics.

In the nations mentioned previously, the level of expertise needed to sustain network development is assumed to be rather high. This, however, is not true for the Pacific Rim nations universally. The nations differ substantially in the depth of their computer capability. To a certain degree, the Gross National Product of a nation is a good indicator of its level of expertise.

Experimental networking will require that a certain amount of expertise be resident in the participating institution so that minimal operations can be maintained. This technical capability of some countries surpasses this level while in others, it is marginal or almost non-existent.

This study was undertaken to determine the extent of the disparity and the amount of interest other universities in other nations had in developing a Pacific region network.

Data for this paper was gathered primarily from questionnaires sent to selected institutions in countries in the Pacific Rim. Reference books and United Nations Economic and Social Council publications were also consulted.

Country selection was based on (1) the range of a satellite placed to include the greatest number of countries; and (2) whether the country had educational institutions capable of technically supporting a ground station in network development. The Pacific Rim satellite range used in this study encompassed eastern Asia, including the USSR, mainland China, southeast Asia, westward to the Indian border, the South Pacific countries, Australia, New Zealand, Hawaii, the west coast of the United States and Canada, and Alaska.

Institutions were selected by previous interest, content of curricula, and either technical ability to support a ground station or interest in using the services offered by a developing network. The proportions of institutions queried is somewhat indicative of the known capability of the country in the computer-communications field, although the USSR is an exception to the rule.

Country	*No. of Inquiries*	*No. of Replies*
Australia	4	4
Cambodia	1	-
Canada	2	2
China (Taiwan)	2	2
China (Mainland)	5	-
Fiji	1	1
Hong Kong	1	1
Indonesia	1	1
Japan	9	8
Malaysia	2	2
New Zealand	1	1
Philippines	2	2
Singapore	2	2
South Korea	3	3
South Viet Nam	1	-
Thailand	3	3
USSR	1	-
USA	9	9
TOTAL	51	41

Table 4.1.

PACIFIC RIM NATIONS WITH NETWORKING CAPABILITY

Of the 51 questionnaires sent out, 41 were returned, indicating at least 80% interest in such a project. Informal communications from some of the non-responding institutions indicated that they were interested but could not aprticipate at the present time.

4.2.2. SURVEY RESULTS

The sample from which the data was extracted represents 14 of the 18 countries considered to have computer-communications capability in the Pacific Rim. Included are the major qualified universities of Australia, Japan, and West Coast United States and Canada, the nations which have a great majority of the technical computer-communications expertise of the region.

Interest. Interest in the network was positive though varied. The following breakdown shows as much interest in uncommitted observation as in actual participation in network planning and development.

Interest	*No. of Responses*
Mailing List Only	13
Using Only	6
Planning Only	3
Mailing, Planning, and Using	19

Table 4.2.

DEGREES OF INTEREST

In terms of commitment, mailing list status would be the least involved. Using the network, considered a somewhat passive activity compared to development, is next. Planning, which involves the preparation of design and development plans, bears the highest degree of involvement.

Computing Equipment. Computing equipment used by the responding institutions were classified by size, type, and manufacturer.

Category	*Purchase Price (U.S.$)*	*Number*
Mini-Small	to $ 100,000	19
Small-Medium	$100,000 - $ 500,000	6
Medium-Large	$500,000 - $1,500,000	17
Very Large	$1,500,000	14

Table 4.3.

BREAKDOWN BY SIZE

The data received did not give a good basis for the determination of the size of the equipment, except insofar as a cost figure could be attached to the computer. Model numbers for some series were useful but the modularity of the computers sometimes made this difficult. Only equipment at central computing facilities was included in this survey. Other equipment, ranging from specialized large machines to minicomputers does exist at a number of these institutions.

In determining the size of the equipment by corresponding cost, all figures are given in $U.S., 1972. Despite the attempt to standardize this figure, some problems were experienced in determining the current rate of exchange and for determining prices for external and internal economies. An attempt to derive figures for non-computer expenditures also ran into difficulty because of various systems of including personnel pay into computer system budgets.

The somewhat arbitrary delineation of categories for computer size was developed to separate the very large computation machines from the general purpose processors. The IBM 360/67, valued at $6 million and the HITAC 8800, valued at $20 million are examples of the very large machines, which under the breakdown in Table 4.3 are distinguishable from large computers, exemplified by the Burroughs 6700 and the IBM 360/50. It should be noted that unresolved problems in international rates of exchange made the relative values of some computers somewhat misleading.

Manufacturer	*Number*
Burroughs	4
Control Data	7
DEC (PDP)	8
Fujitsu (FACOM)	6
GE - Honeywell	1
Hitachi (HITAC)	5
Hewlett-Packard	2
IBM	24
ICL	3
Data General (NOVA)	2
Nippon Electric (NEAC)	6
UNIVAC	1
Wang	1
XDS	2

Table 4.4.

BREAKDOWN BY MANUFACTURER

Insofar as size is concerned, the distribution of computing equipment is fairly even. If this sample is representative of a network population, the distribution indicates that there are both resources and users for the resources, a critical requirement in amassing the participants for network development.

The breakdown by manufacturers shows a domination by IBM, which accounts for 33% of the total number of computers reported. About half of the IBM computers, however, are second generation machines with capability more in the mini and small computer range. Japanese computers also showed up well, accounting for 22% of reported equipment. Almost all of the Japanese computers are installed in Japan.

The breakdown by model shows a diverse array of equipment. With the distribution shown in Table 4.5, processing compatibility with larger network computers and the ability to transfer overloads are possible network benefits. Also evident is a complementary arrangement of computational versus general purpose equipment, e.g., note the balancing of the B 6700's, CDC 6400's, and HITAC 8800 by the IBM 360/40's, 50, and 65.

Model	Number
B 5500	2
6700	2
CDC 3150	1
3200	1
3300	2
6400	2
CYBER 72	1
FACOM 230	6
HITAC 10	1
850	1
5020	1
8350	1
8800	1
Honeywell 200	1

Model	Number
HP 2100	2
IBM 1130	7
1401	1
1620	2
7040	1
360/40	4
360/50	2
360/65	1
360/67	2
360/91	2
370/145	1
370/155	1
ICL 1940 A	1
4000	1
KDF 9	1

Model	Number
NOVA 800	2
NEAC 2200	6
PDP 8	2
10	1
11	4
12	1
UNIVAC 1108	1
WANG 3300	1
XDS SIGMA 5	1
SIGMA 7	1

Table 4.5.

BREAKDOWN BY TYPE

Languages. Of the responding institutions, those who had computing facilities used FORTRAN universally. The distinction between FORTRAN II and FORTRAN IV appeared to be more of degree

than of kind and though the difference does exist, the significant point is that one language is implemented on all machines in the sample.

Language	*Number of Users*
FORTRAN	37
COBOL	24
Algol	17
PL/1	12
Assembler	3
SNOBOL	2
Others	11

Table 4.6.

LANGUAGES

COBOL is also a relatively widely used programming language, but not to the degree that FORTRAN is. Algol's utilization is primarily outside of the United States or on Burroughs equipment. PL/1 is implemented only on Japanese and IBM third generation equipment.

Telecommunications. Over 50% of the respondents had telecommunications capability. The differentiation between the transmission rates in Table 4.7 was to determine the degree of sophistication to which remote processing could be supported.

Transmission Rates (in Bits Per Second)	*No. of Responses*
to 1200	20
1200 - 9600	14
9600^+	6
None	18

Table 4.7.

TELECOMMUNICATIONS CAPABILITY

Rates to 1200 bits per second can support most man-machine interaction terminals, of which the most popular type is

the teletype. The 1200 - 9600 bps rate can accommodate remote job entry stations and moderate speed printing devices. Rates in excess of 9600 bps can be used for computer-to-computer communications.

The higher transmission rates are found primarily in the United States, where the ARPANET and leased lines provide capabilities up to 50 kbps. Japan is currently using teletypes and remote job entry stations, for which 50, 200, and 1200 bps speeds are used.

User Characteristics. The total number of students enrolled at the 41 responding institutions was 421,717.

No. of Students	*No. of Institutions*
Under 2500	9
2500 - 5000	5
5000 - 10,000	9
10,000 - 15,000	9
15,000+	9

Table 4.8.

SIZE OF INSTITUTIONS

The smaller institutions are found in the Southeast Asia and Pacific area. The middle-sized institutions, from 2500 - 10,000 students, were fairly well distributed among the responding countries, while the larger universities were principally in Japan, Australia, and the U.S. This corresponds with the general level of computer expertise in the country.

The number of computer center users for the responding institutions exceeded 70,000. The figure includes student, faculty, and research usage.

About 10% of the students enrolled in the responding universities were taking computer courses. Of the 39,178 computing students, 2047 were candidates for computer science degrees. There was no correlation between the size of the university and the number of students taking computer courses.

User Training. Most of the institutions offered some type of training in programming, computer design, or computer science.

In the non-degree curricula, programming and computer design courses were offered by 23 institutions. Programming only

was offered by 15; computer design only was offered by 1; and 2 institutions provided no training in the computer science area at all. Four of the institutions had no on-site computing capability.

Degrees Offered in Computer Science	*No. of Institutions*
Bachelor's	0
Master's	2
Doctorate	0
Bahcelor's, Master's	2
Master's, Doctorate	6
Bachelor's, Master's, Doctorate	15
None	16

Table 4.9.

DEGREE PROGRAMS

In the degree curricula, 25 of the queried institutions offered at least one degree in computer science. In many programs, advanced degrees in computer science are offered after the completion of undergraduate work in an applicable discipline.

The data indicates that a substantial amount of computer science training is taking place in the universities. Again, the universities in Australia, Canada, Japan, and the U.S. lead in the offering of computer science degrees.

4.2.3. CONCLUSION

From the data collected from the various Pacific Rim institutions, it appears that the conditions which promulgate computer network development are present, i.e., educational costs are constantly a problem; the distribution of resources are heavily weighed in favor of the more industrialized countries; the mass of resources and users does exist even though it is not organized at the present time; and the development of a large-scale regional computer-communications network can indeed alleviate some of the shortcomings of the present situation.

5. ORGANIZATIONAL REQUIREMENTS, ISSUES, AND ALTERNATIVES FOR DEVELOPMENT

5.1. INTRODUCTION

This study has so far shown that the potential and the interest for international network development exists. The experiences in network development have indicated that it is a long, difficult, and expensive undertaking.

Developments in the United States are motivated primarily by economic reasons, which result in several jurisdictions combining resources for their mutual benefit. Under such a cooperative structure, coordination between the participants is an essential characteristic, but this is brought about only by considerable attention to the process of network administration.

In the international context, a variety of attitudes toward network participation and development is anticipated. The assumptions on international development made in an earlier chapter suggest that multinational network development will likely be based on an informal consensus of the participating entities rather than by the mandate of any central group. If this assumption is true, the linking of the project objectives to the organizational form which will execute the objectives will be important. The effectiveness of project development by loosely-related groups will depend heavily on a good system of communications and coordination.

An organization of participants, whatever its degree of formality or informality, should pinpoint the responsibility for communications between the participants and for the coordination of their efforts. This responsibility can be centralized or dispersed--the key element in the development of a widespread network of heterogeneous resources and talents is that its foundations be understood by the participants and the potential participants. Once this is accomplished, there must be a somewhat formal mechanism by which information for continued efforts is exchanged and communicated.

Only the rudiments of a network organization have been initially assumed. Informal communication and coordination are the very minimal functions that could be established by a group of potential network participants. The following sections attempt to outline what such an organization would be required to do, what issues face its establishment, and what possible alternatives it has in developing a Pacific Educational Computer Network.

5.2. ORGANIZATIONAL REQUIREMENTS FOR PROJECT DEVELOPMENT

The organizational functions which will be required in the Pacific Educational Computer Network project are:

- Planning
  - Interest articulation
  - Pilot studies
  - Proposal development
  - Fund solicitation
  - Project organization
- Development
- Control and Evaluation
- Transition
- Operations

Planning. Planning includes the functions of interest articulation, preliminary feasibility studies, pilot studies if needed, the preparation of a project proposal, the solicitation of funds, and project organization. The classification is arbitrary but tends to separate the enabling activity from the actual design and development. The sequence implies a chronology but it is not a strict one. The suggested sequence of events, however, should minimize the duplication of effort or the development of superfluous network components.

Interest articulation is the process of developing an idea and eliciting support for it. It can either be formal or informal. Formal interest articulation would include the presentation of papers to learned societies, proposing feasibility studies to research-supporting agencies or publishing articles on the subject. Informal articulation takes place through contact with colleagues, possible supporters and participants in the idea development, and other interested people. Through a variety of means, the idea receives publicity, feedback, interaction, and revision. Agreement by all contributors is not an expected result.

Not all ideas are capable of immediate meaningful articulation, the impact of using geothermal energy being one example. For this reason, preliminary feasibility studies, or pilot projects may be necessary to produce preliminary data for the evaluation of the idea. Results of these studies can then be used to increase the interest articulation or to be a basis for project proposal development, solicitation of funds, or awards from interested organizations.

The functions of the planning phase require: (1) publicity; (2) evaluation of reaction; (3) structuring of a feasible idea; (4) planning a course toward the implementation of that idea. Included in the process of interest articulation are many people, few of whom are involved past non-committing interest. The idea structuring from the various imputs again does not involve many people. Planning the actual project also follows the same pattern once the inputs have been received.

The organizational requirements for the planning stage are not independent of the scope of the project but can be summarized as best being a large group of contributors and a small group of actual planners. The size of the groups is somewhat relative to the type and size of the project.

The contributing group can involve all of the possible participant institutions that are willing to make the effort to react and to develop the initial idea. The constituency of the smaller group should include the persons who have originated the idea or who have devoted substantial time to its development and a reasonable cross-section of interested people. Participation of others because of interest and ability to contribute should be limited by the size of a workable group. In the formative process, being involved in detailed initial planning may be a dubious honor, for the considerable amount of work to be done has no guaranteed reward at this point.

In the solicitation of funds, the rifle approach may initially be better than the shotgun approach, i.e., proposals for specific parts of network development may be more likely to receive funding than a proposal for total network development. Both the feasibility of funding and the feasibility of producing a workable development plan play a part in the overall strategy for building a network. In this regard, then, the evidence of demonstrated success may be necessary to solicit the scope of funding necessary for larger network development, and the solicitation of funding for specific parts of the network may be both desirable and necessary.

The search for funds is both a formal and informal process. The informal process can begin as early as the interest articulation phase, with representatives from funding agencies being invited to participate in the formulation of the development plan from its inception. Further, appropriate personnel at possible funding agencies can be kept continually informed of the progress by mailings or other general means of communication. The value of personal contact is not underestimated in the process.

If the funds are secured, the process of getting the project organized is the next task. The problem of assigning the subprojects in the network development to the proper parties in terms of interest and ability is not particularly easy in an international environment when political overtones may easily be misinterpreted. Organizational alternatives are discussed later in this chapter.

Development. As implied by the functions above, a project is divided into several phases, generally described as planning, development, and operational. The development phase is concerned with the actual design and implementation of the technical and nontechnical systems described in the proposal. Once the development phase begins, the number of actual persons working on the project increases substantially. The need for more formal organizational structures also increases and the specific functions required are collected under the term, "project management".

Project management involves the management of the available resources to accomplish the goals set forth in the project plan. The resources are classified as manpower, funds, time, and material. The specific functions of project management are: the development of the specific plan to achieve the objectives, the delegation of the responsibility to carry out the parts of the plan, the allocation of resources to those responsible for accomplishing specified objectives of the overall plan, the coordination between the parts of the project with special attention to the mechanisms of interfacing the output of the separate project groups, the monitoring of performance of the project groups, and the adjustment of plans to fit changes in conditions.

The degree to which these functions are carried out depends largely on the type of organization formed by the participants and the direction they take in implementing the network.

In Pacific network development, it is conceivable that simultaneous efforts could be carried out in ground station development, portable terminal development, communications channel organization, transponder design, transceiving equipment, and associated applications systems. Given this possible scope of activity and the technical integration required for the future connection and smooth functioning of the parts, the task of project management can be seen to be a difficult task. Without sufficient attention to this aspect of the development process, the success of future integrative efforts can be seriously jeopardized.

The function of control and evaluation and the transition from development to operations is generally placed under the development process. In this case, however, they were separated because of the separate attention each function requires in a large network project.

Control and evaluation are normally conducted by the project management to insure that each delegated assignment is being satisfactorily developed. If the Pacific network is composed of a series of loosely-related cooperative ventures between educational institutions, this may be a difficult function to perform. It may be more appropriately carried out at another level, e.g., by the funding agency or by the Board of Participants, rather than by the project managers.

Transition from development to operational status has also been singled out as a separate function because of the difficulties encountered by previous projects in this respect and because there are many unresolved issues in international telecommunications that will either be faced when the transition takes place or solved at that point. Pacific network development will be at the frontier not only of the satellite computer-communications technology but will be exploring impacts on international telecommunications law as well. Because of its far-reaching importance, the transition stage has been delineated as a separate function.

Operational status is the final link in the development process. The organization at this point must be capable of self-maintenance and perpetuation. Its personnel are permanent and its funding is stable. This state is not immediate and its organizational requirements may best be decided after the participants have had experience with each other in international project development.

5.3. ORGANIZATIONAL ISSUES

In the current context, organizational issues are broadly defined. Clarification can only come when a somewhat formal organization is formed and its members reduce the issues to workable policies.

These broadly defined issues are:

- Context for development
- Determination of participants
- Determination of the policy-making structure
- Determination of the administrative structure
- Determination of the operational structure

Informal organizations can exist for an indeterminate period without paying particular attention to these issues. However, as network participation increases, some mechanism for resolving differences at the policy, management, and operational levels must exist.

Generally, the participant group and/or the target public are well enough defined to determine some of the issues. In the case of the Pacific network, the project can be considered in the interest articulation phase to the point that informal interest and working groups are being formed. The interaction between participants has not yet reached the stage that definitive action can be taken on settling the issues.

One strategy for approaching such a nebulous set of problems is to develop a model organization through a set of assumptions, using the model to illuminate the issues and the areas where change is necessary to develop a viable working organization.

In this section, the issues are briefly described. In the following section, a normative model organization for the Pacific Educational Computer Network is developed, further identifying and clarifying the organizational issues described here. Alternative strategies for network development will also be discussed.

5.3.1. CONTEXT FOR DEVELOPMENT

There are several alternatives for establishing the context of the Pacific Educational Computer Network (PacNet) development: (1) PacNet as the transmission network for a larger development, e.g., the United Nations UNISIST concept; (2) PacNet as a subsystem of a larger educational network which also includes television, radio, facsimile, and other means of transmitting educational materials; (3) PacNet as <u>the</u> educational network project of the Pacific; or (4) PacNet as the cohesive organization for all the affiliated educational network projects in the Pacific.

These are discussed in more detail in Section 5.4, Organizational Alternatives for Developing a Pacific Educational Computer Network.

5.3.2. DETERMINATION OF PARTICIPANTS

Besides interest and personal/professional references, no formal means of selecting participants for network development and use exists. There are, however, some discernible criteria for participant determination: expertise, funding agency influence, desire, cultural background, political environment, and capability to support research and network usage.

It seems reasonable to assume that if large funding grants are received from an international body, participation will be widely encouraged. If no such funding is anticipated or received, the participation will be limited to those countries which are able to contribute and support the efforts through funds and technical expertise.

Realistically, the development of bilateral efforts between interested nations could well be a starting point for future network forms. These bilateral arrangements can be incorporated as a pair of nodes in the later organization. In this

rudimentary form of network organization, participation is an informal arrangement which exists by way of definition rather than contract.

This arrangement does not solve the problem of inclusion of nations under a grant structure. The assumption is that if international funding is secured, that the interests of such agencies, e.g., UNESCO, may be toward the successful transfer of the telecommunications technology and the benefits of the educational resources from the nations which are relatively well-endowed in the area to those which are not. Under this assumption, the participants may also be determined by the potential for using the technology.

Interest, the cultural background, and political environment will also play a part in the determination of participants. With or without resources, interest and desire on the part of the participants is an important and positive factor in network development. As an intangible factor, it can make the difference between success and failure.

Cultural backgrounds may influence participation in the network. Though an institution may have the desire to participate in networking experiments there may be difficulty in providing meaningful experiences for the institution's faculty and students. For example, if an institution were interested in network participation for the capabilities offered by computer-aided instruction, it should be noted that the majority of available computer-aided instruction programs and packages have been produced in the United States and bear the cultural influence of America. Learning German through American-developed programs may include references to such Americana as hamburgers and highways. These terms may be meaningless to a Cambodian.

An even more serious cultural consideration is whether the introduction of computer-communications is a service or a disservice to lesser-developed countries. The introduction of technology to a country is generally regarded as "good" by the Western world. However, without conducting a technology assessment of the impact of computer-communications on the particular country, it cannot be certain that no negative results will be produced as secondary and tertiary effects of the introduction of a technology developed in one culture and transmitted to another. Technology assessment has been a topic of serious discussion among the technologically-advanced societies and possible participants without the technology at the present time should consider the impacts of its introduction.

Politically, formal participation in the network may be constrained by the relative international postures of the participants' nations at the time. The world political situation is expected to influence network participation, whether or not the respective governments are in direct conflict.

It may also be appropriate to speculate on the obligations and benefits that network participation effects. Previous networking experiences suggest that the implementation of a network is difficult at the very least. The participant groups will likely divide into developers and users in the formative years and into suppliers and consumers of services after the network is established as a working entity.

The developer group will probably be involved in the development of the technical transmission network and its associated facilitating mechanism, which could be classified as the user services component. If the participating institution does not already have the technical expertise to contribute in the development of network technology, it must be in the position of being able to receive it in a rapid manner, i.e., it must have a program of study which includes electrical engineering. The initial use-oriented participants should have some familiarity with programming and computer technology. The objective of setting these qualifications for at least some of the participants is that there will be a base of technically competent nodes from which to develop the larger network from.

In summary, these are some of the factors which may influence the determination of participants in the Pacific Educational Computer Network. As further discussions take place on network development, others will certainly emerge.

5.3.3. DETERMINATION OF THE POLICY-MAKING STRUCTURE

An organization is usually divided into three levels -- policy-making, administration, and operations. Figure 5.1 shows a model organizational structure which separates the levels. The following sections will discuss the functions, background, and possible structures for each.

In determining the policy-making structure, the functions of policy-making, the context of policy-making, and possible policy-making structures should be considered as relevant background information.

Functions of Policy-Making. Policy-making is the highest level of organizational decision-making. Action taken at this level generally has an effect on the total organization.

The following decisions will have to be considered by the policy-makers of the network:

- What are the major goals of the network?
- What is the scope of the network?
- Who can participate in the network and under what conditions?

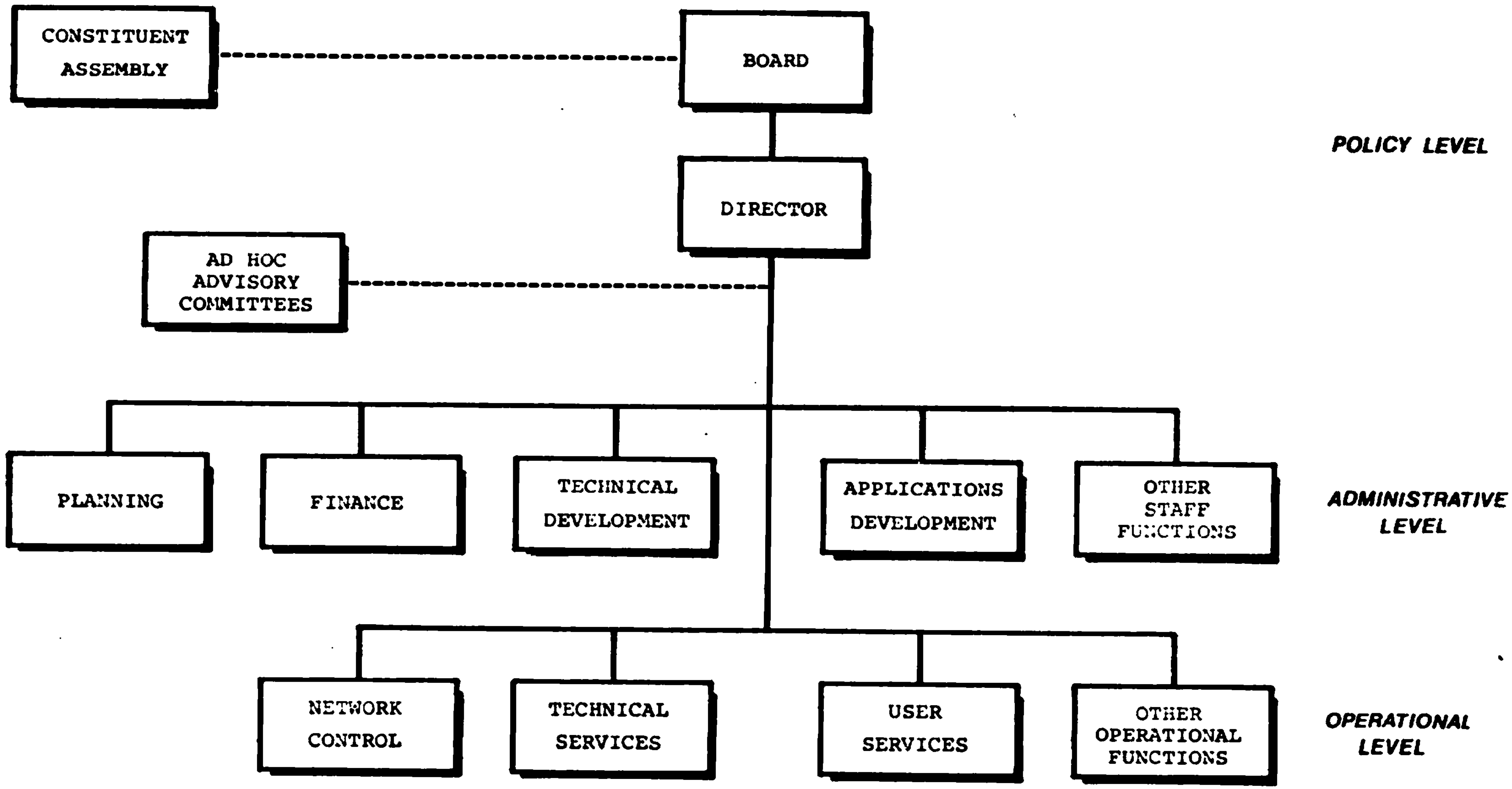


Figure 5.1 MODEL ORGANIZATIONAL STRUCTURE

- What will the financial structure of the network be?
- What will the administrative structure of the network be?
- What will the operational structure of the network be?
- What will the relationships between members, non-members, outside organizations, and outside individuals be?

Answers to these questions do not come immediately but are the result of deliberation among the policy-makers. Each question implies that the consequences on several levels of organization, i.e., administration, project development, and operations, have been examined by the policy-makers.

As an example, in considering the goals of the network, should the transfer of technology and educational resources from institutions which have them to institutions which do not be a major goal in the development of the network? If this is to be a major goal, how much emphasis should the project place on providing the mechanisms for technology assessment and transfer? Technology assessment and the development of suitable techniques for technology transfer are desirable preconditions to introducing technical and educational resources from institutions in industrialized countries to institutions in less-developed countries and may ultimately affect the success of the project in that area. The provision of these preconditions are not vitally related to the development of overall computer-communications networks but they can, however, be extremely important to the implementation of network facilities in lesser-developed nations. This gives rise to a policy question on the goals and the scope of the network.

Context of Policy-Making. Policy-making in a network organization will take place within the context of factors, among which are: (1) the constituency of the network participants; (2) the role of the funding organization; (3) the goal organizational structure; and (4) experiences of other networks. While this does not represent a complete list of background factors, it does give a set of universal conditions which would have to be considered in any networking venture.

The network participants are delineated into several groups, basically classified by their interests in the network project. These groups are users, suppliers, administrators, and technical developers. With regard to policy-making the vested interests of the various groups create different viewpoints on representation in the policy-making process.

Suppliers of educational resources through a network, for example, have felt that the policies for the total organization

should be primarily determined by the supplier group since they have made the greatest contribution in the provision of capability to the network and since they are highly vulnerable to irregularities produced by the network users. They tend to favor a network which imposes no operating restrictions on the suppliers and prefer to rely on the marketplace to determine the level, standard, and price of services needed by the users. Their portion, in essence, is to preserve their autonomy and accept no particular responsibility for being involved in the network.

Users of the network, on the other hand, are distinguished as large and small. The implication of computer networking is that it provides the data transmission system for computer and information utilities. Small users buy increments of computing power from a central facility in the same way that electricity and water are sold. Extending the utility concept to a computer-communications network environment, it can easily be seen how small users can benefit by having computing capacity available to them without the outlay necessary to establish and operate a computing center.

Availability of resources through the network can also induce some larger users to eliminate their own computing centers and use resources available through the network. In this case, it amounts to transfering substantial computer budgets to other facilities. With justifiable concern, the users believe that they deserve a voice in the policy-making structure of the network under such circumstances.

Both sides have convincing arguments but the missing element in network development is that the type of commitment which would require stronger responsibility on the part of either the user or the supplier has not yet been made. If the suppliers viewpoint were carried to its logical extent, a laissez faire environment would exist, similar to the commercial marketplace. The quality of services rendered to the public, as opposed to the in-house clientele, has yet to be determined. If the users prevail, the logical extension of their expectations would be the availability, reliability, and cost of services which would approach that of a well-run public utility.

Network administration has substantial interest in policy-making, but it is traditionally an arm of the policy-making machinery rather than a contributor to it. As such, its influence on policy-making may take the form of an upward flow of information and recommendations to the Board of Directors rather than being a formal participant in policy-making. The usual form of this participation is for the administrative director to sit on the Board of Directors as an ex officio member.

Technical development of the network has played a predominant part in newly-developed networks which were experimenting with new forms of data communications. The innovative effort

for land-based store-and-forward type networks for data communications is largely completed and the technology for microwave systems is taken for granted.

Under satellite communications development, however, more highly efficient data communications can only take place with improved transponder design and utilization techniques. There exists a substantial enough impact upon the transmission and use of communicated data that far-reaching implications of the technical development can be foreseen. For this reason, in this context of international development, the plans for technical development should be well considered by or with the policy-making machinery. Noninclusion of technical personnel may have serious effects on the optimization of the system in its implementation.

The role of the funding organization(s) should also be considered in the policy-making process. Funding organizations generally award grants in subject areas which are being emphasized at the particular time. The subject matter of the research may not necessarily be restrictive but the conditions and intent of the grants may be somewhat tailored to the programs of the major funding agencies.

For smaller research and feasibility study awards the influence may be less, but when funding for larger programs is solicited, the influence of the funding agencies may be more widely felt. Although multiple sources of funds are ideal, it may also be reasonable to expect conflicting goals of sub-development areas within the project.

The possibilities for the future permanent structure of the organization, if determinable at the time, may also have a significant influence upon the policies of the network. If, for example, the future structure is a non-profit international organization administered by a council of participants and fully funded by the participants themselves, a major policy toward a functional network with few frills may be decided upon. If it appears that educational subsidies may continue for the network for an undetermined people, the policy direction toward self sufficiency may be different.

Some possible future structures are: (1) a non-profit corporation; (2) a sponsored association, that is, one which receives a continuous stream of operations funding from an outside source; (3) a cooperative subscription service for network resources which may be under the primary jurisdiction of one particular institution; and (4) a consortium of users, loosely integrated for the purposes of cooperative networking. These and other alternatives can strongly influence the decisions made during the development phase to the degree that they contribute to a foundation for the future organization.

Experiences of other networks or similar organizations provide some background into the possibilities for policy-making structures. The most frequently-used device in the U.S. is the establishment of a non-profit corporation as the adminstrative structure and the appointment of the Board of Directors as the policy-making structure.

Representation on the Board of Directors varied. In most cases, the institutions which provided the major financing to the joint facilities were represented. In other cases, the selection of the Board was governed by the contribution the potential director could make to the total organization by nature of his particular expertise. In this case, lawyers, accountants, and professors were considered more highly than university administrative and fiscal officers.

In INTELSAT, the international consortium of satellite users, the Board is made up of representatives from nations which have financial interest in the satellite. COMSAT, the consortium of American users, was contracted to administer the satellite operations because of its expertise in the field. COMSAT's effectiveness, however, has been diminished by nations sitting on the INTELSAT Board of Directors who were reluctant to capitalize technical expertise for fear of U.S. domination.

The INTELSAT/COMSAT situation represents an innovative attempt at international technical management for which less than expected effectiveness was achieved. Any other development of this nature will be subject to similar political overtones. It was, nevertheless, an attempt which involved government and private industry in technical progress for which international agreements and law did not previously exist.

Possible Policy-Making Structures. Considering the background of constituents, supporting organizations, past experiences and future structures, the alternatives for possible policy-making structures can appear to evolve from a combination of entities within the network.

The more obvious entities are: (1) the constituent group; (2) a council of constituents; (3) a Board of Directors; (4) the funding agency; and (5) a corporate entity, either profit or non-profit, which serves to facilitate the operations of the constituent groups in the network.

From this list several possibilities and combinations exist for the network's policy-making structure. For example, the constituent group could en toto act as the policy-making body. This alternative has the drawback of being unwieldy in the actual decision-making process because of the size and the geographic distance separating the members, but it does have the characteristic of total representation.

A more reasonable structure may be a Council of Constituents, which would be made up of representatives from groups of constituents which are either national, applications-oriented, or function-oriented. This alternative has the advantage of representing the different interests at the same time as reducing the working group of policy-makers to more workable proportions.

The Council of Constituents, if still too large a body to effectively deal with policy decisions, can further distill itself to a portion or all of a Board of Directors. This type of organization and policy-making is somewhat analogous to the public - the Congress - and the committee system in the U.S. political process.

The Board of Directors alternative depends heavily on its make-up as the key to its effectiveness and fairness in representation. Its make-up was discussed in the previous section.

In another alternative, the funding agency alone could dictate the major policy of the network. This was somewhat the position of the ARPANET development in the United States. Almost all responsibility for the development, administration, and operation of the network was delegated to a variety of institutions while the major funding agency, ARPA, maintained official though not particularly formal policy control.

Structures discussed so far have tended to assume that a hierarchical organization exists, i.e., that there are levels of organization and management throughout the network. The informal decision-making structure of the ARPANET project illustrates how policy-development by dispersed administrative, technical and interest groups can affect the total network.

Formal policy-making authority is theoretically vested with the Advanced Research Projects Agency in Washington, D.C. The prime technical contractor is Bolt, Beranek and Newman Inc. The day-to-day communications network operation is handled by the USAF Range Measurements Laboratory in Florida. There are a host of informal special and general interest groups which, in the course of their business, do the research work necessary for policy adaptation regarding specific parts of network implementation. The level of decision-making may in a sense be classified as policy-making, but, for general purposes, the kind of questions considered may be too detailed and technical to be considered as top level policy-making which would affect all members of the network. Some of the groups included in this category are: ARPANet Satellite System; Computer Based Instruction Group; File Transfer Protocol Group, International Network Working Group; International Packet Network Working Group; Network Graphics Group; and TIP Users Group.

As an illustrative mechanism in policy-making, however, this decentralized model of decision-making can be adapted to

international network usage. As an experiment in the communications and effectiveness of a dispersed set of policy-makers, it is an interesting concept which holds much promise in organization and management theory.

The corporate entity, whether non-profit or not, can be set up by the constituents to facilitate the arrangements necessary to establish and operate the network. As a maker of network policy, it can assume the role of the common carrier, leaving the users and suppliers in the position of abiding by the policies it sets. An alternative arrangement would be to have this facilitating corporation be responsible to a Board of Directors representing the groups with commitments in the network.

Other possibilities for policy-making structures are various combinations of the mentioned entities -- constituents, Board of Directors, funding agencies, and corporate entities. In summary, the possible role that each group could take in the policy-making process varies. The major problem is the identification of other entities and the determination of a policy-making structure which is both effective and fair.

5.3.4. DETERMINATION OF THE ADMINISTRATIVE STRUCTURE

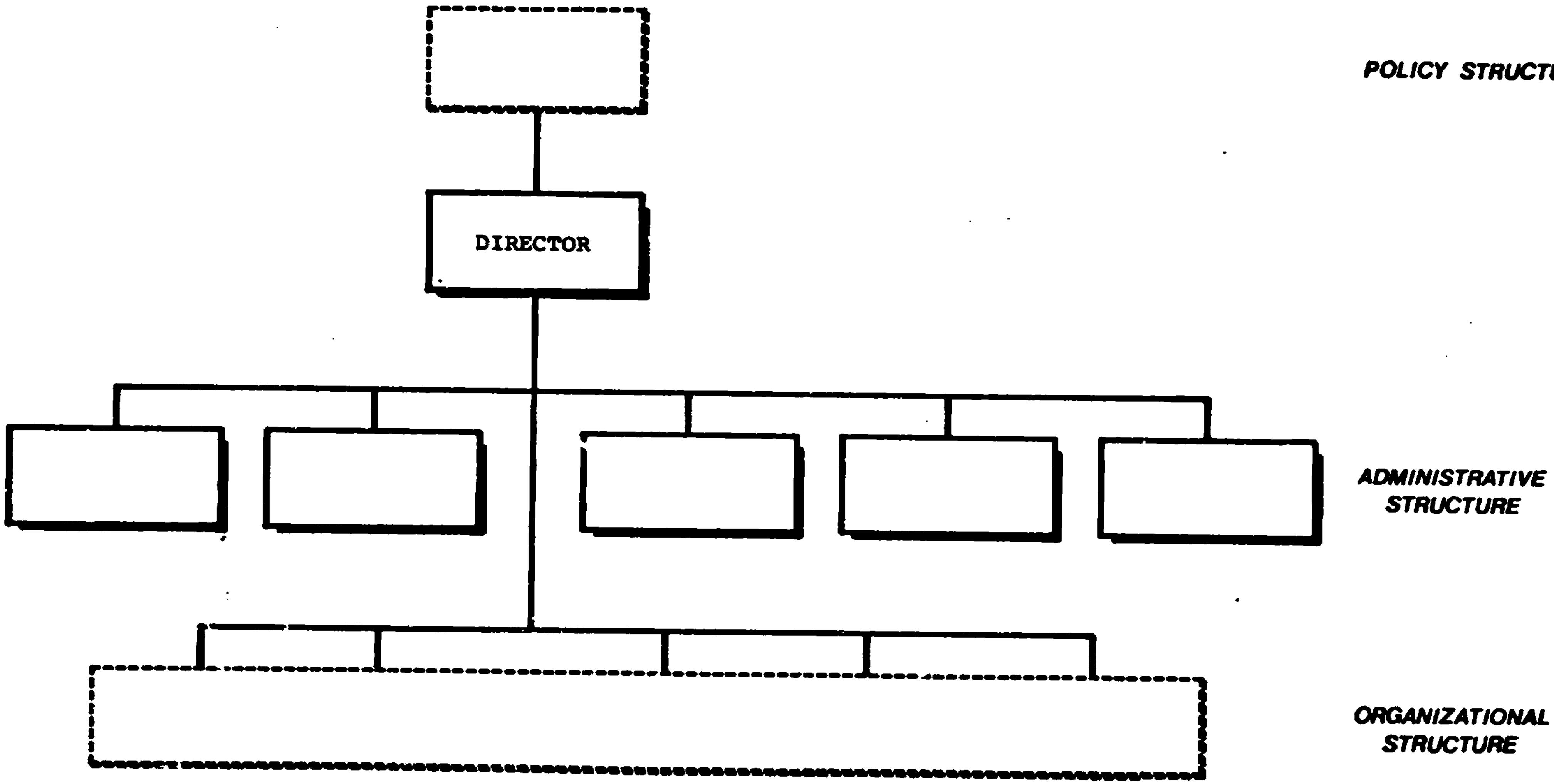
The policy structure is likely to remain fairly static from the inception of the project to the operational phase but the administrative structure will undergo a much more dynamic evolution. The placement of the administrative structure in the organization is shown in Figure 5.2.

The function of management and the different aspects of administration within an organization are pertinent to the consideration of the alternative administrative structures and are summarized before the discussion of the possible structures.

Functions of Management. In organization and management theory, the functions of management have frequently been identified as: Planning, Organizing, Directing, Staffing, Coordinating, Reporting, and Budgeting. Other definitions of these functions are similar, differing in detail but not in general concept. Action taken at this level affects both the administrative and operational levels of the organization.

Planning is the process of determining the best way to achieve the goals set up by the policy-makers. Steps in the process are fact-finding, development of alternatives, selection of the most appropriate alternative, and the development of a concrete set of plans to achieve the objectives. In large organizations, a master plan, coordinating all the goals and targets of the organization, is developed to put the individual projects in proper perspective and to resolve the conflicts between their plans.

Figure 5.2 ADMINISTRATIVE STRUCTURES — OVERVIEW



The function of *organizing* is concerned with the development of an organizational structure that will mobilize the resources of the organization to satisfy its goals and objectives. These resources are commonly classified as manpower, funds, equipment, facilities, and time.

Structures which evolve at the administration level will have to accommodate aspects of administrative, technical, and project management. Structures for the operational level are discussed later.

The administrative organization has the quality of permanence. Its structure is well defined in organizational charts. Technical management is either a subset of the organization or an overlay with functions assigned to specific organizational units. It is essential to technically-oriented organizations but is sometimes transparent. The project organization is temporary and less rigid than the administrative structure. It is created on a special purpose basis and is terminated when its duties are completed.

Directing involves the person-to-person and person-to-group interaction in the execution of the other functions. It is carried out personally or through written directives.

Staffing involves the recruiting, selecting, training, and maintaining the personnel required to perform the functions of the organization. It also includes the allocation of manpower resources to organizational units and project groups.

Coordination involves the direction of resources toward a common overall goal and the resolution of conflicts in the path to that goal.

Reporting is a means of feedback and control over the various functions and entities of the organization. Reporting takes place in a variety of situations, e.g., end of month accounting reports and project progress reports. This is the primary way that the actual progress toward achieving goals and targets can be determined.

Budgeting is primarily concerned with the determination of cost and the methods of financing the activities of the organization. In some organizations, the after-the-fact accounting function, because of its fiscal relationship, is also included in the budgeting function.

The coordination between budgeting and planning is conceptually close. Budgetary constraints do have an impact on the planning process. As plans are developed, the feasibility of financing them is a major consideration. Once the plans are set, however, they have to be financed. This involves the securing of the necessary funds for both the execution of the plans and the continuing operation of the organization.

The functions of management are implicitly part of any administrator's duties, whether the level is that of top, middle, or project management. The method by which these functions are organized for an international computer-communications network is the problem. Some alternatives are discussed later in this chapter.

Aspects of Administration. In dealing with technical and project-oriented organizations, substructures of the administrative and operational levels develop. In organizations which handle relatively static processing, e.g., manufacturing organizations, the units remain relatively static. In organizations where a substantial part of the activity is devoted to the development of large new projects which require technical standardization and massive resources, the administrative activity separates into administrative management, technical management, and project management.

Administrative management is generally concerned with providing the staff functions necessary for the functioning of the organization as a whole. Organizational units which perform the functions of management are designated as staff departments. Between these departments, support for the functions of management are assigned in a way which is most conducive to the effective operation of the organization. Different functions will receive differing degrees of emphasis depending on their relative importance to the type of organization they are to serve. For example, banks may pay substantially more attention to finance and accounting than to research and development while aerospace engineering firms may place emphasis in quite the opposite manner.

Figure 5.3 shows the functions of the administrative management organization. Figure 5.4(a) shows the transition from functions to a possible staff level arrangement which can support the functions of management. This is representative of a typical business organization. Figure 5.4(b) illustrates how the staff departments of an organization can be manipulated to more effectively serve the needs of a technically-oriented organization.

The administrative management structure serves the purpose of handling the administrative details necessary for the smooth functioning of the organization. This would include the personnel, finance and accounting, office services, and legal services.

Within the administrative management function, the subgroup of technical management functions emerges. Technical management is the planning, coordinating, and controlling of all technical development so that the efforts of the various project groups are consistent and can be integrated. In large scale undertakings, technical management is a significantly complex effort and is therefore a major component in organizations geared toward technical development. Figure 5.5 shows an administrative structure which accords the Technical Management group a major slot in the

Figure 5.3 ADMINISTRATIVE STRUCTURES 2. FUNCTIONAL BREAKDOWN

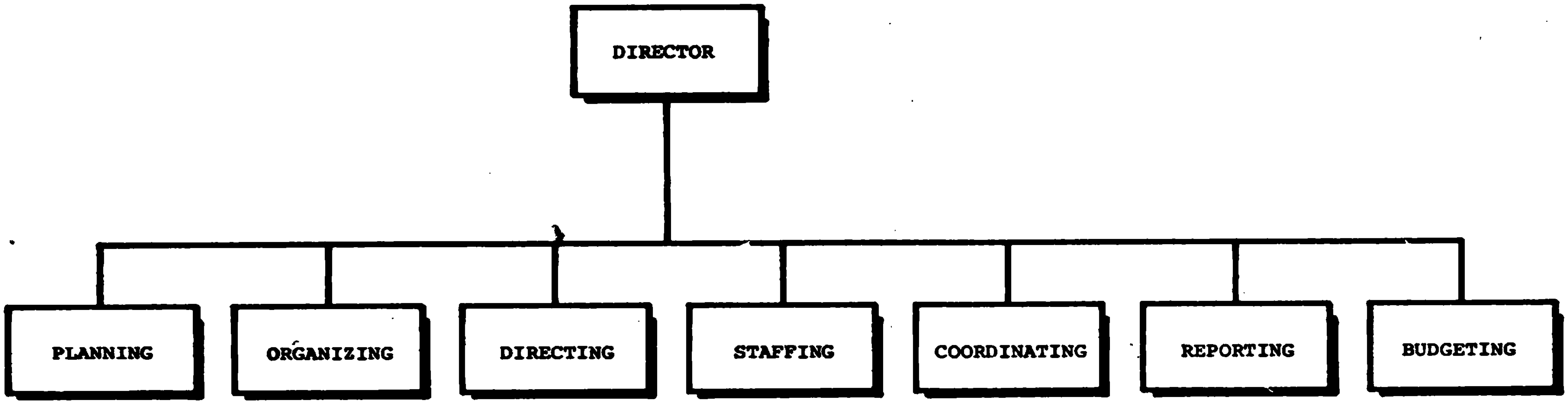
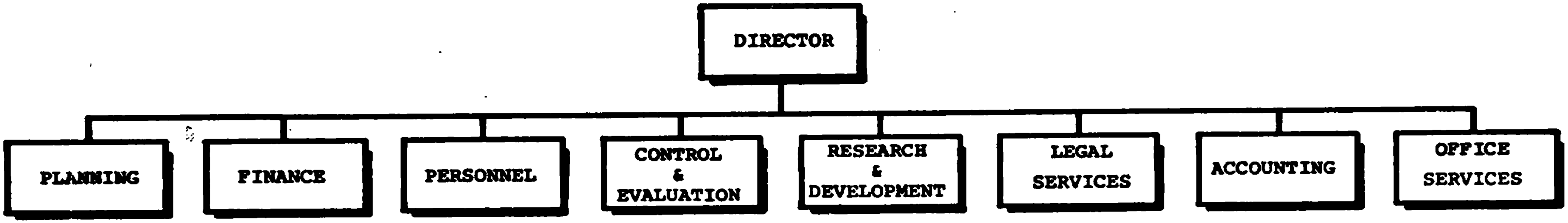
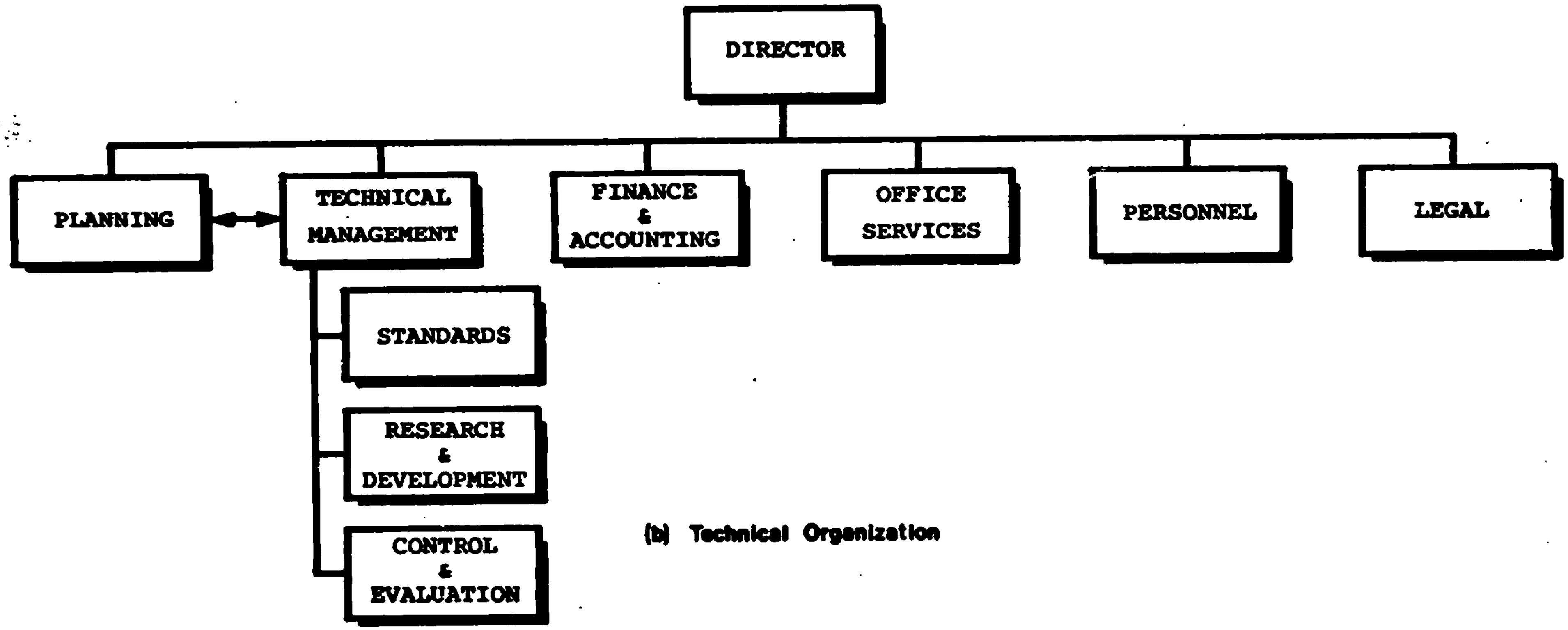


Figure 5.4 ADMINISTRATIVE STRUCTURES 3. STAFF DEPARTMENTS

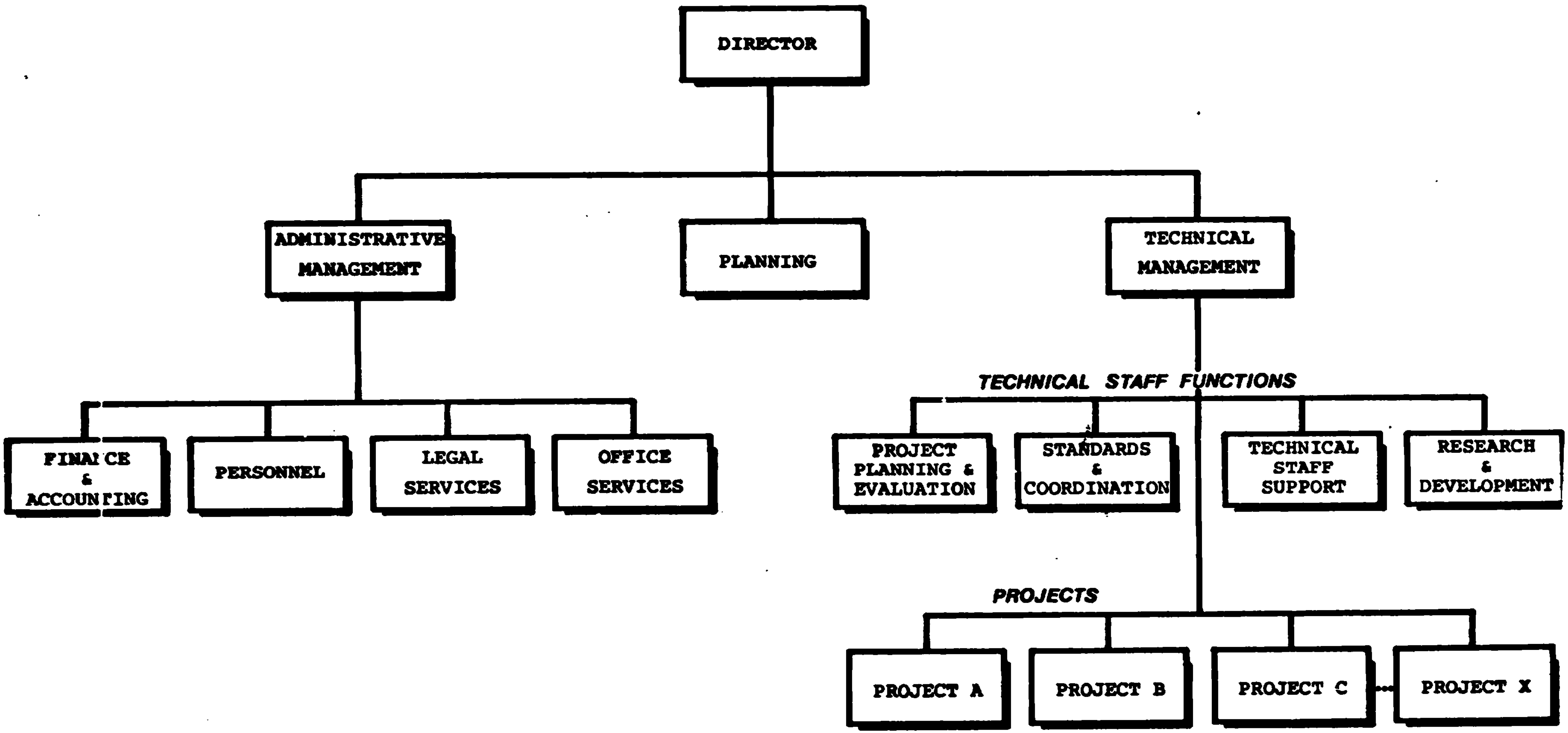


(a) General Organization



(b) Technical Organization

Figure 5.5 ADMINISTRATIVE STRUCTURES 4. TECHNICAL MANAGEMENT



organization chart. In this structure all functions which relate to technical development are gathered together and administered as a unit. The projects, which are discussed in the following section, are organizationally responsible to the Technical Manager. Very briefly, the functions of the Technical Management staff are to provide coordinated planning for all projects under execution, evaluation of progress of each of the projects, the development of standards and mechanisms for coordination, technical staff support, and research and development.

The manpower pool for technical assignments as well as experts in specific areas would be headquartered in a conceptual technical staff support unit for facility in handling personnel and other administrative matters. Project personnel assignments can be made through this type of unit.

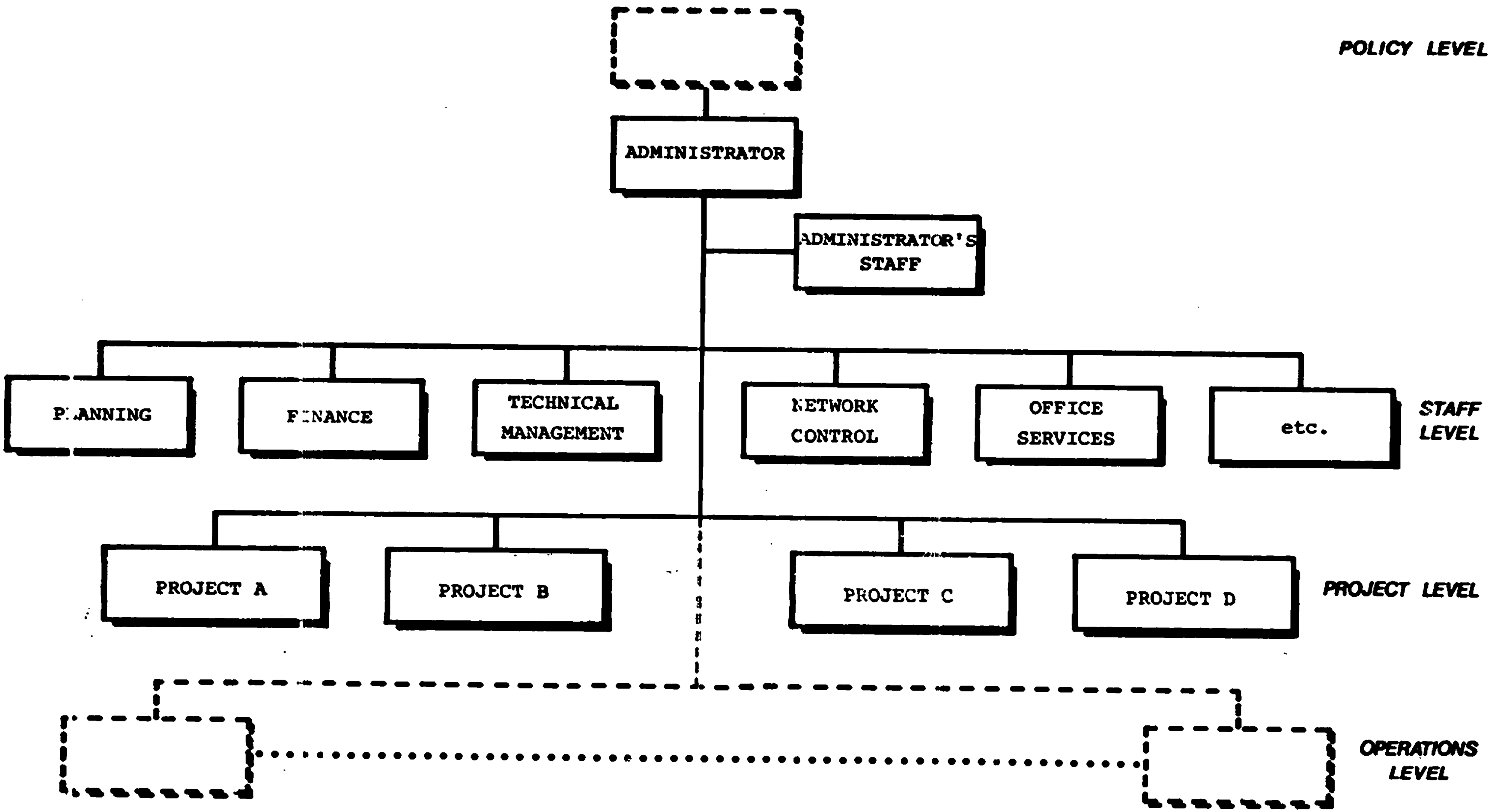
The project, on the other hand, is a transient organizational entity which exists only until it completes its goal. Its personnel are either assigned from other units in the organization and return there upon the completion of their duties or are hired specifically for the project without the suggestion of permanence. Its financial resources are provided by the organization, as are its equipment and other material. Except for the fact that it is directed toward the accomplishment of a specific objective, its concerns regarding the functions and responsibilities of management are very similar to those of the parent organization.

Relating the project group to the administration, the linkages are through the administrative technical management structures. The projects are administered by project managers, who are responsible to the Top Administrator or to designated subordinate structures such as the Technical Management Unit. Figure 5.6 shows an alternate placement of the project groups, making them responsible to the Top Administrator and establishing relationships between them and each of the staff support units.

Though project organizations are not generally classified as staff units, they do not properly belong in the operational level since they have the characteristic of being transient special purpose organizational units. For the purposes of this study, they are being classified as ad hoc special purpose units to the administrative structure. A potential administrative problem arising from project structures is that the line of authority within the organization is ambiguous. Persons working on the project have a dual allegiance - one to the project manager and one to their base organizational unit. In a network situation this is a potential problem area because the project and the parent institution of the personnel may not have consistent goals, either for the network or the personnel working on it.

The structure of the project is another level of hierarchical subdivision of the organization. The project is divided into tasks and the tasks are further divided into subtasks until workable units are defined. The result are work units which can

Figure 5.6 ADMINISTRATIVE STRUCTURES 1. PROJECT LEVEL



be assigned in terms of time and resource commitments. The work units of the total project are directed and coordinated by the project manager until the final goal is achieved or unless changes in plans dictate some other result.

In terms of time, especially in the case of an evolving organization, the components of the administrative structure described above are likely to vary in importance as the development progresses. At the outset, primary emphasis will probably be given to the formation of the project groups which will get the work started. The development of the staff support units will likely come after the initial projects have been started. As more project groups are defined and become operational the need for staff unit assistance for both the top administrator and the project managers will be apparent and they will emerge as definable units.

For large scale developments, the staff complement may not achieve stability and efficiency in operations until the middle of the project. Time and experience are needed for the operational pattern to emerge and stabilize. As the development passes its midway point, the project groups will begin to complete their assignments and will terminate, leaving the more permanent parts of the administrative structure and the operational level to carry on the work.

Alternatives for the Administrative Structure. At this point, the issue on administrative structures is not so much concerned with the definition and assignment of function to the staff units but more so with the type of organization which will make up the administrative unit. The immediately obvious types are: (1) funding agency leadership, e.g., ARPA; (2) non-profit corporation; and (3) research cooperative under the direction of one or more primary institutions.

In evaluating the feasibility of these alternatives, the concept, components, and functions of administration should be considered. The network concept encourages the involvement of many institutions which can contribute to or benefit from the goal of sharing educational resources through a computer-communications network. The concept of administration includes the coordination of the administrative, technical, and project efforts within the bounds of a large scale development. While the participants will be involved in the project groups, the question is what structure will be the most effective for the long-term and more permanent administrative and technical management organizations. Participating institutions are not necessarily stable components in the critical mass needed to develop a Pacific network.

Factors which have to be considered in the design of the administrative structure are: (1) that during the development years, the emphasis on the functions will shift; (2) that the geographic dispersion of the participants will have an effect on the administration of the network; (3) that the participants will

be from widely diverse cultural, social, and technical backgrounds; and (4) that because international computer networking is a new application of the technology, the non-technology impacts may be quite significant, requiring knowledgeable staff in the social and political areas in addition to competent technical personnel.

With these qualifications, the alternatives for network administrative structures can be considered.

The first is administration under the leadership of the funding agency. The prime example of this structure is the ARPA development, in which the major responsibility remained with ARPA and the specific administrative and technical management tasks were delegated to others.

Technical management of the network was delegated to Bolt, Beranek and Newman, Inc., (BBN), a private engineering consulting firm. BBN assumed the role of prime contractor and had the responsibility of working with subcontractors and participants in the technical development of the network. Technical control over the network operations continues to rest with BBN.

Other administrative functions, such as information dissemination and collection of operational statistics rest with other groups, headquartered at participant universities and research institutions. Day-to-day operations management is handled by the USAF Range Measurements Laboratory.

The personnel at ARPA were prominently involved in the conceptual development of the experimental network and were technically proficient in the subject area. Funding was also allocated from the ARPA office, giving the project administrators a good means of controlling the development.

An interesting factor in the ARPA development is the diversity of participating groups -- universities, non-profit research institutions, private firms, governmental agencies, and units of the armed forces. Another is that the sponsoring agency was technically strong and had the power to allocate the development funds, implying a high degree of control over the project. Further, the institutions that participated in the initial experiments were those which were already recognized for their efforts in the computer-communications field, implying that the participant group possessed a high degree of technical proficiency.

In international network development, however, a philosophical question arises on whether the network administrative structure will be a benevolent dictatorship or a participatory group decision-making organization. Another question is whether a funding agency has the desire to administer such a large undertaking. If it is outside the agency's sphere of expertise and immediate interest, the agency may be more inclined to assume an attitude of review and evaluation rather than direct administration.

Using a non-profit corporation to handle the administrative functions of the participant group was the major device employed in regional network development in the U.S. Its use for inter-state organizations was avoided because of complexities involved in expanding beyond the legal jurisdiction of incorporation. International efforts may run into the same type of complexities on a larger scale.

An advantage offered by an international non-profit corporation, however, would be that continuing attention could be given to the problem of facilitating network development. Among other things, this would include securing the necessary clearances for experimental operation in all participant countries and continuing to keep these channels open.

By the same token, the aspect of 'corporation' implies a degree of permanence not necessarily consistent with experimental educational use and this may be more detrimental than helpful.

The third alternative is to designate a primary group or a primary institution which would be delegated the responsibility of "prime contractor" for the network. Inevitably, this would come to rest at a particular institution because of logistics and the need for support staff to carry out the administration. The delegation of administrative functions to a particular group or institution does not necessarily imply that the technical functions are similarly clustered.

The characteristics of the situation suggest that the primary group alternative may be a suitable structure. The Pacific network has the characteristics of:

(1) being heavily based in the educational community;

(2) having a variety of technical expertise with concentrations in identifiable areas;

(3) attracting interest from institutions whose participation objectives ranged from being users to taking part in the technical development of the network;

(4) attracting interest from institutions whose ability to support their participation in networking ranged from no resources to those whose major research is currently in the area of networking; and

(5) being widely dispersed geographically.

PEACESAT, a radio-based educational communication project originated on the University of Hawaii campus with counterparts in the South Pacific, employed a similar primary-institution type arrangement. All participants in the PEACESAT network, which is

linked through the ATS-1 satellite, maintain their own individual transmitting stations. Coordination between the participants and arrangements for satellite usage are made through the PEACESAT operations center at the University of Hawaii. Both federal and State of Hawaii funds are used to support the effort.

The ground stations are the major technical components in the PEACESAT network. These ground stations were developed and fabricated at the University of Hawaii and distributed to other network participants for a modest construction cost. Once the equipment is placed, the network is capable of operation during the time allocated on ATS-1 to PEACESAT operation.

The use of the network is coordinated through the University of Hawaii but this does not prevent the other participants from making arrangements between themselves. The participating institutions remain independent and the linkage between remains an informal cooperative agreement.

Perhaps the most interesting part of the PEACESAT development is the informal network of cooperation and participation which exists among its participants. The network has provided its participants with a communication mechanism which is low cost and which can be used to develop means of remote education. Class lectures have been transmitted from one university to another using the network; experts in the same field on different campuses have used the network to communicate with each other directly using the teleconferencing feature. Even with its limited use of the satellite, the radio communications project has proven itself to be a useful tool in sharing educational resources.

Obviously, independent groups can form a consortium to exchange ideas and develop operating procedures. Under a group participation structure, this can be effective while the group is small. The administrative functions can be assumed by the institution which has sufficient resources to contribute in the area. However, if the cost for these functions are not supported by the participants, network coordination and administration are as consistent or as vulnerable as the funding of the institution which accepted the responsibility. As an example, the operations of the PEACESAT network were threatened when the funding support for the project at the University of Hawaii was reduced. The environment for development and the premises for education of the PEACESAT and the Pacific network projects are very similar, indicating that the PEACESAT experiences could be a valuable base for Pacific network development.

Given the current state of Pacific network evolution, it appears that variations of either of the three administrative forms can be adaptable. The sequence of events which precedes the formulation of the organizational structure of the network will have a great impact on the form which emerges.

5.3.5. DETERMINATION OF THE OPERATIONAL STRUCTURE

Consideration of the operational structure presents a philosophical problem not explicit in the discussions on policy-making and administration. The major question in considering operational structures is whether there should be one or not.

'Operational' has two connotations -- one, as the last step in a project, and two, the third level of the organizational hierarchy which includes policy-making, administration, and operations. The two are related in that the operational structure does not emerge as a significant entity until preparations for the phasing of the project into operational status is made.

The Pacific Educational Computer Network has two premises which affect its 'operational' status: (1) it is educationally-oriented; and (2) it is experimental. Organizational units which are accorded project status support the transient nature of the network and its development.

The educational base of the network resides in the universities and other institutions of higher education in the Pacific Rim. The network participants will consider themselves as primarily belonging to their institutions and incidentally to the Pacific network. As such, no permanent dedication of staff or equipment is being made to the Pacific network.

The experimental nature of the development also suggests a temporary research organization and it further implies that the network is not intended to carry traffic which requires consistently reliable transmission.

Moves which would tend to make the network a permanently operating organization may destroy some of the original premises and cause otherwise latent political forces to take negative action. Specifically, network development in the context of today's technology is justifiable under experimental bases because international common carriers have no adequate means for efficient and economical data communications. Sponsored research in this area can well contribute to improving the situation.

For research projects, successful completion of a project does not necessarily mean self-perpetuation of the result. In the Pacific network project, the objective is to see if the new techniques in the utilization of satellites can be applied to the sharing of educational resources. If the Pacific network development concentrates on this aspect, it may more appropriately be in the purview of another group or organization to undertake the establishment of a permanent organization to continue the services of a network.

Operations under a more permanent organizational entity will face a set of problems which do not exist under project organization.

First of all, the network may have to be self-sufficient or depend on its constituents for its operational funding. Financial and economic problems which did not arise under subsidized status will emerge. For example, the relative values of human labor and computer time are different in the different cultures and the different nations. Yet, in international networking, the exchange of funds for services will eventually have to be made and series of problems will exist in (1) rates of exchange, which are constantly fluctuating; and (2) the reluctance of some nations to let their institutions contribute an outflow of dollars from their country.

Secondly, if the experimental nature of the network gives way to more reliable services, the common carriers may challenge the existence of the network as a threat to their businesses.

It is beyond the scope of this paper to speculate on the development of an organization to continue the work of the project on a more permanent basis. The method of network development, the administrative structure during development, and the policy of the experimental network toward establishing an operational organization will all have an impact on the structure.

5.4. ORGANIZATIONAL ALTERNATIVES FOR DEVELOPING A PACIFIC EDUCATIONAL COMPUTER NETWORK

The background, requirements, context, and issues for Pacific Educational Computer Network development have been presented in the preceding sections. The remaining task is to discuss approaches for organizing the efforts contributing to the Pacific network during its development phase.

The derivation of an integrated set of alternatives from the various possibilities is a difficult task without interaction from the involved parties. This section develops a framework for considering some possible courses for initiating and extending international networking efforts. A Development Model describing one set of organizational development alternatives is presented as a background for considering more workable solutions. The model was constructed to focus on the problems of organizational development rather than on feasibility.

Different approaches toward initiating and extending network development efforts are then discussed, establishing a foundation for further substantive planning by parties involved or interested in further Pacific educational network development.

5.4.1. THE DEVELOPMENT MODEL

The Development Model was constructed as an heuristic device to highlight the organizational problems of international network development. The model represents a set of alternatives selected not to illustrate feasibility but to stimulate thought on the other possibilities for development.

As one example of organizational development, the model takes positive positions on the questions of context, funding sources, development patterns and other such issues.

Context. The Development Model designates the Pacific Educational Computer Network (PACNET) as the major integrated data communications and educational resource-sharing network for education and research in the Pacific Rim. This implies that all efforts relative to network development will be planned for, financed, and developed by the Pacific Educational Computer Network Project. PACNET cooperates with other developments but is a major undertaking in itself.

Policy. Policy considerations are of two types: (1) Policy-making; and (2) Policy Issues.

Policy-Making is a two-level process. PACNET will be developed on the assumption that a viable and valuable network will result and that it will have to become a self-perpetuating entity to continue to serve its project participants. To encourage the development of the large critical mass necessary to maintain network operations, inclusion in the policy process will be extended to all participants from the inception of the project.

All participants will be included in an Assembly which will be a formal body made up of representatives from institutions, regions, interest groups, and other appropriate entities. This group is expected to be large in number and will be apportioned to reflect a fair representation of the participants and interests involved. From this Assembly, a Board of Governors will be selected. The Board will distill policy and establish policy directives from the discussions which take place in the Assembly. The Board will be limited to a size which is conducive to effective decision-making and will not exceed twelve. The constituency of the Board will include representatives chosen from the Assembly and persons of prominence in international law and finance.

The policy issues concern goals and decisions for the establishment and the development of the network.

The primary goal of PACNET is to develop a data transmission and usage network to support educational resource sharing in the Pacific Rim. As a subsidiary goal, it will also provide a vehicle for the education of students in the various aspects of network development. The major technical goal is to develop an effective means of economically transmitting data via satellite,

inexpensive ground stations, and portable terminals. The major non-technical goal is to develop a user services organization which will facilitate the use of network facilities by participants. Optimizing the utilization of the network while under development and experimentation will be a stepping stone toward establishing satisfactory and extended usage when the network eventually becomes an independent entity.

The future goal, which has been implicit in the discussion so far, is to establish a permanent network for effective educational and research resource sharing in the Pacific Rim.

Some of the policy decisions which will govern the PACNET model are:

1. The participants of PACNET include research and educational institutions in the defined Pacific Rim who can effectively utilize computer-communications technology in the development of higher level educational programs. During the development stages, PACNET will financially support participation in the network to the degree practicable. Because network resources will not be inexhaustible, there will be a theoretical limitation on the number of participants. The budget and funding goals shall be large enough to subsidize temporary participation in the network to the point that the institution can decide whether the service is worthwhile or not.

   It has not yet been determined that the use of computers in the process of education is apropos for all nations. Modern technology, in some cases, may be inappropriate or ineffective for particular social, political, or cultural situations. Prior to introducing network capability to any institution, a brief technology assessment will be conducted to alert the potential participants to the impacts, implications, and responsibilities of network participation.

2. The scope of the PACNET project will include both the previously defined technical effort and non-technical developments, among which are technology assessments, plans for effective technology transfer, development of educational material for the use of computers through a network, a compendium of network resources, and administrative mechanisms for facilitating the transfer of services and payments for services between network participants.

   Further, the transmission portion of the network can be extended to service other network applications such as UNI-SIST.

3. Primary funding will be solicited from pertinent agencies of the United Nations focusing on the aspects of 1) technological development; 2) technology transfer; and 3) sharing or extending educational resources between nations.

   Funding from other sources, e.g., foundations, regional agencies, and other educational and research sponsors, will also be sought, in a manner which does not constrain participation.

   Once the network becomes an independent entity, the responsibility for funding will fall more heavily on the participants.

   The central network administration will be responsible for the reconciliation of bills and payments for services rendered. Users will be aware of but will not have to solve the problems of international exchange individually. A workable method of charging will also have to be worked out. Given the different values allocated to human and computer resources in the different countries, coupled with the rates of exchange, a complicated potential problem in reducing the usage figures of the network to workable proportions exists.

4. To carry out the administrative functions, an international non-profit corporation will be formed. Its staff will be members of the constituency or persons hired specifically for administrative duties.

   Since the project will initially be conducted as an educational research project, an academically-oriented Principal Investigator will head it administratively. Leadership will phase over to professional management as the organizational functions stabilize and as the project progresses toward the operational phase.

5. The operational organization will be a permanently staffed non-profit corporation which evolves from the structures set up during the development phase. Its capacity is primarily that of a caretaker organization for completed network applications. New developments will continue to take place under a project structure.

<u>Administration</u>. The Administrative Group will be responsible for Planning and Evaluation; Technical Development, which will include the planning and coordination for the design of data transmission techniques, ground stations, and terminals; Technical Monitoring and Maintenance, which will monitor the network operation to make sure that the technical components are functioning satisfactorily; Finance, Accounting, Legal Services, and Office Services; User Services Development, which will include training, documentation, and communication among the participants of the network;

and Network Resource Coordination, which will provide means to facilitate the use and transmission of data banks, files, software problems, hardware, and consultative resources through the network.

The proposed structure for the administrative group organization during network development is shown in Figure 5.7.

The relationship of the administrative group to the project groups will be such that: (1) where expertise is available to handle a subproject, the expertise will be coordinated into the development process; (2) where educationally-based work forces are available to staff a subproject, their efforts will be coordinated into the development process; and (3) where neither expertise nor project staffing is available, the administrative group will make the arrangements necessary to contract out the subproject.

Since this project is being developed on an international scale in a geographic area which far exceeds the bounds of most organizations, it will be assumed that the administering organization is skilled in project management.

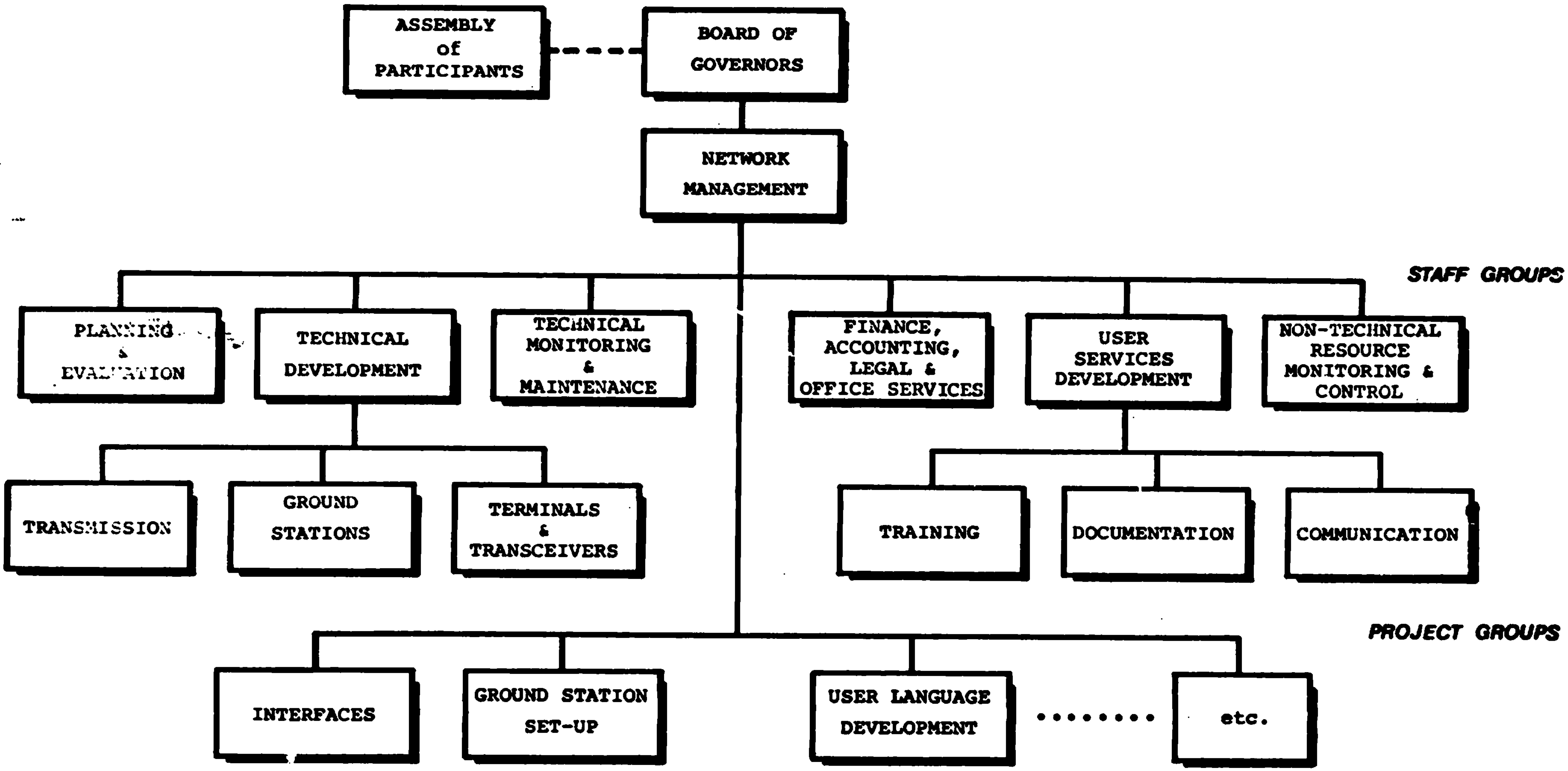
The administration of the technical component of the PACNET project involves the development of the data transmission network and the devices for communications. Various network hardware development philosophies exist, and for PACNET, a highly standardized and efficient network design will be adapted, as opposed to developing a flexible non-heterogenous network connected through interfaces.

The development and coordination of groups dedicated to the promotion of user-oriented services is a complementary effort. The purpose of these units would be to (1) attract users; (2) provide assistance in the orientation and use of the network; (3) provide training and documentation on general and specific systems usage; (4) insure, to some practicable degree, that the reliability of the hardware and software in the network is high enough for experimental work; (5) to assist in the formulation of inter-installation or internetwork resource exchanges.

The administrative functions will be headquartered where the major network activity is being conducted. In the beginning, it will be located at the institution of the project's Principal Investigator. As the project increases its scope and size, the major administrative functions may be transferred to a location which can adequately service the needs of all of the network's participants.

Operations. Once the network reaches operational status, the relationships between the administration of the network and the participants of the network will undergo a subtle change. Whereas the participants filled the administrative posts when the network was established, the administration will now consist of full-time professional staff whose relationship with the participants is that of supporting the needs of the project groups and providing

Figure 5.7 DEVELOPMENT MODEL ORGANIZATION



satisfactory service on one hand, and regulating and controlling the actions of the clientele participants on the other.

The participants, through the Congress and Board of Governors, will still maintain control over the administrative group. A primary objective of the participant group is to keep the network functioning efficiently and economically in the interests of education and research. The Board of Directors will maintain control over the solicitation, collection, and expenditure of funds to insure this relationship.

In the provision of services to the participants, the administrative group will be responsible for periodically assembling interest groups to articulate the needs and desires of the different educational sectors. Further, communications between the participants will be supported by the administrative group. The network itself may be the vehicle of communication.

Financing in the operational phase will come from several sources: (1) from the participants themselves; (2) from funding agencies for new projects; (3) from funding agencies for continuing operations; and (4) from revenues collected from other systems or networks that find PACNET a satisfactory medium for communication.

Except for policy determination and special assignments to network projects, the relationship between the participants and the administration will be on a business-customer basis.

Relationships With Other Organizations. PACNET will be represented in its dealings with other individuals and organizations by designated personnel in the administrative structure. The main focal point in this structure is the Administrative Director, who, initially, will be the Principal Investigator of the PACNET project.

It is assumed that the request for initial funding has been prepared with substantial thought and knowledge so that the proposal is conceptually and technically sound. This implies that the institution sponsoring the proposal and the designated Principal Investigator are qualified to handle the proposed project. As the project progresses, however, and as more of the network functions become stabilized, the transition to professional management will be made.

Among the organizations that PACNET will likely come in contact with are: the participant universities; regional or international academic or professional societies; national governments; regional or international political organizations; funding organizations; interest groups; groups interested in using the facilities of PACNET; and other networks interested in connecting to PACNET.

The PACNET relationship with the participant university will be for the most part as the provider of the facilities which makes the exchange of resources possible. The administration serves at the pleasure of the Board of Governors, which is dominated by representatives from the participant universities. The PACNET operation, therefore, should be highly responsive to the needs of the participants.

Association with related regional or international academic or professional societies, such as the International Federation of Information Processing Societies, is encouraged. If these societies have academic or research interests which can be aided by network usage, their participation will be encouraged.

The PACNET administration, in its role of securing necessary clearances for telecommunications operation in the various countries, will have to interface with the national governments. In some countries, the role of the governments in the educational structure is much more involved than in the United States. In both cases, the PACNET will have diplomatic and official responsibilities vis a vis the government agencies of the countries which are interested in participating in PACNET.

PACNET administration will also have to maintain official and diplomatic relations with other regional and international political groups as a matter of course in the interest of continuing the operation of the network. It is not intended, however, that the network be extended for governmental or other non-academic use.

The relationship of PACNET to the funding sources will consist primarily of the actions of the members of the Board of Governors. The PACNET administration will be required to develop the background work necessary to solicit funds from a variety of sources but it will be the final responsibility of the Board to make the necessary presentations and formal solicitation.

The attitudes toward interest groups vís a vís the network will be dealt with on an individual basis. Those with legitimate academically-oriented objectives will be treated in the same manner as the participant users. Others may be denied access to network facilities. Because of the educational, non-commercial character of the network, it is possible that its activities may be sanctioned where others may not be and it would not be in the interest of the network administration to give these sanctions up.

The same attitude would extend to other groups who are interested potential network users.

Interconnection with other networks poses a difficult question. There are obvious advantages to being able to access networks with other resources or to use them as connecting mechanisms to even other networks. In the same manner, however, the

resources of the educational network may have to be opened to others. Rather than face the problems which extended usage will bring, PACNET will be developed as a closed, tightly controlled, and efficient network for its clientele.

In the Development Model, PACNET is characterized as a large, totally inclusive network whose technical design was selected to be efficient rather than flexible. Its development is accomplished through one massive centralized project utilizing both participant universities and contractors to develop the network. Participants play a significant role in policy-making and financing the network operations. Its administrative structure evolves from project management to professional management.

The Development Model sets the background for the comparison of other approaches to network development. These are discussed in the following sections.

5.4.2. APPROACHES TO DEVELOPMENT

Because of its inability to coherently integrate the alternatives for development, the Development Model serves only as the background for the consideration of other proposals.

The following approaches to network development attempt to describe concrete methods of initiating action for future large-scale networking efforts. They are not mutually exclusive and, in certain cases, are complementary. The concept, implications, advantages, disadvantages, and feasibility of each approach are discussed in the following sections.

These approaches are: the bilateral approach, which naturally extends itself into multilateral developments; the pilot study approach; the total systems approach; the interdisciplinary approach; the building block approach; the ad hoc approach; and the consideration of networking as a tool for other approaches.

<u>The Bilateral/Multilateral Approach</u>. The bilateral approach to networking assumes that, at the very least, communications capability between two institutions has been established. The ability to communicate is then extended to include data transmission, remote computation, and educational resource-sharing capabilities. This concept, in essence, is a two-node network joining the facilities of two institutions and their respective internal networks.

The bilateral approach to computer-communications networking assumes that the individual institutions will find that the sharing of computer and information resources can be mutually advantageous and that the first and simplest step administratively is to establish relations with one external organizational entity,

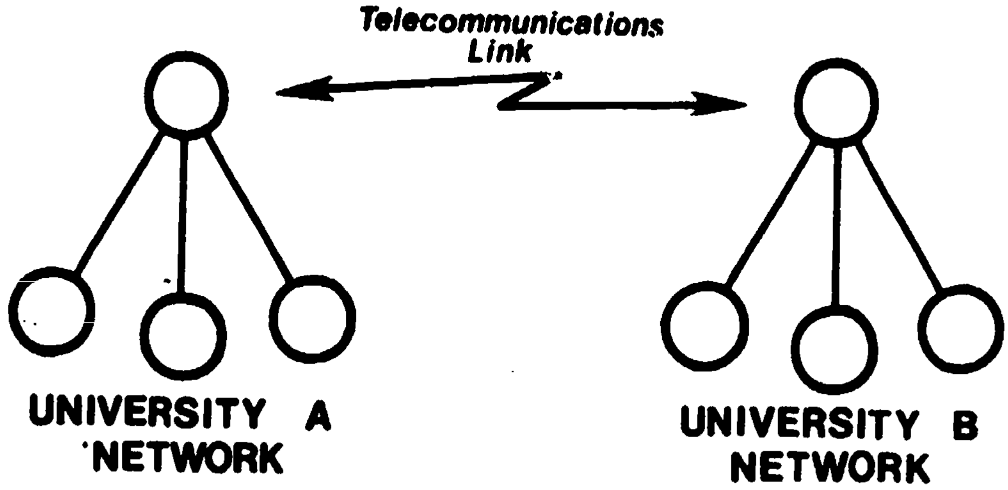


Figure 5.8 SIMPLE INTER-UNIVERSITY BILATERAL ARRANGEMENT

another institution with compatible goals and technical developments. Once the first interconnective capability is achieved, it can serve as a basis for further expansion. Expansion can take place in several different ways: (1) through interconnected bilateral networks, (2) through multilateral agreements, or (3) through a combination of these.

In Pacific network formation, the creation of bilateral agreements can be an effective first step toward the establishment of a network. Using the first option, the two-node network arrangement may be replicated in several jurisdictions and interconnected at a later time, forming a multi-node network, as shown below.

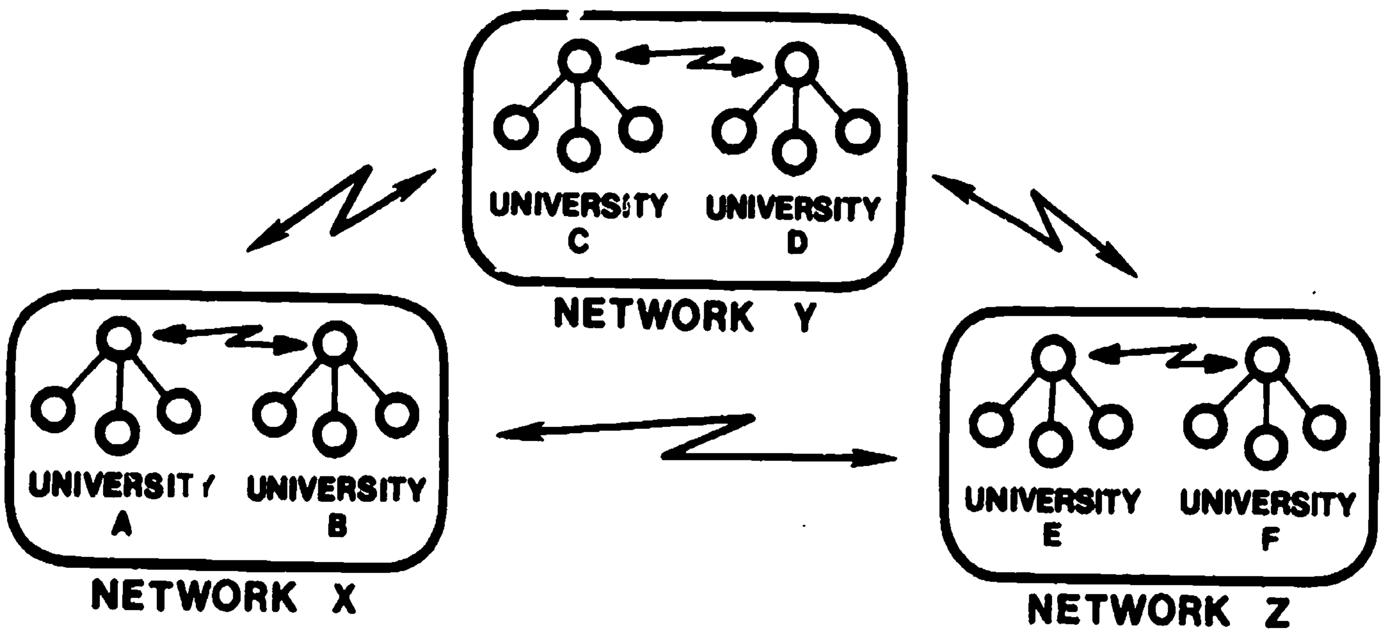


Figure 5.9 EXPANDED NETWORK FORMED FROM BILATERAL ARRANGEMENTS

A primary task of the larger network will be the integration of the independently developed bilateral networks into the larger one. It is assumed that even if the individual bilateral developments are in communication with each other it is unlikely that they will implement identical communications and interface philosophies.

An alternative method of expanding the network from bilateral status is the creation of multilateral agreements between institutions.

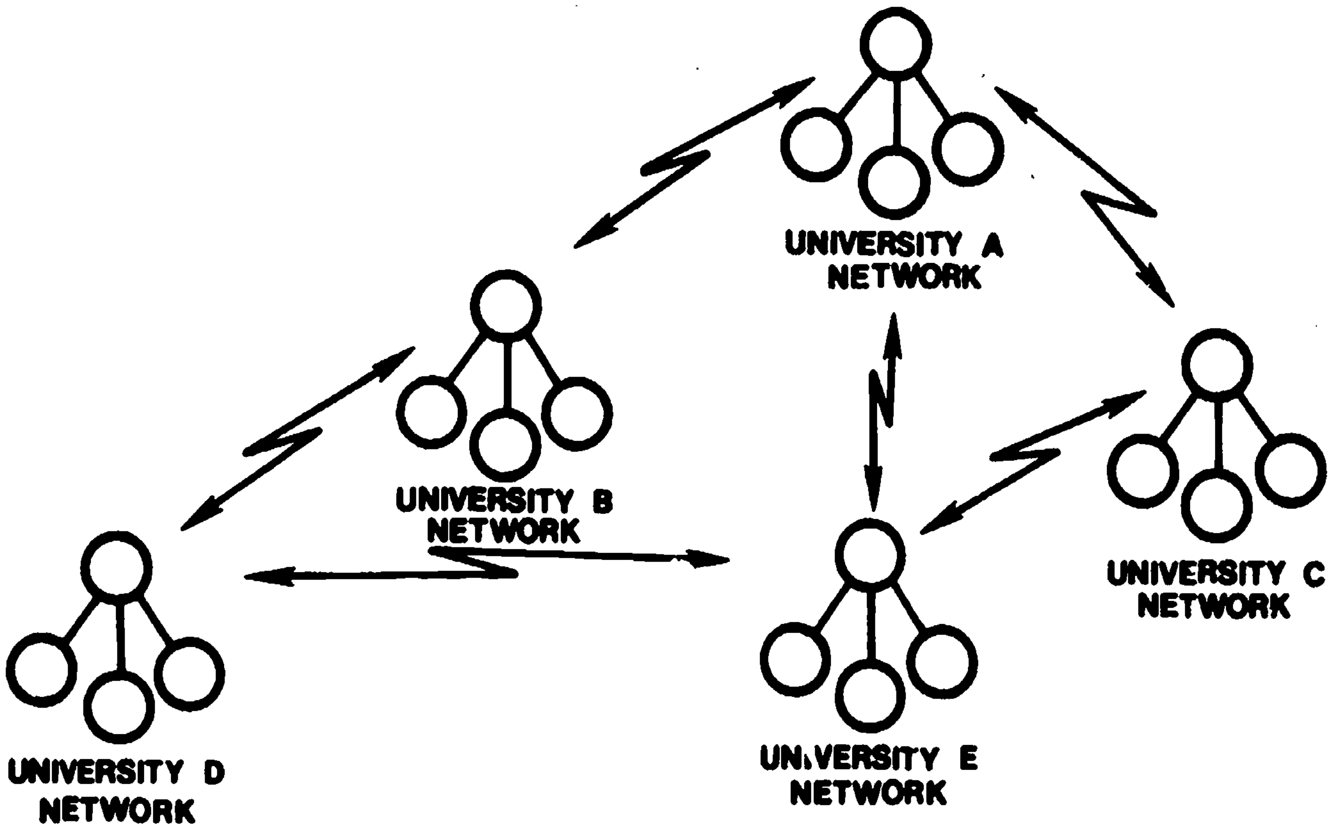


Figure 5.10 EXPANDED NETWORK FORMED BY MULTILATERAL ARRANGEMENTS

Each institution is responsible for establishing its own arrangements with the others. No node in the multilateral arrangement is responsible for switching requests between other nodes. This multilateral arrangement is strictly a series of bilateral agreements, executed by the individual nodes as independent organizational entities. Similarly, the technical connections are also independently arranged.

The third alternative, a combination of these expansion arrangements, introduces a new range of complexities into the situation. Possible combinations, for example, are illustrated in Figures 5.11 and 5.12.

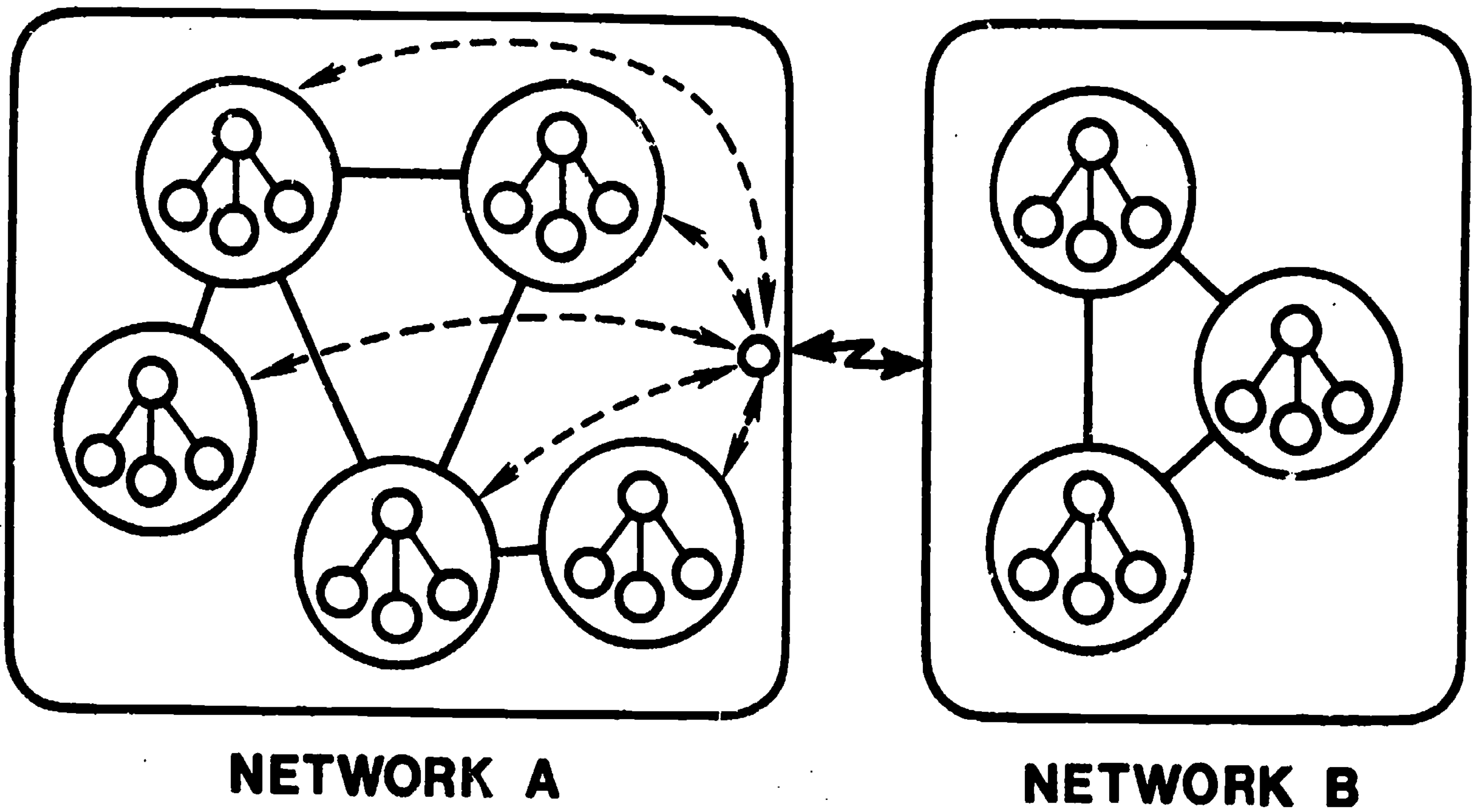


Figure 5.11 BILATERAL AGREEMENT BETWEEN TWO MULTILATERAL NETWORKS

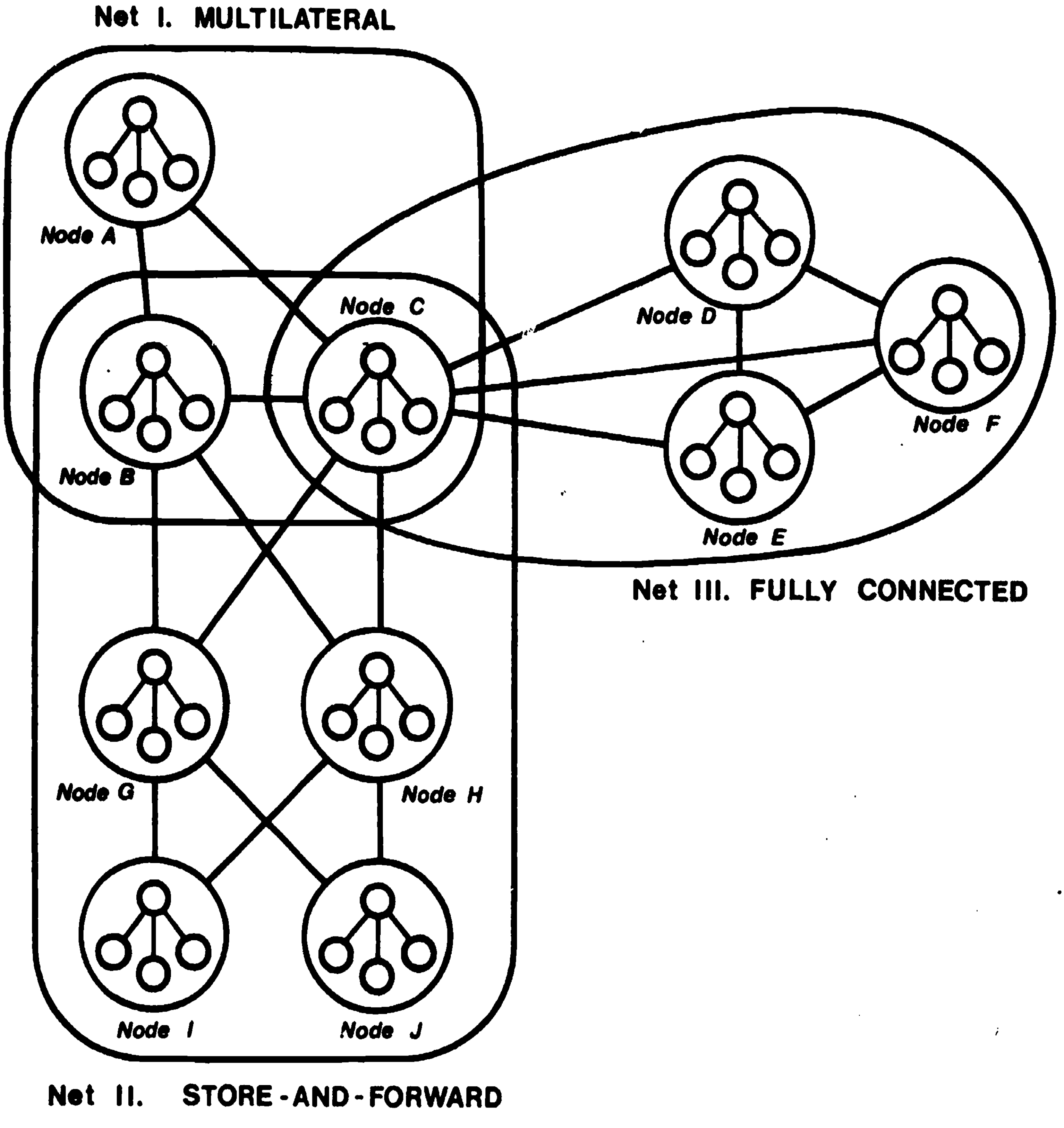


Figure 5.12 COMPOSITE NETWORK

Figure 5.11 depicts a bilateral agreement between two multilateral networks. By nature of the agreements executed, all institutions in Network A have access to all institutions in Network B and vice versa via a central connecting node. All institutions in Network A, however, do not necessarily have access to each other. Network B is fully connected. To execute the agreement between Network A and Network B, it is necessary to get the permission of all eight installation nodes involved.

A composite network, whose interconnectivity is emerging by default rather than by design, is illustrated in Figure 5.12 The various nodes of Net I have multiple arrangements, neither of which administratively affect the other nodes in its group. Net II, on the other hand, is a store-and-forward network. Each node is accessible by all of the others. Node A is officially not part of Net II but the technical availability for interconnection through the common nodes B and C is obvious. Likewise, between Net II and Network III, the factors required for technical interconnectivity are all available.

The administrative desirability for making these interconnections, however, is another question. Where security, distribution of overhead costs, the possibility of an increased drain on scarce resources, and other such issues are of major consideration to any of the participating nodes, the concept of the composite network becomes difficult to work with. There are, nevertheless, several experimental efforts which are taking place under similar circumstances.

The scope of the bilateral agreements, like any of the other approaches, can range from data transmission only to the exchange of computing, informational, and educational resources. Participation in these bilateral agreements can take place between countries of relatively equal sophistication with respect to telecommunications capability or between nations of unequal basic capacity, where the focus is more on educational resource-sharing rather than on technical development.

Equipment, techniques, and facilities now exist to make experiments of the first sort possible. The latter type of experiment, however, will require more initial preparation and planning in the political and social aspects of the educational resource transfer before it can be effectively undertaken.

The advantages of using the bilateral approach for initiating network development are: (1) that bilateral agreements are administratively easier to execute than multilateral or expanded network agreements. With the less complex structure, attention can be focused on the subject of networking itself, rather than on the arrangements which make it possible. Frequently, informal agreements between institutions for experimental testing can suffice as a first preliminary step; (2) that bilateral agreements will likely cover a limited amount of experimentation and operation. With a limited scope to the effort involved, the results can be

expressed in terms of actual achievement and hence be a measurable evidence of efforts. This incremental type of success can be of strategic value in attempting to secure funding for larger scale developments; and (3) that bilateral testing of satellite transmission will produce results immediately applicable to all participants in the Pacific Rim. For all practical purposes, the use of the satellite will eliminate the difference between regional and local processing. The concept of the "international" computer network will have implications politically, but not technically.

In summary, the advantages are a quicker start with less administrative interruption, a shorter period for positive results, and possible system-wide benefits from bilateral technical development.

The disadvantage of the bilateral approach is that the efforts may be undertaken without formal coordination between the independent groups carrying on networking experiments. Though informal groups can probably reach some agreement on standards for data transmission formats and interfacing requirements, there is no guarantee that this will result in the independent developments being able to connect later without substantial efforts devoted to the interconnection problems.

This situation exists between the various networks in the United States today. While interconnection is not impossible, it does present an obstacle to the concept of being able to easily exchange computing and educational resources between the participating institutions. Often, desirable connections are not made because the interconnection effort will take a substantial commitment of additional effort, rather than being readily available.

The effectiveness of the informal organization of network participants should not be overlooked as a method of avoiding later problems caused by different standards between networks, however. With sufficient communication and publicity, it is possible to greatly reduce the possible problems by informal agreements. This requires that the base of those involved in the interest articulation effort be fairly broad and representative of the type of future participants in the network, particularly those interested in technical development.

In general, the bilateral approach offers an extremely feasible approach to the development of networks considered in this study.

Bilateral relationships can begin with the limited redirection of current efforts and funding to initiate network activities within the constraints of current activities. This amounts to a no-cost, ad hoc effort extension of current work.

Only a limited amount of experimentation can be accommodated by these minute diversions from current activities and as this becomes more extensive it requires formalization, i.e., definition of specific ends -- products, proposals, and commitments.

The Pilot Study Approach. The pilot study approach allows concentration on specific aspects of the total system development. Pilot studies are conducted on microcosms of the larger systems concept or on specific aspects of it. This is in contrast to the bilateral arrangement, where there is more flexibility in goal definition.

Taken individually, the pilot study is conducted to test the feasibility of a particular approach, with the results of the study being the measure of feasibility. If the results are favorable, the achievements of the pilot study may be used in the context of larger applications or may be replicated for use in other jurisdictions. If the results are unsatisfactory, the approach can be considered unsuitable for the problem. Taken as a series, pilot studies can be used to determine the comparative feasibility of various approaches to the same problem. The results provide the basis for comparing techniques of development, from which standards or methods of maximum effectiveness can be derived. This approach has been used to test the effectiveness of several different methods of large scale regional information systems projects in the United States.

Pilot studies are envisioned to be undertaken either in a single country or between a limited number of institutions within a region. The size should be such that the ability to develop and test the technical feasibility of the idea is not hampered by the political and other ramifications of the situation, unless that in itself is the objective of the study. In multinational projects, the nontechnical arrangements required can hamper progress to the point of reducing the study to marginal effectiveness. While the commitment of time and resources required to resolve this type of problem may be worthwhile on a project of larger scope, pilot studies should be defined to avoid the inclusion of debilitating arrangements.

The advantage of the pilot study approach is that the goal is specific, a characteristic which creates a definite and positive direction toward the implementation of the concept. This is in contrast to feasibility studies, for which the product is nebulous at the outset, and bilateral agreements, for which the commitment to positive action may depend on other factors.

While pilot studies can provide positive steps toward network development, the disadvantage can be the same as the bilateral approach, i.e., that the direction of the studies can become uncoordinated, leading to problems of interconnection with other networks at a later time.

The scope of the pilot study is limited; the intent of the pilot study is to test the feasibility of a concept; the ultimate result of a pilot study may be wider-spread implementation. In terms of being a steppingstone toward networking, then, the pilot study is an effective device developing positive and useful approaches for solving larger scale problems. Its ultimate effectiveness is highly dependent on the communication with other networking efforts.

The Total Systems Approach. The total systems concept, the method advocated by the Development Model, suggests that the scope of effort undertaken in network development be all-inclusive. This implies that network planning establishes the ultimate network and its associated support systems as the goal and then defines all steps required for its realization. The deliberate planning effort theoretically covers all aspects of network development and integrates them into a coordinated sequence of events.

In terms of Pacific network development, this implies the requirement of a large-scale planning effort which totally defines the development of all network components, the pilot studies, the organization of participants, the schedule for development, the method of funding, and other such concerns.

The advantage to this approach is that positive leadership can be exerted, increasing the probability that such a large undertaking can be brought successfully to conclusion. Further, the a priori knowledge of the common goal enables the delegated parts of the project to address themselves to positive contribution toward the goal rather than supporting of varying concepts of the end product network, a situation which can emerge from efforts which are officially independent.

The primary disadvantage is the questionable feasibility of the approach. Amassing the interest and agreements desirable from the geographically dispersed participant base for such a total concept may be more than a planning committee or feasibility study group can handle in a reasonable length of time. In other words, as a total project undertaken by a primarily educator-based group, the development of a network may be too large for effective action. Certainly, the effort required to put together an integrated plan with enough agreement and detail is not trivial. By the time such a plan is formalized and put into proposal form, other approaches can well have produced incremental successes toward networking. In addition, the likelihood of receiving the massive funding necessary to implement such a total concept is questionable without demonstrated successes on a smaller scale.

In summary, though the desirability of a totally integrated planned approach toward Pacific Educational Computer Network development is obvious, the deliberative nature of large, informal group undertakings make its success questionable. The real value of the total systems concept in this project may be as

the exercise which describes the master plan to reach full network status; the means, however, may more effectively be individual projects which employ other approaches in accomplishing their objectives.

<u>The Interdisciplinary Approach</u>. The discussion of network participation so far has implied groupings based on technical homogeneity, regional proximity, or special interests of funding agencies. Another base for possible network establishment and/or participation are the related professional societies and interest groups.

Network development in the United States illustrates the substantial contribution made by the discipline-oriented societies, in contrast to those with major interests in computers and communications. In chemistry, for example, a study for the establishment of a National Laboratory for Theoretical Chemistry is being conducted. The objective is to establish a dedicated computer center large enough to handle the problems in theoretical chemistry and make this resource available to all the universities and research laboratories in the nation. In physics, CACHE, a data bank for physicists, has been established. In the medical field, MEDLINE gives researchers access to the abstracts of hundreds of thousands of pieces of medical literature. Though these efforts depend on a distribution system external to their own interests, the development of their data banks is a valuable contribution to a resource-sharing computer-communications network.

Professional societies, such as the International Federation of Information Processing Societies (IFIPS), may be interested in the development of international network standards. The World Meteorological Organization may be interested in the collection and reduction of data using such a network. It is possible that an independent discipline-oriented organization could form the basis for the establishment of a network.

The approach has the distinct advantage of having a limited mission to accomplish. For example, an all purpose network has to e into account the different requirements of each identifiable group of users. The possibilities for implementation alternatives escalate geometrically. In the case of a dedicated system servicing only a specific and well-identified target group, the network and its accompanying system are developed to service this particular group in an optimal manner, rather than being developed to adequately servicing a variety of groups, each with sub-optimal performance.

The extension on this advantage, however, points directly to two major weaknesses of large, singularly-dedicated networks. These are: (1) That networks of the geographic scope and coverage envisioned in the PACNET concept represent a tremendous financial investment. Whether this can be justified for a network dedicated to a single discipline is the question. The capacity for

transmission and processing indicates otherwise. (2) The other weakness, also philosophical, supposes that several groups decide to jointly develop and use the network. Unless attention is specifically given to the development of standards for processing and transmission and to the development of overall operational procedures in the network, problems in utilization of the network will emerge. The problem is identical to that faced by individual developments without informal or formal coordination. The result is the reduced effectiveness of the total network because of the disorganized use of the common channel of transmission and equipment.

Regarding the feasibility of interest and professional group participation, it is probably a more reasonable approach to have the groups view the network as a communications channel and to concentrate on the development of the means to effectively share the educational resources which they have available, e.g., data banks, computer-readable abstracts, and specialized computation programs.

With such a delineation in the scope of participation, i.e., between technological development and applications development, the accommodation of many such groups becomes a feasible notion. Standards in at least the transmission of data formats and the interfaces between the diverse equipment used by the users will make interconnectability theoretically possible.

The Building Block Approach. The building block approach banks heavily on the distribution of a basic model node to all participants. The development of this model node would be developed at a 'host' institution and subsequent distribution of this basic equipment to all participants would be the technical means of establishing the network.

This strategy was successfully employed by the PEACESAT project, which developed low-cost radio communications stations for educational teleconferencing, and remote instruction. Basic equipment and the primary center for communications was established at the University of Hawaii. Project staff set up other participating stations at various points accessible by the ATS-1 satellite in the South Pacific. At each site, basic transceiving equipment developed at the University of Hawaii was installed at a very low cost.

The participants were responsible thereafter for the maintenance of the ground stations and had the continuing capability for inter-site communications, in much the same manner that radio ham operators have continued access after they install their basic equipment.

Extending this to computer-communications network concept, the technological development necessary to adapt satellite communications and ground station development for widespread network usage

would probably take place in a small number of technically competent universities. Once the technical aspects have been resolved, the ground stations could be packaged and distributed to the participants for a modest start-up cost.

This mode of development is contrasted to other approaches, in which the development responsibility was distributed to a widespread number of technically competent universities in order to provide a network learning experience for both faculty and students.

The advantages of this approach are that, with a fixed technological package, effort can be placed on optimizing the performance of the total network, in both technical and non-technical terms. In the development model, continuous experimentation with techniques and the adaption of improvements to the existing system was assumed. Under these circumstances, optimization is seldom achieved. In addition, the fixing of the technical component enables the low-cost reproduction of the site equipment. With this approach, low start-up cost is a key factor.

The major disadvantage, understandably, is that in a field in which technology is continuously leapfrogging itself, improvements and advances in equipment and technique may be ignored, to the ultimate detriment of the users.

The feasibility of this approach is illustrated by the Dartmouth Timesharing System, where most of the hardware components were assumed, rather than developed. The net advantage is the increased ability to achieve success by not proceeding on too many new fronts at the same time.

The Ad Hoc Approach. The ad hoc approach uses currently operating or developing systems as the basis for eventually establishing a network. Network activity is viewed as a secondary priority and if undertaken, will be carried out in the course of current programs at little or no extra cost. This approach resembles the bilateral arrangement but is even more tenuous.

The ad hoc approach provides two advantages. First, experimentation without commitment is possible. It provides potential participants with a vehicle to wait-and-see whether networking will yield them any benefits. The burden of the development effort falls on the institutions which are perhaps the most able to carry out the core of the work necessary to establish the network. The second advantage is that, for institutions which are engaged in telecommunications research, the ad hoc approach allows the work to be used in an effective manner, i.e., as a device for technology transfer.

On the other hand, as a by-product rather than as the focus of networking efforts, the ad hoc approach results in a situation where the aspect of non-commitment makes it too easy to give up when difficulties arise. By virtue of the power of

key personalities in the project environment, the effort could be sustained, but by the same token, the effort can be left by the wayside.

The feasibility of the approach is high because the normal procedural delays usually associated with the formalization of proposals and funding are subdued. Combined with the elements of reciprocal action generated by the bilateral approach, ad hoc efforts could emerge as one of the most expeditious starting points for network development. Though the approach may be organizationally unsophisticated, it nevertheless results in having the initial developments being borne and tested by the more advanced institutions. The potential is great but no responsibility for continued participation will be expected of the users or providers of services. Whether the interest can be generated and sustained by the participating institutions is a matter of the personalities and commitment on the part of the parties involved.

Networking as a Tool to Other Approaches. In most of the approaches discussed so far, the predominant attention has been devoted to the technological development of the network capability. In the United States, the network development cycle has evolved to the point that the technology is assumed and attention is focused on making the network an effective tool for its ultimate users.

For this reason, an alternative approach to the development of networks is to concentrate on fulfilling the ultimate purpose of the network, leaving the technological development as a means of implementation, rather than as the primary force.

One possible blanket network of this nature would be the UNI-SIST concept. UNI-SIST, the World Science Information System proposal, presents the concept of having universally accessible data capture, processing, and retrieval mechanisms directed toward the dissemination of scientific information. It is, in a sense, a tool for international discipline-oriented resource-sharing.

As it stands now, the UNI-SIST concept lacks a mechanical means of implementation. Conceptually, it is also somewhat unwieldy because of the expansive scope and the number of diverse participants involved in its implementation plan. While the development of a Pacific Network or its technological component does not solve the total UNI-SIST problem, it is a candidate for at least one of the means of transmission required for such an information system.

Another approach to networking would be the creation of a transmission system for a variety of educational resources. For example, the spectrum of possibilities would include voice, video, and facsimile, in addition to data transmission. Television broadcasting, as well as two-way video transmission, has been considered

in educational circles as a means by which experts have been made available to remote audiences. The receptability of voice as a remote conferencing mechanism has been demonstrated in the PEACESAT project. Where documents have to be transmitted, the feasibility of facsimile has been proven.

Data transmission alone makes up a limited subset of possible educational materials which can be transmitted via communications channels. Data transmission, however, is one of the areas in which intensive research has only recently begun. The industry has previously relied heavily on the existing telephone system technology to transmit computer-readable information.

Given a mandate to develop more efficient means of transmitting digital signals, however, computer-based technology may well open other avenues of implementation.

Other possibilities for a sponsoring organization might be the World Meteorological Organization or the World Health Organization. The advantages of such an approach, i.e., developing a network under the auspices of another more widely applicable discipline, is that the communications network development itself is put into perspective, making it an element of a project, not a development in itself. As a supportive effort rather than as a prime effort, the focus on the ultimate user is more pronounced. The delay of involving the ultimate user until after the system has been developed is a common criticism of pre-network computer systems developments. It is found also in current network implementations but has not emerged as a major criticism because of the newness of the networks.

The disadvantage of this approach would be the submergence of potentially powerful network capabilities to the administration of another group. Whether or not other disciplines or other applications would be welcome under this scheme of implementation is an unanswered question. Nevertheless, the relatively high cost of underwriting such a network would require that the highest and best use be made of it -- and this may or may not include the realm of possibilities envisioned for a Pacific Educational Computer Network.

Establishing a Pacific Educational Computer Network as a tool for other approaches is intuitively less feasible than attempting to establish a Pacific network itself at the present time. Because of the lack of articulation, developments other than UNI-SIST do not exist in a widely circulated form. The UNI-SIST concept, however, suffers from the characteristic of trying to accommodate everything, to the point of being unable to proceed in its current form. While the concept of international educational networks has been discussed, no definitive work or proposal has yet been widely available. Neither has a proposal for an umbrella project which would serve as a vehicle for Pacific network development.

In summary, the viewpoint of PACNET as a subsystem to another major system may be an exercise in developing perspectives but has little practical value at this time because of the relatively undeveloped state of the other conceptual systems.

Summary. The study of educational computer-communications network development has been only sporadically approached. The major studies of educational networks and their support systems have been done in the United States, primarily because they have been a focus of government sponsored research. Japan also has made significant advances in the development of large-scale networks, with their attention directed to the technical aspects of interconnection.

This report has covered the background, the uses, and the experiences of educational networks. It has also attempted to present the context and the administrative and organizational requirements for undertaking the Pacific Educational Computer Network development. Approaches for initiating networking efforts were also discussed.

Together, these topics form the basis for serious organizational planning in network development. From this background material, potential participants should add to the concepts or articulate the other concerns from which definite plans and proposals can evolve. The participation of interested persons and institutions on an international basis is vital to the development of a large multi-purpose network.

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