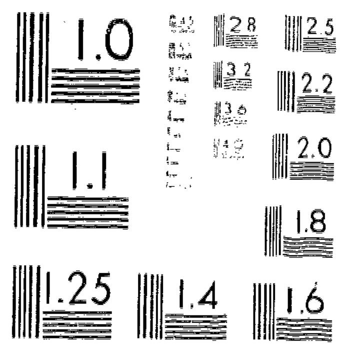
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ABSTRACT

New possibilities for colleges and universities in a networking environment and the role of minicomputers in higher education were the two main topics of the conference. William Miller of Stanford presented policy prospects for the late 70's. Other speakers indicated some more immediate steps which administrators and faculty might take to utilize the advantages of computer network arrangements. A progress report on the EDUCOM Planning Council on Computing in Education and Research described the first steps in the implementation of a facilitating network designed to help a particular group of institutions respond to the challenges of network computing. Several papers addressed the policy and management issues faced by colleges implementing distributed computing on campus, noting particularly the influence of state government on public college systems. An analysis of the new technologies which will bring increased computing resources to higher education in the next few years was the subject of a speech by David Winkel. (KB)

POLICIES, STRATEGIES, AND PLANS

For Computing In Higher Education

PROCEEDINGS OF THE
EDUCOM FALL CONFERENCE

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PREFACE

College and university administrators will have to make some very different choices as we move into a networking environment. Accessing scarce resources and shopping for better costs or response time is already feasible. It may be longer before we begin to feel the effects of a new medium for intellectual exchange and new information system structures resulting from national networking. There is very little question, however, that there will be major benefits for higher education in each of these four areas. Highlighted by a demonstration of an embryonic version of a computer network for higher education, the EDUCOM 1975 Fall Conference illustrated the potential benefits and choices available to higher education in a networking environment.

Beginning with a keynote address by William Miller, Provost of Stanford University, which outlines the prospects and problems likely to be important to college and university administrators in the late 70's, this proceedings includes papers from the conference plenary sessions. A first group of papers develop the theme initiated by Dr. Miller. In Part II authors explore the possibilities of using distributed computers as a resource, paying special attention to the growing role of the minicomputer on campus. Authors experiences in regional sharing of computer resources described in Part III, illustrate real achievements of networking for higher education made by many states.

As a familiar portion of the EDUCOM Conference, workshops developed the ideas raised in plenary session and gave conferees an opportunity to share individual experiences. Reports on each workshop, prepared immediately following the conference, were distributed by mail to those conferees who requested them. Additional copies of these reports which average four pages each are available at the cost of reproduction from EDUCOM.

On behalf of all conference participants, I thank Conference

Chairman Gene F. Franklin, Stanford University, who led the program committee in the design and implementation of this timely and interesting program. Thanks are also due to other members of the program committee: James Emery, EDUCOM; Robert Gillespie, Washington State Computing Consortium; E. Rex Krueger, Oregon State System of Higher Education; Melvin Peisakoff, University of California; and Robert Scott, MIT.

Joe B. Wyatt
President
EDUCOM

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INTRODUCTION

The theme, "Policies, Strategies, and Plans for Computing in Higher Education", is developed in this volume in two aspects: new possibilities for colleges and universities in a networking environment; and the role for minicomputers in higher education now and in the immediate future. Presentations, included here in edited form, are addressed to college and university administrators who hold responsibility for computer resource management within an institution as well as those who have the responsibility for allocating computing and other resources within the institution through the budgeting and planning process.

Addressing the first theme, William Miller, Provost of Stanford University challenges readers with his view of policy prospects for the late seventies. Additional papers on this theme indicate some immediate steps educators, administrators and faculty need to take in order to prepare for the future: the administrative environment required to take advantage of networking, policy issues that are raised and the impact of technology on the university as a policy making entity. A progress report on the EDUCOM Planning Council on Computing in Education and Research, outlines a specific response to the issues raised previously, and describes first steps in implementation of a facilitating network designed to help a particular group of institutions respond to the challenge of computing in a network environment.

It is becoming too obvious to be ignored that the cost effectiveness of minicomputers is going to cause them to be selected for more and more computing in higher education. The only question now is the definition of their territory. They stand uncontested in the field of the laboratory and process-control, and are beginning to prove themselves increasingly capable of handling data base and interactive functions. Several papers address policy and management issues faced by colleges and universities implementing distributed computing on campus, noting particularly the influence of state government on public university systems. Looking to the immediate future, David Winkel provides readers with an analysis of computer technology (available now on an experimental basis) which will likely bring significantly increased computing resources to higher education within the next few years. Administrators in higher education, will want to note the trends outlined by Dr. Winkel in order to plan and budget for computer resources during the late seventies.

As usual, the time necessary for production of the proceedings will render some of the ideas discussed in this volume obsolete by the time of publication. For further information and updates to the ideas presented here, readers are referred to the authors and to the literature of technical professional societies. Names and addresses of all authors, together with those of other conferees, are printed in Appendix A of this volume.

As we move into a networking environment colleges and universities will indeed face some very different choices regarding allocation of resources for computing. This volume presents some of the options for institutions in this environment, which should be useful and provocative for administrators and faculty in a variety of institutions of higher education.

Gene F. Franklin
Conference Chairman

CHAPTER 1

by William Miller

Computing in a Network Environment: A View of the Future of Computing in Higher Education

Introduction: Social and Economic Conditions

Higher education, both public and private, is facing an economic crisis that has severe, continuing, and long-term consequences. The economic crisis that threatens us today is not simply one of poor business conditions, so to speak — it is more serious than that. We have run up against an economic principle that offers us few attractive alternatives — fortunately there are a few.

Let me try to present a simple expression of the present conditions of higher education and the economic law that confounds us. For this oversimplified description of the economic model of the University, I apologize to my economist friends. I am well aware of the complications and refinements which can and should be introduced, but the refined descriptions lead us to the same conclusions.

In a normal economic time and over the long term, for a society which experiences increases in productivity, salary and wages will grow more rapidly than inflation. That is, gains in productivity are translated into real gains in salaries and wages of society as a whole. However, in an activity or a sector of society which does not experience increases in productivity, then either salary and wages of the workers in that activity will fall behind the salary and wages of society as a whole, or that activity must receive an increasing subsidy support from the rest of society.

Applying this to higher education, productivity is intrinsic productivity or productivity in the input-output sense; more students per dollar (and per faculty). In this simplified model we are not using productivity defined as increased quality of education, the benefits of which are external. Through research and better education we may improve the productivity of the rest of society, but we may not improve our own intrinsic productivity in the throughput of students.

Intrinsically, higher education has experienced very little increase in productivity in many decades. William Bowen once said that higher education has not experienced any increase in productivity since the introduction of the microphone Essentially, teaching and research are one-to-one or one-to-few activities.

To restate the economic principle as applied to higher education, if we do not find ways to increase academic productivity, then either increases in salaries and wages will fall behind those of society as a whole or we shall require increasing support from the rest of society through increasing flow of philanthropic giving, increasing proportion of the tax dollar, or increasing rates of growth of tuition.

Now you may immediately ask, if this is an economic principle and we have not been experiencing increases in productivity, why have we not had the crisis before now? The answer is fairly simple. Heretofore, higher education has not represented a large enough portion of the Gross National Product (G.N.P.). The academic consumer price index has been growing more rapidly than that of society as a whole. However, as long as higher education represented a sufficiently small portion of the G.N P., that sector could obtain increasing support without having a big impact. That is now no longer the case.

We may gain increased support for a while in recognition of higher education's external contributions to increases of productivity in society as a whole But it can't keep up for long. So where do we turn? We must find ways to increase our productivity by improving overall efficiency throughout the University. University administrators with some expertise in computing have special opportunity to make a major contribution to increased academic productivity.

Computing has already contributed greatly to enhanced quality of education, as well as to increased productivity on the administrative side of the academic enterprise Unfortunately, the increased productivity in the administrative areas has largely gone unrecognized because it has been offset by huge increases in administrative burdens due to increased demands for various forms of accounting, audit, and regulation imposed from outside the institution.

The Role of Computing in Higher Education

Computing is not the only means of increasing productivity or improving the quality of higher education but it is an important means, and we shall no doubt see greater use of computing in the laboratory, the library, the classroom, and the administrative offices.

Although computers are familiar in laboratories, libraries, classrooms, and certain aspects of administration, they are not so common as tools for academic planning and modeling Some work we are doing at Stanford which is rather interesting in its own right, also illustrates how computing finds new applications.

At Stanford we have developed a number of models of the different processes such as (1) age and tenure distributions of faulty varying in time under different assumptions, (2) research volume, and (3) indirect cost recovery as a consequence of a variety of assumptions. Perhaps the most interesting of all is the budget equilibrium model. The budget equilibrium model projects both the expense side of the budget and the income side of the budget in terms of various economic indices and the basic parameters of Stanford University such as the present faculty size, student body size and composition, research volume, and endowment income.

Taking financial equilibrium as a constraint, the model uses a budget which is balanced *on the average* over time and permits one to calculate trade off functions by choosing two interdependent parameters and holding all others constant. For example, we can calculate the relationship between faculty salaries and tuition under various assumptions about faculty and student body size, endowment payment and total return, research volume and gift flow. Because parameterization occurs on both the expense side and the income side in terms of economic indices, errors on estimates of economic indices will enter both sides of the budget calculations.

At Stanford we have found this model and its various component parts to be a very important tool for institutional planning. Other institutions are doing similar things. Such techniques will become commonly used in the near future.

Because of the prominence of computing, both as an intrinsic contribution to all aspects of university activity and as a significant item in the budgets of most universities, it will and should get a great deal of management attention in the future. It is terribly important that the computing be done well, and that we find ways to do it economically. Computing can and will contribute to increasing the productivity of universities, but economic pressures throughout will create pressures on the growth of computing budgets.

Role of Networking

In networking college and university administrators have an opportunity to improve the contribution of computing to the overall productivity problem of higher education. Networks and large scale computers do not have to be a mutually exclusive alternative for minicomputers and microcomputers. Each has an important role-opportunity, and there will and should be competition at the margin where the two roles interact. However, in general, each will support and enhance the opportunities for the other.

Where are the opportunities for networks? Most of the opportunities have one characteristic — they allow colleges and universities to share computing resources which are costly to acquire and costly to maintain.

One useful analogy is the expensive specialized book collection in a library; a collection which might be an invaluable resource for certain areas of research but would be expensive to acquire and expensive to house and maintain even if one did acquire it. It is those very collections in libraries which are being shared or for which plans and procedures for sharing are being developed.

In computing, the opportunities for sharing which fit into this category are:

- *Large data bases* whose development is expensive and whose storage and/or maintenance is expensive. Census and voting data, astronomical and astrophysics data, library card catalogues, and so on require a great deal of intellectual effort to develop, expensive data storage equipment to hold them, and continued updating with commensurate maintenance costs.
- *Large special programs* like the Stanford University economic modeling program. This program was moderate in development costs, but the confluence of particular talents which happened to be present at Stanford provided a necessary special opportunity for its development. The actual incremental cost of developing these programs was not expensive, but the cost of bringing together a group for that explicit purpose would be costly. More obviously, this program is one which is undergoing continual refinement and upgrading, which, in addition to regular maintenance is expensive. Sharing it via networks would be easy and economical of both intellectual efforts and computing (programming) maintenance costs. Additional examples of such special programs include graphics programs, teaching programs, etc.
- *Large collections of specialized program libraries* such as statistics programs or physics data analysis programs. These programs are similiar in terms of opportunity to the large special programs. Sharing these types of resources provides opportunity to share intellectual development costs, continuing maintenance costs, and storage costs.

Library automation programs which do card cataloguing, book ordering, and in-process accounting illustrate all of these qualities: large data bases; large special programs. The development of the data structures and the processing programs is expensive. Development of the card catalogue data base itself is expensive. Storage of data and programs is expensive, and the cost of continually updating is non-trivial.

Other opportunities are also provided by networking.

- *Load balancing and resource shopping.* Via networking a user may find more accessible computing or more economical computing than is available to him or her at home at a particular time. This is an important opportunity that provides for better averaging of use and averaging of cost by spreading use over a broader base of equipment. Networking can also provide access to some relatively rare specialized equipment such as very powerful number crunchers. During transitions of local equipment changes, networking also provides opportunity to smooth off peak load problems or provide capacity.

- *Exploration via networks.* Administrators in an institution could find out whether the Stanford University financial economic models are of any use to them by trying the programs. Through a network, this exploration can be done with a minimum of investment in time and equipment until one has come to a conclusion on the utility of the programs.

Problems to Solve

The opportunities for networking to contribute to increasing productivity, both intrinsically and in terms of improving quality, are clear. There are many problems and sharing concepts yet to explore.

Technical problems involve both hardware and software. In 1975 I do not believe that the technical problems are the principal obstacles to effective use of computer networks. Many of the technical problems have been solved within a single organization (corporation) or they can be seen to be at hand.

Policy and management problems are another matter. First there are legal and/or government regulation problems. Let's take the question of unrelated business income for non-profit organizations which raises an income tax problem and perhaps property tax problems. Because the IRS has in several cases rendered a narrow interpretation of income derived to academic computer centers in universities and in other non-profit organizations, this issue clearly must be solved before extensive wide-scale network computing can come into popular usage. There may be a number of ways to solve this problem, but leaving it unresolved leaves the income deriving institution exposed to later claims at a time when it will be too late to build the tax cost into the rate structure.

There are problems related to indirect cost recovery and government audit regulations. For example, with government audit for direct and indirect costs, a uniform pricing policy is required at all supplier sources on the network. Some organizations employ a cost related charging scheme which relates the charges for the use of resources directly in terms of the cost of aquiring and maintaining the resources. Other organizations employ pricing schemes which are intended to provide incentive to shape the utilization of the machinery in various directions. Most schemes are in reality a mixture of these two ideas.

Will government regulation and audit take a broad general view of this problem or will one university's sale of computer time to another expose it to the other's audits on pricing practices? How far does the audit reach? Networks provide an exposure to persuasive audit practices and possible conflicting ones for public institutions, subject to both state and federal audits.

Networks may force greater attention to security issues. A small collection of hyper-inquisitive users at a given location is provided a larger playground or greater challenge to "screw up" the system.

Networks may expose us more to simplistic application of agency policies. For example, an agency may mandate the use of a particular facility over a network at a distance because the agency has an investment in that facility or simply has ambitions for that facility even though there is such a high cost in user effectiveness as to generate losses in productivity. This is a very complex issue which has no simple solution and is linked to the next issue.

Who will be a supplier and who will be a user? The cost of acquiring and/or developing some of the highly special facilities is so great that a supplier may need some guarantees through agencies or consortium agreements. Under what conditions would a consortium be willing to provide guarantees and what controls do they obtain in return for their guarantees?

It is this array of management and policy problems that the EDUCOM Planning Council for Computers in Education and Research is attacking.

Epilogue

I want to close with a brief epilogue. This message is "keep the faith." Computing is increasingly an exciting activity. The problems are challenging, and we can make additional significant contributions to higher education. Additionally, education is still magic. The public may be giving us a hard time right now, but they want us and know they need us. If we make it clear that we are attacking our problems directly and courageously, they will have good cause to support us.

CHAPTER 2

by Joe B. Wyatt

EDUCOM 1975: A Forward Look

The opportunities provided to our society by computer technology are very exciting. From the large specialized computer systems and the minicomputers to the microcomputer processors, including the software that makes them useful and the new communications systems that can connect them all, computer technology is presenting a host of new opportunities to higher education in particular. Indeed, it appears that computer networking will provide a new and important dimension to schools in the development of their technological resources for reseach and teaching. In the long run there are likely to be some administrative benefits to networking as well.

At a time when the relevance of higher education is being questioned and the financial resources available to most institutions are diminishing in the face of rising costs, wisdom and skill are going to be required on the part of every college and university in allocating its resources. Computer technology is a costly and important resource. We need to share computer technology through networking and to benefit from doing so. Naturally, networking will have its limitations and there will be better alternatives in some situations. In a few words, I will attempt to summarize here my view of the opportunities, the commitments which must be made to overcome certain problems, and the role that EDUCOM can play in dealing with both.

The Opportunities

There are four types of opportunities which can result from computer networking among colleges and universities. Two can be attained relatively soon (within a year or two); the other two may take a longer period of time.

ACCESSING SCARCE RESOURCES

For the short term, it appears that colleges and universities can benefit now from an ability to access, by networking, scarce computer and information resources, including hardware and data as well as software. There are already a number of national hardware resources that will most likely not be duplicated and are of interest to a large community of researchers. (NCAR, LRL, and ILLIAC 4 are three existing examples and there are others in the works, including the proposed National Center for Computation in Chemistry.)(1)

There are also national data resources which are important in teaching and research but cannot be replicated effectively. These include the bibliographic data base of the Library of Congress, the economic data maintained by the National Bureau of Economic Research, the demographic data supplied by the Bureau of the Census, smaller research collections, and a host of other data resources available in the public and private sectors.

Finally, there are software resources. Many of our attitudes in the past have been shaped by the notion that sharing software resources means getting a copy of someone else's program to run on one's own machine. For some software this continues to be feasible. In fact, our efforts to develop mobility in software through standard programming practices and appropriate documentation should be stepped up. (The CONDUIT activity is an example of such an effort.) However, there are an increasing number of important software resources that are not easily transferred. Large and complex, these systems function best on the computer system used for their development. (Many, in fact, are actually "tuned" to operate on a particular computer system.) Because individual users often require only limited use of such software over long periods of time, these resources might be more effectively accessed remotely.

Consider for an illustration the set of programs called SYMAP and SYMVU offered by the Laboratory for Computer Graphics in the Design School at Harvard University.(2) These programs have been developed over a period of about ten years, and although they are quite complex, they have been distributed to more than 300 different computer installations around the world. The programs were initially developed on IBM 7090 equipment and later converted to IBM 360 and 370 equipment. Major conversion efforts are required for non-IBM use of these programs. Moreover, each of the 300 computer installations communicates separately with the Graphics Laboratory at a very detailed level in order to install and operate the programs even though good documentation is provided. The programs are continually improved; therefore, maintaining the ever-changing programs is a significant requirement. As a result, each institution must have a computer system capable of operating the programs and must acquire the services of a systems programmer to install and maintain a local copy of them. The systems programmer (or a local consultant) must also provide some user consultative services. This observer's experience indicates that about 10% to 15% of a local system's programmer's time is required for full productive use of the programs in addition to the training courses and documentation offered by the Computer Graphics Laboratory. Extrapolation shows that if over 300 systems programmers spend approximately 10% of their time working with the programs and the users of the programs, the cost of the systems programmers alone will be likely to be in excess of half a million dollars a year.

With good network access, of course, a viable alternative to this situation becomes available. The programs can be maintained at a small number of centers by staffs of experts who are continually engaged in the program's development; only these installations with very heavy use of the programs might adapt them to a local computing resource. Improvements in the programs could be more immediately available to end users, as they would not have to be distributed and integrated into so many local versions of the programs. Moreover, the development staff in the graphics laboratory could spend substantially less time answering repetitive letters and telephone calls and more time in the development and improvement of the programs. Perhaps most important of all, teachers and researchers at institutions who do not now use the programs because of the problems discussed might then gain access to them.

Most large computing centers spend a substantial amount of time implementing, maintaining, and operating "borrowed" programs. In a networking environment a choice could be made that is much more pleasant for the director of a computing center. In the past, the decision has been whether or not to move the program (with all of the costs and liabilities) on the basis of such questions as whether the income potential to a computing center would offset additional costs. In a networking environment, software users would be able to use resources remotely and experimentally first, and then decide whether or not to move them into their local centers. There are a great many software and data resources that fit this model. Making these scarce resources available to a wider audience, at less cost and in a more timely fashion for experimentation and continual use, is a major opportunity provided by networking.

SHOPPING FOR BETTER PERFORMANCE OR PRICE

Another relatively short-term benefit of computer networking would be the ability to shop for prices and response times that are optimum in relation to basic computer services. The basic services are loosely defined as those which are offered at a variety of resources and which are mobile insofar as use is concerned, i.e., with no significant conversion effort required in order to transfer use from one resource to another. There is little question that there currently exists substantial opportunity for optimization of cost and response time by choosing from among many computer resources. A 1973 study at Harvard, which compared use of the computer resources at Columbia, Princeton, and MIT, indicated a factor-of-three range in the cost for performing a typical monthly workload by choosing the best case resource for each job in the workload.(3) Another more recent study by Peter Alsberg at the University of Illinois using several ARPANET resources yielded even more significant results.(4) By performing a set of mathematical benchmarks typical of numerical calculations, Alsberg showed a difference of over two decimal orders of magnitude (that's a factor of 100) in the cost of performing these tasks at different resources (see Figure 1). The comprehensive set of benchmark programs recently performed by fifteen Planning Council member institutions tends to support these pricing differentials for individual types of jobs.

Machine	Time (seconds)	Cost ($)
360/195	.5	.41
/91	.7	.20
/75	7.4	.35*
/67	23.0	1.65
H 6180	35.7	2.80
DEC 10	80.0	6.72
B 6700	60.0	6.00

*excludes $1.00 cover charge

FIGURE 1 — Alsberg Results: For Matrix Multiply Benchmarks

Although response time is a less concrete phenomenon (it depends on conditions at a particular moment in time on a computer system), there is little question that users consider it important. In fact, most computer installations set up for batch computing service offer a pricing algorithm that is scaled on the basis of priority. In other words, users pay more for faster response time. An analysis of the accounting records for installations of this type will show that many users consider it worth spending extra money in order to acquire job results sooner.

On the basis of these and other data available at the present time there is little doubt that selection of optimum computer services via networking would benefit a large number of computer users.

INTELLECTUAL EXCHANGE FOR RESEARCH AND TEACHING

Over the longer term, there are likely to be even more pervasive and important opportunities provided by networking. One of these is a new medium for intellectual exchange of research and teaching materials that are based in computer technology. In effect, the national networks will become a vehicle for "publishing" technologically based works.

For example, researchers may have access to data and algorithms at a variety of research-oriented universities. This will offer the opportunity for research faculty members and graduate students at large and small institutions to share research results and techniques. A recent letter from Professor G. Robert Boynton, Director of the Laboratory for Political Research at the University of Iowa, illustrates this point. Professor Boynton is currently engaged in collaborative research with political scientists at five different universities. The raw data, comprising a set of rather large data files, have already been collected and are available at each location. It is possible for each of the five researchers to access the data at his own university. However, a considerable amount of refinement is necessary before the analysis of the data can effectively begin. Moreover, each researcher must make some transformations as well as use the transformations of the other researchers, which presents a major communication problem. If there were a computer network available to each of the researchers it would be possible for the individual making the transformation to have that same transformation performed at each of the other universities. To quote Professor Boynton directly, "It would save us all many hours of false starts."

Another illustration — this one in teaching — occurred this past year at the Harvard Law School. One of the classes in the 1975 spring semester used a computer-based exercise that required factual analysis and applications of the provisions of the Code of Professional Responsibility to a series of problem situations. The computer-based exercise was developed by Professor Robert Keeton to augment traditonal teaching materials. Students use the exercises by means of an interactive computer terminal. The computer-based exercise allows each student to play a role in a legal action which has been introduced by printed material and lecture. The student is presented with situations relevant to the case that require a decision on the student's part. The result is a tree of decisions, each of which depends on the student's previous decisions. Several such exercises have been developed, each requiring about five hours to perform. The student's answers are recorded by the computer at each point in the exercise and the student is given a statistical summary of how his answers compared to other students, lawyers and judges who have done the exercise.

Professor Keeton, who spent some time on the faculty at the University of Minnesota Law School, used a general purpose computer-based instructional system developed at the University of Minnesota by

Professor Russell Burris and his colleagues. Because there was no network functioning in 1974-75 that could be used for the law programs, they were transferred to an "identical" computer system at Northeastern University in Boston (both were CDC 6400 computer systems using the KRONOS 2.1 operating system). The transfer was successful but only through extraordinary efforts by computer systems people at Minnesota and Northeastern. A multitude of differences in local conventions, system subroutines, and the like turned out to be significant problems. To quote Professor Keeton: "All of us have learned that the technical problems and expense of transferring programs even between computers that are supposedly compatible, are substantial enough to discourage all but those who are most determined to explore and develop the potential of computer-aided exercises." However, even after the experience, Professor Keeton goes on to say, "this type of exercise is in itself a very valuable addition to methods of instruction in law, and I believe even more significant additions to the available techniques for both instruction and research in law are on the horizon."

It is important to note that there are similar examples in other disciplines including statistics, economics, and the sciences. Technology-based publication by networks can amount to a new horizon in intellectual exchange of both research and teaching materials.

NEW INFORMATION SYSTEM STRUCTURES

Another opportunity in networking is the use of network resources in the design of new information systems structures. There continues to be a good deal of research in the area of distributed and hierarchical systems involving networks. There is already some evidence of positive benefits. There is now available a variety of microcomputer and minicomputer technologies and compatible computer components usable in conjunction with larger computer systems in networks. In such a distributed hierarchical structure, multiple network resources can be adapted to individual user needs by removing deficiencies in language and processing capabilities of raw network services.

There is some evidence that performance and cost benefits can result from the application of the distributed hierarchical structure. It is difficult to generalize about the benefits, as each situation must be analyzed specifically and rather carefully. However, to illustate the concept, a recent analysis was completed of a simple hierarchical structure involving the use of network access for information storage and retrieval applications.[5] In this case the network resource was used for large-scale information storage and processing. Minicomputer processors were used for parochial editing and processing tasks as well as small-scale storage. A comparison was made between the hierarchical network structure and another structure in which terminals directly accessed the large-scale information storage facility in traditional time-sharing fashion.

The results showed the the distributed hierarchical structure was superior in performance to the centralized structure by 10% to 20%, with the benefits increasing with the portion of transactions processed by the minicomputer configuration. More impressive, however, was the reduction in cost per transaction, which ranged from 25% to 53%, with the percentage of reduction increasing on the same basis as performance. The graphic representation of the results in shown in Figure 2.

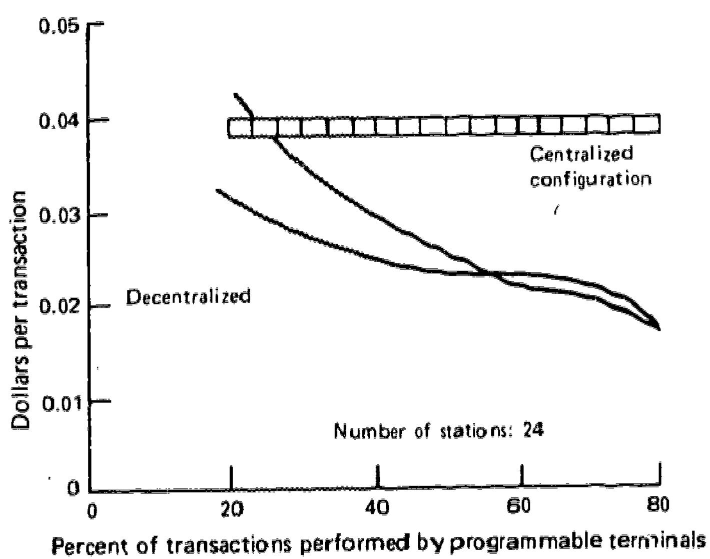

FIGURE 2 — Comparison of Configuration Unit Cost Per Transaction.

Recent implementations of a two-level version of this structure support these findings as conservative. At the University of Illinois, a group has used the structure to alter their use of the MULTICS system at MIT via the ARPANET. Both the performance and the cost improvements exceed the above results. The structure is also being used in administrative systems development at Harvard University. A two-level structure is currently being implemented using an IBM 370/145 and Datapoint minicomputer. The initial cost and performance improvements also exceed the simulated estimates. A three-level structure is now being designed about the same principles.

It appears that we can begin to experience the first two benefits of networking very soon. Accessing scarce resources and shopping for better costs or response time is already feasible and should be broadened. More experiments should be carefully performed and the results distributed widely. It may be longer before we begin to feel the effects of a new medium for intellectual exchange and new information system structures resulting from national networking. There is very little question, however, that there will be major benefits for higher education in each of these four areas.

The Commitments

The obstacles to the opportunities in networking are far from disabling. However, to ignore them would be a serious mistake. Some real commitments will be required from each institution to overcome the obstacles. The nature of the commitments depends on a variety of factors.

ROLE AND SCOPE

One of the major commitments will be to identify the appropriate role and scope of networking at individual institutions. Major changes are occurring in the economic and political climate for higher education. The financial crunch facing many institutions is already causing them to re-examine their traditional role and behavior. Some institutions will view networking as an opportunity to reduce the expense of providing computer resources. Institutions with computer resources that are underutilized but not adequate to meet many of their teaching and research requirements may need to shift the balance of computer usage to networks rather than to in-house resources. This will require a significant commitment for planning and management within these institutions.

On the other hand, networks will almost certainly initiate pressure for the use of services currently inaccessible for teaching and research. For some institutions this pressure will be manifested as requests for additional funds from individuals and departments not previously using significant amounts of computer or information processing resources. This may be particularly true for reseachers at institutions with limited computer resources. The already financially troubled libraries may be another source of such new requests. In short, network access is likely to trigger very intensive trade-off decisions at individual colleges and universities.

In the larger political arena the privacy issue may affect the role and scope of networking. Although Congress has been prudent to date, legislation has been proposed that would seriously hamper the ability of colleges and universities to undertake productive networking activities. Even though personal privacy issues are not involved in the network uses envisioned, we must be prepared to protect against abuses. We must also recognize that privacy is a politically sensitive issue, and those involved in networking at the national level must also be seriously involved with developments in legislation regarding privacy.

There are also technological questions of role and scope for networks. The emergence of minciomputers and microcomputers as the most cost-effective means to accomplish a variety of computing and information processing needs is self evident. Just as the hand-held calculators provide more power at less cost than the early time-sharing systems, small computers are taking care of a variety of more sophisticated problems that were formerly the province of large-scale systems. To some managers of large-scale computer resources, this appears as a threat, and in some cases, particularly in the short run, minicomputers do challenge the fiscal health of the large-scale center. It is certain that minicomputers will be used in a substantial portion of computing activity even with the advent of large-scale computer networking. There are some problems for which minicomputers and microcomputers are simply best suited in the current computer pricing structure. Small time-sharing systems for programming represent a well-known example. Another example occurs in the use of small computers as supplementary laboratory instruments. Another less well recognizable phenomenon is the "number crunching" minicomputer system. In the Chemistry Department at Harvard there are a number of computer-based research experiments which require the processing of large amounts of raw data with a variety of processor-intensive algorithms. The algorithms are relatively stable; they do not change substantially from experiment to experiment. The data processed is very large in volume, which discourages transmission by all but very large bandwidth communication systems. In such experiments there is no benefit from multi-programming, since the algorithm involved utilizes all available processor cycles. Only the condensed output of the minicomputer processor is fed to larger computer systems at MIT and Columbia for further processing. Hence, a dedicated minicomputer processor of sufficient power is ideal for this role. In other cases, such as the Chemistry Department at the University of California at Berkeley however, a highspeed minicomputer processor is used for both computational processes. In cases where such dedicated processors are appropriate, network access may play virtually no role. However, even limited access to a network as part of a hierarchical structure may ultimately be of great value for the reasons described earlier.

TRANSITION

Another commitment which must be made is to the development of institutional understanding, at both executive and faculty levels of both the initial impact and the transitional effects of networking. Networking usually involves changes in resource allocation decisions. This may mean increasing or decreasing the total amout of resources dedicated for computer access to allow for network use. It almost certainly means redistributing existing resources to allow for some network use. Examples in which a significant redistribution and reallocation of funds used for computer resources were made include the development of the Triangle Universities Computation Center in North Carolina and, later, the divestment at Harvard of two major computing facilities in favor of purchasing outside services from MIT and other groups. Major shifts of this sort require careful evaluation and a firm commitment to dealing with the organizational and behavioral problems associated with moving from major in-house resources to substantial reliance on external computer resources.

Another perspective of the transition problem will occur for those institutions that become suppliers in the network. Most institutions in the past have based computer resource planning almost exclusively on in-house needs. Beginning in the 1960s, some institutions began acting as resources for networks in which other institutions were provided access to their computers. Most of this sharing took the form of regional STAR networks until the initiation of ARPANET. Even on a small scale, the decisions and the planning necessary to perform the supplier's role in this sharing function have altered the character of some computer resources substantially. It is necessary not only to plan well in the supplying institution but also to consider the needs of the outside group of institutions (the "market," if you will). However, it can be of substantial benefit to both supplier and user. For example, in the Harvard-MIT arrangement, MIT as the supplier of services is able to justify the use of an IBM 370/168. If it were not used by Harvard and other institutions, the hardware would be replaced by something on the level of an IBM 370/158. There is no doubt, on the basis of the quantitative data available, that this would adversely affect the cost and performance of MIT's service to all, including its in-house customers.

TECHNOLOGICAL FACILITATION

Another commitment which must be made concerns the development of facilitation mechanisms to deal with the vagaries of exposing nontechnical users to incompatible and idiosynchratic technological resources. These vagaries are matters of degree and can be overcome individually by a courageous and persistent user. However, there are a number of problems which should be resolved straightaway in order to make large-scale networking comfortable for most computer users. They include the following:

1. It is not a small matter to move a computer program from one computer system to another even when the computer systems are "completely compatible." A translation facility to assist in overcoming eccentric differences in control and programming

languages will be useful for network usage. More standardization would be even better.

2. Network protocols for program execution and file transfer are different. For example, ARPANET, the TELENET network and the TYMESHARE network require different types of computer terminal interfaces as well as host computer interfaces to the networks. With the establishment of other networks, this problem is now likely to become intensified. In addition, computer systems themselves require remarkably different formats for communications at the present time. At present, there is no alternative to the development of multiple interfaces.

3. Log-in, start-up, and accounting functions typically differ for each computer system. Almost all computer systems are different in the presentation and requirements of these data relative to individual computer usage. Adaptation mechanisms for these functions would significantly relieve the burden of the user in the network.

4. Disseminating basic information about network resources (including specialized facilities and services) will require facilitating services. Documentation, seminars and other traditional mechanisms must be adapted and refined. The network itself will be useful for this activity. A network file storage and retrieval system to assist in user consultation and communication should be designed and developed, based perhaps on the distributed hierarchical structure previously described. Information of particular interest to each institution could be stored locally while a principal data bank would be maintained for the whole network as well.

5. A facility to assist users in finding an appropriate computer resource for a specific problem will also be useful. This "locater" facility could help find computer resources which meet certain criteria, such as price, response time, accuracy, etc.

There are undoubtedly numberous other functions that will be found to be useful in this facilitating mechanism. Initial network usage can probably rely on bilateral arrangements between users and resources. However, most of these facilitating services will become mandatory if a network is to be useful to a variety of users.

EDUCOM'S Role

It has long been the conviction of those people most closely associated with EDUCOM that computer networking on a national scale is both feasible and useful. It is my own conviction that EDUCOM should not only develop computer networking in higher education but also provide leadership in the application of other types of computer and communications technology to the broader needs of universities and colleges. We are now engaged in turning these convictions into action.

In 1973, we began to develop the idea of a Planning Council for Computing in Higher Education and Reseach, an idea conceived from the NSF-sponsored EDUCOM seminars on Computer Networking held at Airlie House. This idea has now been transformed into an action-oriented group of twenty-one institutions that have committed money and time over the next four years to provide a "critical mass" for the development of national computer networking. The EDUCOM Planning Council is directed by James Emery and is governed by a Policy Board composed of senior university executives and a Technical Committee composed of senior computer scientists/administrators from the twenty-one member schools. Supporting grants have been received from the Ford Foundation, the Carnegie Corporation, and the Exxon Education Foundation.

The Council is engaged in the development of both short-term and long-term networking activities. A prototype national network activity has already started with the objective of incrementally developing computer resource sharing. While building on the experience and capabilities of regional and state networks, the prototype EDUCOM network, EDUNET, will incorporate incrementally the benefits of related reseach and development activities. The embryonic version of EDUNET was demonstrated at the 1975 Fall EDUCOM Conference in Portland, Oregon. In this demonstration, the communications facilities of Telenet Communications Corporation were used by conferees in Portland to access the MULTICS and IBM 370/168 systems at MIT, the Dartmouth Time Sharing System at Dartmouth, the Bibliographic Data Service offered by the State University of New York, and a typical minicomputer configuration of the PRIME Computer Corporation located in Framingham, Massachusetts. The demonstration was eminently successful. The next step in the development of the prototype network will be to encourage further bilateral resource sharing and to develop specific experiments in the use of EDUNET in a large number of academic disciplines. Some development has already begun in law and chemical engineering; further development will take place in statistics, economics, and numerous other disciplines, as well as in libraries. libraries.

For the longer term, a network simulation and gaming project, funded by NSF, will develop techniques for dealing with the evaluation of the role and scope of networking as well as the transitional effects for individual institutions. Sixteen institutions, both large and small, are providing data and expertise in the development of the model. Moreover, the incremental development of the prototype EDUNET will provide an ongoing laboratory for model development and validation. Ultimately, it is expected that individual institutions will be able to use the model to assess the benefits and liabilities of networking and to develop specific plans for participating in EDUNET.

The other divisions of EDUCOM will provide not only for the dissemination of the beneficial results of Planning Council activities to the full EDUCOM membership but also for other technology-related activities.

The EDUCOM Consulting Group, now under the direction of John Austin, will provide analysis and prescriptive services relating to the planning and use of computer and communications technology. The Consulting Group will use experts from EDUCOM member schools to supplement its staff in the development of consulting teams to address needs ranging from the use of networks to the role of minicomputers. A consultation on the use of minicomputers is now being completed. Recently, other consultations have been successfully completed relating to computing center organization, university management information systems, and other contemporary problems facing colleges and universities.

EDUCOM can also act for the benefit of its members as an intermediary with suppliers of computer-related components and services. We have already completed two arrangements which will bring substantial price discounts to EDUCOM members. An agreement with PRIME Computer Corporation will provide for a 20% discount on PRIME products and services to EDUCOM members. A similar arrangement with Data Dimensions, Inc., provides for a comparable discount on interactive computer terminals. We are currently working with other suppliers; Gene Kessler is directing this activity.

Through EDUCOM conferences and publications, both basic and general information can be disseminated. The organization of special workshops and projects within EDUCOM, which has been begun by Bob Gillespie, is also a powerful alternative in exchanging useful information about specific computing activities.

Finally, the EDUCOM Library will provide for the publication of computer-based technology. The basic idea is to create a library of high-quality programs and data from a host of network resources that will be available through the EDUNET network. The library will be developed by and operated in conjunction with publishers of printed material to provide computer-based materials that will be useful in research and teaching. EDUCOM will operate and manage the library, provide for appropriate disciplinary review to maintain the quality of resources, and collect use fees and pay authors' royalties as well as render basic bibliographic services about the collection.

Through these efforts it appears that some of EDUCOM's long-term goals can now begin to provide very tangible benefits to large and small schools alike. Work of excellent quality may be found in many places, and when it is found in computer-based form it should be developed and shared with others in higher education who would find it useful. EDUCOM will now concentrate on putting these goals and concepts into action.

REFERENCES

1 National Academy of Sciences. "National Center for Computation in Chemistry." (Division of Chemistry and Chemical Technology, NRC Washington, D.C.) 1975.

2 *SYMAP Handbook* (Laboratory for Computer Graphics, Harvard Graduate School of Design, Cambridge).

3 Wyatt, J. B "Toward Computer Networking — The Harvard Experience." *Annals of Economic and Social Measurement*, vol. 3, no. 3, 1975

4. Alsberg, P. A. "Distributed Housing on the ARPA Network — Measurements on the Cost and Performance Tradeoffs for Numerical Tasks. In *Proceedings of the Eighth Hawaii International Conference on System Sciences*. (Western Periodicals Co.) 1975.

5. Wyatt, J. B. Computer Systems: Simulation. In *The Information Systems Handbook*, eds. F W McFarlan and R. L. Nolan (Illinois. Dow Jones-Irwin, Inc.) 1975 pp 383-403.

CHAPTER 3

by James C. Emery

Implementation of A Facilitating Network

Introduction

The advantages of computer resource sharing over a network have been discussed at length since the early sixties. A number of relatively specialized networks, such as ARPANET, have now been operational for several years. What is missing, however, is a general network available to all members of the higher education community.

While conceptions about such a network have not changed substantially over the past decade, experience with existing networks and the advances in technology during this period have given us a clearer picture of the likely characteristics of the network. There appears to be a growing consensus about the following points:

- *The existence of a general network for higher education is no longer in doubt;* only its extent is still to be determined. With technological advances in common carrier communications, the entry cost for an institution to join a network is becoming low enough that primitive sharing arrangements can be established at any time a serious need arises.

- *Even in a mature network, most computing will be performed locally or regionally.* The cost of hardware is dropping rapidly enough that it is ceasing to be a major factor in the economics of computation. The majority of users at an institution can usually be served with a fairly limited variety of software, and so the cost of providing standard software is not particularly significant. Most institutions will therefore choose to pro[illegible] standard computing services at their own computer cente[illegible] or obtain them through a regional arrangement.

- *In all but a few quite specialized cases, hardware economies* will be the least important motivation for developing a national network. Minicomputers can compete very well with the large machines for most applications, and any significant economies of scale for very large jobs can usually be exhausted by regional centers. A national network will be justified primarily for the purpose of sharing software and databases.

- *Even though network computing will constitute only a small part of the total computing within higher education* — 20 percent would certainly be a very generous estimate — it will nevertheless be an important part. The network can offer specialized services that would otherwise not be available or available only at a high cost.

- *A mature network will develop over a long evolutionary period.*

Despite considerable justification for optimism, one should have no illusions about the difficulties in implementing a viable national network. A number of very difficult technical, economic, and administrative issues must be faced before a mature network becomes a reality.

Technical Issues

It is currently fashionable to dismiss technical problems as the least formidable barrier to implementing a network. Current technology certainly permits a fairly sophisticated network, and is unlikely seriously to hinder short-term development efforts. Nevertheless, a number of difficulties still remain, and they will become more serious as attempts are made to expand the use and capabilities of the network. Among the most important are communications, security, and on-line user services.

COMMUNICATIONS

Considerable progress has been made over the past decade in reducing the cost and increasing the reliability of communications. Packet switching, in particular, appears to offer substantial advantages over previous technology. Its distance-independent price structure (i.e., price to the user is not a function of the distance transmitted), relatively low cost, and high reliability are especially important for a national network.

Two serious problems still remain, however. One of these is the difficulty of interfacing a wide variety of computers to a common communications network. The other is the high cost of broadband transmission. These are appropriately viewed as primarily economic limitations, and are therefore discussed in more detail in the next section of this chapter, which deals with economic issues. Suffice it to say here that technical advances are still needed to bring down the cost of network interfacing and high volume communication.

SECURITY

Current operating systems provide inadequate protection against malicious or unintentional access to system resources. Although this limitation may be tolerable when only local users are served or when relatively insensitive data are maintained within the system, it is entirely unacceptable when serving remote users or when an application calls for a high degree of privacy.

Until this situation is corrected, most institutions will choose not to maintain sensitive data on storage devices that are accessible to a network. Applications involving personnel or student records, detailed financial data, or other confidential information will thus be unlikely candidates for early implementation on a network.

Another aspect of security is protection against unauthorized use of network resources. When a university provides its own computing services, its total financial risk is limited to the expenses of running the computer center. In the case of a network, an institution's potential consumption of resources could be virtually unlimited. The institution must therefore have assurance that it can control the charges that will be levied against its accounts. It is not enough merely to protect against unauthorized users; controls must also be provided so that an institution can set limits on such things as its total expenditures, the particular resources that can be accessed by a given class of its members (students might have different restrictions than faculty, for example), the maximum priority level permitted by each user class, and the time of the day at which certain resources can be used.

ON-LINE USER SERVICES

The provision of services to aid remote users is a critical requirement for widespread computer sharing. To keep costs reasonable, a national network will probably have to rely fairly heavily on automatic user aids, rather than person-to-person consultation. Included in such services are on-line retrieval of information about available resources and computer-assisted training aids. Both of these present difficult technical problems. The classification and indexing of computing resources and the development of retrieval procedures requires considerable further research. A great deal of effort will also be required to develop computer-assisted instruction aids for training remote users how to use a computing service and how to correct program bugs if difficulties arise.

Economic Issues

Although some technical problems cannot currently be solved satisfactorily at any cost (security, for example), most of them are viewed as problems because the cost of performing a given function is greater than its perceived value. Communications is a prime example. The technology available a number of years ago could have provided adequate communications to support a network, but only recently have technical advances lowered costs to the point that networks have become economically feasible for fairly general use within higher education. A number of economic issues of this sort will clearly have a major impact on the design and use of a network.

LARGE VERSUS SMALL COMPUTERS

Economies of scale in computer hardware have traditionally been one of the primary justifications for concentrating a variety of computing functions into a single large central processor. Although this argument still holds for certain very large "number crunching" jobs found in such fields as physics and meteorology, for the most part hardware economies of scale are becoming less and less significant.

For one thing, the cost of the central processor as a fraction of total computing costs is shrinking rapidly. In the early days of computing, the central processor typically contributed over two-thirds of the total cost; now it may be as low as ten percent or less. As advances continue in integrated circuit technology, the cost of the central processor is becoming almost negligible for most applications.

A second reason for the reduced significance of hardware is the availability of powerful yet low-cost minicomputers. The cost-effectiveness of minicomputers stems from several causes:

- *Economies of scale in the high-volume manufacture of minicomputers* offset intrinsic economies of scale in the operation of electronic devices.

- *Minicomputers generally offer somewhat limited capabilities* compared to large conventional machines, permitting the vendor to use off-the-shelf hardware components and to reduce software development costs.

- *Minicomputer vendors typically do not offer a full range of on-site customer services,* allowing them to lower their costs of marketing and technical support in the field.

- *Minicomputers have a relatively short design and production cycle* because of their simplicity, which permits designers to take advantage of more recent technology than is possible for the very large machines. With technology advancing by an order of magnitude every five years or so, even a year's advantage can be significant.

- *Less capital is required to enter the minicomputer industry* than is needed by conventional computer vendors. This has resulted in a large number of competitors and strong incentives to keep prices low.
- *Minicomputer vendors tend to introduce technical advances as quickly as they can,* because of competitive pressures and the modest-sized base of leased equipment.

Although computer *hardware* no longer exhibits economies of scale for many applications, economies in *software* and *operating costs* may still offer substantial benefits from sharing among many users. For a given variety of services, the costs of maintaining software and running the computer center are much the same regardless of the size of the computer. A centralized center permits spreading these costs over a larger number of users, and thus can provide substantial economies. As hardware costs continue to decline, economies in software development and maintenance — including associated user services such as documentation and training — will tend to dominate other factors.

Because of the hardware economies offered by minicomputers, and the software and operating economies offered by large centralized facilities, both will exist in a network environment. Minicomputers are likely to proliferate at the local level, while the large centers will serve regional or national populations.

GENERALIZED VERSUS SPECIALIZED SYSTEMS

Large computers normally offer a wide range of generalized services in order to attract a large number of users, expand the computational load, and take advantage of any economies of scale. On the other hand, increasing the generality of a computer center adds to the costs of software development and maintenance, overhead in managing system resources, operating inefficiences of generalized programs, and providing user training and consulting. The user may also bear extra personal costs in coping with the inhospitality of some large computer centers and overcoming the frustrations of locating and using a specific service among the full range of services available.

These added costs of generality often benefit a relatively small proportion of users. A majority tend to use a very limited set of system software, such as a debugging Fortran compiler, an optimizing Fortran compiler, a Cobol compiler, and a few statistical programs. It is not uncommon to find, for example, that half of the users at an institution can be served by about 10 percent of the computer center's program library, while the least used half of the programs serves only 10 percent of the users.

The availability of a network allows an institution to provide very cost-effective services for the standard users by means of minicomputers or an austere conventional computer operation; specialized services not available locally can then be obtained from the network. The specialized center benefits from a network by drawing on a larger user population and thus achieving both economies of specialization and economies of scale.

The issue of generalization versus specialization is closely related to the question of standardization. Trivial differences among programs are frequently the source of much of the variation in services that a center must offer. Two different statistical packages, for example, may perform essentially the same function, but the center may feel obliged to offer them both. Similarly, a center might offer a variety of languages that overlap one another substantially. A center serving separate institutions or decentralized departments might have to maintain a variety of such application programs as payroll, personnel, student registration, and accounting. Although standardization on a limited set of services permits the center to reduce costs, it does so at the expense of the user who has to convert to the standardized service or live with a service that does not meet his needs very well.

COMMUNICATION COSTS

Advances in packet switching technology over the past few years has significantly lowered the cost of communications. For example, a user located in a major city who wishes to access remote services from a keyboard terminal would currently pay about $2 per hour for communications, accounting for 5 to 25 percent of the total cost of computing.

As one moves away from major population centers, however, the cost of a leased line or dial-up call to the nearest entry node to the network becomes more and more significant. We can expect that the number of entry nodes will grow rapidly over the next few years, and so this problem will become less important. Nevertheless, it will probably always be relatively expensive to serve the user in thinly populated areas (at least until communications satellites permit inexpensive broadcast transmission to far-flung locations).

The transfer of large files or documents (in a bibliographic system, for example) is still prohibitively expensive except in cases in which urgency is a major factor. Facsimile and video transmissions are also currently too expensive for broad application within higher education. These costs will no doubt diminish over the next decade, thus permitting a wider range of applications that call for high-volume communications. There will always remain, however, applications that are uneconomical for network computing because of the volume of communication that would be required.

An economic issue of current importance is the cost of interfacing a host computer to a network. This can be achieved by modifying the operating system of the host computer, through a programmable front-end, or by means of a minicomputer. In any case, the cost can be considerable — perhaps $5,000 to $50,000. Over the course of a few years' use of a network connection this would add only a relatively small portion to the total cost of providing computing services. Nevertheless, the initial cost is large enough to discourage some institutions from joining a network. Technical advances that lower the entry fee for linking to a network will greatly encourage experimental or casual sharing of network resources.

COSTS OF SERVING REMOTE USERS

A serious inhibitor of network computing is the lack of services to support remote users. such services might include.

- *Local consultants* who are knowledgeable about services available over the network.
- *"Circuit riders"* who periodically visit remote sites.
- *Remote consulting services* provided over a "hot line" or by means of an "electronic mailbox."
- *High quality documentation* designed to serve the independent remote user.
- *Computer-assisted training aids.*
- *On-line information retrieval systems* to assist users in matching remote services to their needs.

Most university computer centers do not provide extensive user services. Instead, they rely heavily on knowledgable faculty or students who can assist new users. Although this approach may work satisfactorily when dealing with local users, it is entirely inadequate when dealing with remote users who do not have access to someone having experience with the service they wish to use.

Commercial firms in the business of providing remote computing services typically provide more comprehensive user services than university computing centers. Many firms spend 25 percent or more of their sales revenue on user services. The largest firms maintain a nationwide sales and technical staff to assist users. Few university computer centers would be able to spend at such a level, but they will certainly have to increase their efforts if a national network is to be achieved.

NETWORK OVERHEAD

Sharing of any resource entails some overhead cost. Network sharing calls for such services as locating a remote computing resource that satisfies a user need, instructing the user how to use the resource, accounting and reporting associated with remote computing, contracting with users and suppliers, and other network administration functions. At least some of these services are required whether the computing is local or remote, but increasing the geographical dispersion of users inevitably results in some additional overhead costs. Because pyramiding of overhead costs at the local, regional, and national levels increases the cost of a given resource, institutions will generally confine their use of a network to those resources that show a clear advantage when shared among a regional or national population.

Administrative Issues

Administrative issues are among the most important ones facing the implementors of a national network. Governance of the network and improved incentives for users and suppliers must be established before widespread sharing will take place; certain legal and regulatory problems must also be solved. The use of a network will conflict in part with established practices, and will therefore require overcoming inertia, entrenched positions, and well understood ways of obtaining computing services. It is likely that administrative problems, rather than technical or economic considerations, will pace the development of a national network for higher education.

GOVERNANCE OF THE NETWORK

Colleges and universities in this country remain largely autonomous, and show no intention of weakening this autonomy in a quest for real or imagined computing efficiency. Although some states have been moving in the direction of statewide centralized networks, most educational institutions have joined only with the strong prodding of legislative committees or state boards of highr education.

This experience strongly suggests that a successful national network for higher education must be largely decentralized. Each institution should be allowed to decide on its own whether it will join the network. It should be able to choose which services it will sell to others and which services it will buy. An institution should also be free to set prices and the quality of services it provides to others.

Although decision making will be largely decentralized, certain "facilitating" functions are best handled centrally. Included in such functions are billing and reporting, developing standards and security procedures, contracting with vendors, and providing network-wide user services. Some sort of national network organization will be necessary to provide these centralized facilitating services.

The Planning Council on Computing in Education and Research is currently serving in the role of coordinator for the development of a national facilitating network. Established officially in July 1974, the Council now consists of the following 21 member institutions:

University of California
California State University and Colleges
Carnegie-Mellon University
Case Western Reserve University
The University of Chicago
Dartmouth College
Harvard University
University of Illinois
Lehigh University
Massachusetts Institute of Technology
University of Minnesota
University of North Carolina
University of Notre Dame
University of Pennsylvania
Princeton University
Stanford University
State University of New York
University of Texas
University of Utah
University of Wisconsin
Yale University

The Council is governed by a Policy Board consisting of a senior executive from each of the participating universities. A Technical Committee, composed of a senior computer manager from each member institution, serves in an advisory capacity. This arrangement is proving to be an effective way of obtaining participation from the educational community. Inputs have also been obtained from regional and statewide networks, vendors, the government, and other interested parties.

Its charter limits the Planning Council to a life of five years. By 1979 the Council is expected to decide whether a permanent organization is required and, if so, what form it should take. Any such organization will clearly have to provide a governance mechanism that will insure broad representation among educational institutions and classes of users.

INCENTIVES FOR SHARING

One of the serious problems that limits growth of network computing is the lack of strong incentives to encouage sharing. Incentives are missing for both buyer and seller of services, and at the level of both the individual user and the institution. Furthermore, the problem tends to feed on itself: lack of incentives to use shared resources reduces the incentive for suppliers to improve their services, which in turn further reduces the incentives for users.

Users often resist sharing of resources because of the frustrations involved. Because programs and databases are often not well documented and carefully debugged, they are very difficult to use. Lack of consulting services to aid the new user, as well as the long time delays typically required to serve remote users, have further hindered the sharing of resources.

Most institutions are quite reluctant to see their faculty, students, and staff spend money to buy remote services even if a remote service is priced lower than a similar service offered by the institution's own computer center. An external purchase requires "real" money, while the cost of providing local service is largely fixed and therefore does not impose significant incremental cost in the short run. For this reason, some institutions may insist on restricting external purchases by their own members to a rate of growth that approximately matches the growth in revenue from their network sales (thus keeping their net "balance of payments" from network activities within fairly small limits). To some extent, network purchases by an institution can result in offsetting savings (or avoided cost increases) in the "fixed costs" at its own computer center, but these savings can usually be realized only over an extended transition period as equipment becomes obsolete and personnel attrition takes place.

Potential suppliers of network resources face disincentives similar to those that apply to the buyer. Faculty members and other individuals who create programs and data bases are typically not rewarded financially when their programs are used by others. Professional rewards, such as those associated with the publication of a paper in a prestige journal, are rarely accorded the creators of widely used software.

Institutions also lack strong incentives as suppliers. Although a university might welcome additional revenue from external users, the financial gain may not be sufficient to justify the considerable additional management effort that serving such an expanded population might entail. Faculty and students served by the center may resent the intrusion of outside users, even when the additional revenue allows the center to lower its unit prices or provide additional net capacity. Serving outside users also requires that a university assume some additional risks, such as uncertainty regarding the level of external income and the expenses of providing remote user services. All of these disincentives are collectively strong enough that many institutions choose not to become suppliers of service, except perhaps as a minor and incidental adjunct to their internal computing activities.

The creation of a national facilitating network is likely to increase substantially the incentives for both buyers and sellers. As the market grows, suppliers will be motivated to improve their user services; this, in turn, will encourage greater use. As a routine part of the regular accounting system, faculty and staff members could be rewarded through royalty payments for use of the software or databases they create. With the completely documented usage that the system would provide, creators of widely used programs could receive appropriate professional recognition for their contributions (in fact, with much better authentication than is possible with a journal article).

Many of the existing disincentives for sharing will be reduced with the development of a network. Fast response available over a network will eliminate the frustrating delays currently experienced by remote users who attempt to share by shipping reels of tape or decks of cards. Faculty and students will have less cause for resenting external users if they are themselves served in part by remote computer centers. To the extent that the facilitating network organization assumes some of the marketing and user service functions, a supplying institution will have less reason to avoid serving external users. All of these factors are likely to overcome many of the difficulties that have been experienced in the past when trying to share computing resources.

PRICING OF NETWORK SERVICES

Because the proposed facilitating network will rely primarily on market mechanisms to provide incentives and allocate network resources, prices will play a critical role in governing the behavior of the network. Information about the services available, along with their price and quality, could be made available to prospective users as part of the facilitating services. Prices could be adjusted as rapidly as thought desirable in response to shifts in supply and demand. Thus, the network potentially can provide a very effective market mechanism for allocating resources and promoting efficiency.

A free market of this sort does, however, raise some very difficult questions:

- What effect would unregulated pricing have on the stability of a network and the willingness of buyers and sellers to commit themselves to a long-term dependence on the network?
- Would unregulated competition lead to the domination of the network by a few large suppliers (and, if so, would this necessarily be undesirable)?
- To what extent do various government regulations against "descriminatory" pricing constrain suppliers from adjusting prices in response to market forces?

- To what extent would it be desirable to impose such quasi-price mechanisms as tariffs, quotas, anti-dumping and anti-trust regulations, constraints against "cut-throat" competition, and the like?

Much of the complexity of pricing and market regulation in a network environment stems from the cost structure of computing: most costs are fixed in the short run, with only a relatively small porportion variable with respect to the volume of computing. This provides a strong incentive for computer center management to boost volume during idle periods and postpone delivery of less urgent services during peak periods. Price discounts can often induce users to take advantage of periods of excess capacity or to accept low-priority service. Price and service incentives can also motivate a user to guarantee a certain level of revenue to the supplier, thus transferring to the user some of the fixed costs of providing capacity on his behalf.

Pricing policies should recognize the different attitudes various users and suppliers have regarding the risk they are willing to bear and the quality of service they are willing to accept. The network facilitating function should therefore provide a variety of pricing schemes, such as the following:

- Differential prices for different levels of priority.
- Differential prices for peak versus off-peak time periods.
- Both long-term contracts and "spot" sales (i.e., with no advanced commitment).
- Both a fixed monthly charge (with perhaps a low per-use incremental charge) and a full-cost charge for each service rendered.
- Charges based on information outputs (e.g., number of students registered) as well as computing resource inputs (e.g., CPU, storage, etc.).

A special problem facing the network organization is the method of charging for facilitating services. Here, too, a variety of options exist:

- A fixed membership charge, which entitles the user to all of the facilitation services.
- "Bundled" prices, in which the charges for facilitation services are included in the general rate for computer services (possibly as

a payment by the supplier to the network organization, with no additional cost borne directly by the user).

- Completely unbundled prices, in which each facil ation service is charged for on a per-use basis.

BUDGETING FOR NETWORK SERVICES

The procedure by which an institution budgets for computing is likely to have an important effect on the users' ability to obtain services over a network. Under the conventional centralized procedure, an institution's aggregate computing capacity is allocated by distributing to users non-discretionary "computing dollars" — i.e., funds that can only be used to buy computing services at the local computer center. This scheme makes it possible for the institution to put a known limit on its total expenditures for computing. The user, however, is denied discretion as to where he obtains computer services — or, indeed, whether he spends the funds for activities other than computing (e.g., hiring an extra research assistant). Furthermore, under this centralized procedure, computer center management is not subjected to the test of a free-market, and therefore may not remain fully responsive to users' needs.

As an alternative procedure, all funds can be budgeted through regular organizational channels. The chemistry department, for example, could be budgeted at a level adequate to support its necessary activities, including computing. The department must then decide how much should be spent for computing services and from what sources they should be obtained. Network services or the acquisition of a dedicated minicomputer might both be considered as alternatives to purchasing from the institution's central facility.

The disadvantage of such decentralization is that it exposes the computer center to an unpredictable level of revenue from users. To deal with this uncertain market, the center should periodically adjust its capacity to bring expenses in line with revenues. The institution as a whole must balance its budget in the face of some uncertainty, and so there is no justification to insulate computing activities from a similar discipline.

In order to mitigate short-term fluctuations in revenue, an institution could require users to enter long-term arrangements — one year, say — for the amount of computing they wish to obtain. The computer center could then rely on this level of support, and adjust its capacity accordingly. It should have the option, however, of retaining some "excess" capacity to meet the demands from unguaranteed "spot" sales.

LEGAL AND REGULATORY ISSUES

One of the haunting uncertainties about a national network is the extent to which governmental restrictions will limits its usefulness. Possible problems include the following:

- *The Internal Revenue Service often takes a narrow point of view in assessing revenue sources of tax-exempt organizations.* The tax status of revenue obtained from network customers is by no means clear, particularly if the service being sold can be interpreted as not being central to the educational mission of the institution. The problem may be especially troublesome for the facilitating network organization that must sustain itself through the revenues it obtains from the services it renders.

- *Constraints on pricing imposed by government contracting regulations could restrict a computer center from adjusting its rates* in response to changes in supply and demand for services. For example, a price discount for low priority off-peak service might be viewed as denying the government the most favorable price if some of the government computing is done at the regular rate.

- *Subsidized government computer centers may inhibit the play of a free market for computing services.* If a university researcher has access to a government computer center at a subsidized rate that might not include any charge for the original cost of purchased equipment, the university's own computer center or other alternative sources of computing cannot compete on an equal basis. The government center is not tested in the market place, and might thereby exist and prosper even if it does not serve users' needs very well.

Approach to Implementation

The development of a facilitating network is obviously a major undertaking. The eventual form of the network, and the extent of its use, are still open questions. Given the environment in which the network will be developed and operated, the following assumptions appear to be reasonable.

- *Once developed, the network must be financially self-supporting.* Even much of the development cost might have to come from prospective users of the network, although financial aid from government agencies and private foundations would certainly accelerate the development process.

- *Network usage is likely to grow at a steady and fairly rapid rate,* but at no point will there occur a sudden surge in growth. A relatively long transition to a network environment is required for buyers to gain experience with network services, institutions to adjust their internal capacities in conformity with changes in demand patterns, suppliers to develop more powerful aids for assisting remote users, and the facilitating mechanism to mature.

- *The network must evolve gradually, rather than be implemented in a "final" version in one major step.* To adapt to changing needs and technology, the design at each stage of implementation should be kept as open-ended as possible. Large fixed costs, such as those that would be required to develop and operate a packet switching network, should be avoided; to the extent possible, costs should be incurred in proportion to the level of network activity (for example, by purchasing communication services from a packet switching common carrier).

EDUCOM is developing a network along two complementary paths. Over the short term, efforts at the Planning Council on Computing in Education and Research are being focused on developing a prototype network in order to gain some early operating experience. In parallel with this activity, EDUCOM is engaged in a research project to develop a network simulation program as a means of gaining more fundamental knowledge of network behavior.

PROTOTYPE NETWORK

The availability of common carrier packet switching services makes it relatively easy to connect terminals and host computers. The Planning Council intends to encourage universities to connect their computers to a common carrier network in order to make services available to remote users. The fixed cost of connection is around $1,000 per month, not including the initial interface cost. The variable cost of actual use tends to be quite low — around $.50 per hour on an interactive terminal, for example. After studying the two available packet switching networks, the Council concluded that Telenet Communications Corporation currently offers the most attractive prospect of serving the needs of the facilitating network.

The prototype network will give its members experience in serving remote users, as well as some early benefits of resource sharing. The insights gained will be very useful in developing a more mature facilitating network. In a number of ways, however, the prototype network will differ significantly from the expected eventual network:

- *The prototype network will involve primarily bilateral relationships* between buyer and seller. For example, the assignment of user numbers, billing, and user services will all be handled directly between the two parties. In the eventual network, the facilitating organization is expected to handle many of these functions on a multilateral basis, obviating the need for a separate relationship for each buyer-seller pair.

- *User services will be limited to those curently offered* by each separate network supplier. Since most suppliers currently deal only with local users, their user services are inadequate to serve remote users. In the eventual facilitating network, a variety of services will be developed to serve the needs of remote users (with the important by-product of improving the services available to local users).

- *Each user of the prototype network must learn special procedures* specific to each host computer he wishes to access. In the eventual network, some standardization may be possible, thus permitting a user to access a variety of standard services using a single protocol.

- *The prototype network will be limited to a relatively few large users,* because of the primitive facilitating services offered. Eventually, as a richer variety of user services are developed, the facilitating network is expected to serve a variety of users who cover the full spectrum of computing sophistication.

An important part of the Planning Council's efforts to develop the prototype network is a program to investigate the special needs of various academic disciplines. The intention is to bring together representatives of several disciplines to determine how a network might best serve their needs. An emphasis is being placed on providing each discipline with network services at a relatively early date. The expereince gained will be very helpful in getting a better understanding of the common needs that cross disciplines, as well as serving the unique needs of each discipline. Among the disciplines that have expressed an interest in participating in the project are chemical engineering, law, medical education, statistics, political science, economics, social science, and psychology.

SIMULATION PROJECT

The prototype network will be relatively limited in scope and is aimed at providing short-term benefits. Although the experience gained will be very useful in understanding fundamental network behavior, this is by no means its primary purpose. To fill this gap, EDUCOM is engaged in a longer-term project to simulate an interuniversity computing network. The objective is to gain insight into buyer and seller behavior in a network environment. Special attention is being given to such issues as pricing and budgeting procedures, the dynamics of network traffic flow, balance of payment problems, reporting on network usage, user attitude about network services, and the response of administators to network alternatives.

The first year of the project has been funded by the National Science Foundation, and further funding is expected for two additional years. In the first phase, which will be complete early in 1976, a rough model of a network will be developed. The model deals in relatively aggregate types of services, and has a time increment of one week (although this could be changed easily if a finer or coarser increment turns out to be appropriate); in particular, the model does not consider individual jobs as they flow through the network. Typical services considered within the model are small student Fortran programs, batch processed statistical programs, and interactive editing. The model will produce a complete weekly traffic analysis (or at a specified longer time interval if weekly details are not needed). Included in the reports will be such information as dollar expenditures broken down by buyer and seller, average response times at each host computer, and special analyses showing trends and any "exceptions" that occurred (such as a center's loss of revenue because of excessive response time).

The simulation program is being written in Fortran, with the intent to make it as transportable as possible. Concepts of structured programming are being followed so that the model can be extended and modified during the course of its development. This flexibility will also permit individual institutions to adapt the model to their special needs.

The second phase of the project will be devoted to tailoring the model to each of 16 institutions that are participating in the study. The following institutions are included:

Bryn Mawr College
Carnegie-Mellon University
University of Chicago
Dartmouth College
University of Georgia
Harvard University
University of Iowa
Lehigh University
Massachusetts Institute of Technology
National Bureau of Economic Research, Inc.
Ohio State University

University of Pennsylvania
Stanford Research Institute
Stanford University
Texas Tech University
University of Texas

Tailoring the model to an institution requires collecting data about the institution and then fitting a set of the model's parameters to the data. In some cases the model will have to be modified to accommodate unforeseen needs. Included in the data being collected are the hardware and software available at the institution, the institution's policies regarding external sales and purchases, and the types of services that might be purchased over a network.

In the third and final phase, the model will be used in a gaming mode. Each institution will be represented by a senior administrator with general policy-making responsibilities, as well as the head of campus computing. The participants will make various policy decisions as the model moves through simulated time, and can change any of their policies as simulated results are presented to them. The purpose of this gaming phase is to gain an understanding of how policy decisions are likely to be made in a network environment.

Based on experience gained from the prototype network and the knowledge acquired from the simulation study, the Planning Council will prepare detailed recommendations regarding the implementation of a national facilitating network. These two parallel efforts have already begun to complement one another. Benchmark studies conducted as part of the simulation project have been useful in developing plans for the prototype network; similarly, results from the prototype network will be incorporated into the simulation model.

Conclusions

It is difficult at this stage to predict the exact characteristics of a national facilitating network. Each advance in computer or communications technology may call for changes in the network. With so little network experience within higher education, the attitudes and needs of buyers and sellers are bound to change as the network matures. The important thing is to keep the design adaptive so that the network can evolve in the most useful way.

Despite the uncertainty surrounding the network, it is nevertheless possible to make some assertions about its likely characteristics. The eventual network is expected to be:

- *Highly decentralized,* with decisions regarding supply, purchases, and pricing made largely by autonomous institutions.
- *Functionally distributed,* with each supplier tending to specialize in a relatively few areas that exploit its comparative advantages.
- *Operated through a centralized facilitating organization* that performs those functions inherently requiring coordination across multiple buyers and sellers.
- *Part of a hierarchical system* consisting of local, regional, and national computing services.
- *Focused on offering relatively specialized resources,* rather than the more standard services that can be more economically provided by local or regional centers.

The availability of a national network will offer new opportunities to educational institutions. An individual institution might respond in a number of alternative ways. Some will choose to remain apart from the network, attempting to offer a fairly complete range of services for their local users. Others may choose to become almost completely dependent on the network, and not maintain any local computing capacity except for terminals of modest "intelligence". Still others will follow a hybrid strategy, meeting most of their local demands with local computers, but buying specialized services that they do not maintain themselves and selling services in which they specialize.

The two most likely strategies appear to be either total dependence or the hybrid approach. Small institutions, in particular, may prefer to rid themselves altogether of the responsibility of operating a computer center; the availability of a network makes this a feasible alternative. Most colleges and universities will undoubtedly find it cost-effective to meet standard demands with their own computer center or a multiplicity of minicomputers, but the ability to obtain specialized resources from a network will relieve these institutions of many of the headaches and costs associated with a full-service center. They will find it attractive to sell their own specialized services, both from the standpoint of making a professional contribution and as a way of raising revenue to solve their balance of payments problems.

Probably the least defensible strategy for an institution is to ignore the network altogether. The benefits of at least limited sharing will be great enough, and the incremental cost will be low enough, that no institution should attempt to remain self-sufficient in the traditional manner.

CHAPTER 4

by David E. Winkel

Planning for New Technology In Distributed Computing

Predicting the course technology will follow in the computer field is hazardous at best. This task can be approached by looking at three areas:

- Presently available front edge computer systems
- Presently available front edge computer components (integrated circuits, etc.)
- New technologies currently in advanced laboratory research and development

The Impact of Available Computer Systems

A surprising range of advanced systems are now available which will take some time to be absorbed into the university computer milieu. The time scale for absorption will vary from campus to campus but is on the order of 1-2 years. The computers mentioned below are not necessarily the most advanced in each category. Chosen simply because the author is familiar with them, they illustrate some advanced technologies.

Microdata REALITY. This system has been optimized for file handling by incorporating much of the operating system primitive software in firmware. The system is a time-shared virtual memory machine with a virtual address space available to each user of 6.4×10^9 bytes. The system will support 32 simultaneous users. All page faults, terminal handling, search to delimeters, and so on are microcoded and supplied as part of the hardware by the manufacturer.

A software system is supplied which is largely tailored for data processing applications. Such processes as file updating, information retrieval, report generation, sorting, and so on are almost trivial. The file language is simple enough to allow end users to do most of their own report generation thereby relieving the computer center of much routine programming. All of these things can be achieved if programmers can be persuaded to give up COBOL and their traditional way of doing things. The entire system is implemented on an 8 bit minicomputer.

High Speed 32 Bit Minicomputers. Systems presently available are the Interdata 8-32, SEL-32, and the MODCOMP IV. Thirty-two bit systems can be expected in the near future from most minicomputer manufacturers which will be able to impact university computing centers because of their raw computing power. The fastest CPU's in the above group are roughly equal to an IBM 370-158. Memory capacities and speeds are also equivalent to the 158. Prices are remarkably low; one of the above machines with one MB of memory (no peripherals) sells for $180,000. The low price implies that something will be lacking compared to an IBM 370-158. That something is software. Nonetheless, a machine with a good FORTRAN compiler only, coupled with raw speed can supply a good portion of the campus computing power. The challenge is to integrate it sensibly into the computing complex.

16 Bit Minicomputers. These systems have benefited from recent technology. As a result prices have decreased or performance has improved. These systems also tend to have better software than the 32 bit systems because they have been around longer.

Summary. Near term (1-2 year) development of computing will depend on presently available computer systems. Real opportunities exist for innovative approaches based on these systems which can permanently alter the way a campus does its computing.

Administrative data processing is one area that can well be revolutionized. With archaic designs and procedures typical in many data processing operations, minicomputer based systems may be the only tool a manager has for breathing new life into a data processing organization. The standard COBOL world can be transferred to a mini at considerable cost savings, but the distribution of computer power to the end user will be the real revolution. If users can generate individual reports, maintain data bases, etc., they will not bother the computing center with these tasks. The computing center can then concentrate on systems design and implementation. At the University of Wyoming this approach has increased data processing programmer productivity five fold.

New systems challenge academic computing in more profound ways. In the past minicomputers have proliferated on campus for a variety of reasons — some valid, some not. However, these systems did not pose a fundamental challenge to campus computing because of their limited power. The situation is somewhat analogous to a proliferation of typewriters. No one worries about it. However, when the item being duplicated is equivalent to an IBM 370-158, new problems emerge. The drive to proliferate computers is a natural part of campus life. Another characteristic of this drive is lack of understanding of what it takes to make these new systems operate. It is not just a matter of larger discs, line printers, card readers, memory, and so on, even though these items will cost more than the computer. The problem is that people will want to *use the full power* of their system and this implies a tremendous programmer investment in local software. If the programmer requirement is duplicated, the personnel will be difficult to come by in today's academic climate. If they are not duplicated, the computers will be under-utilized.

One natural solution is to standardize on a given type of minicomputer for campus *computing*. Note the distinction between mini's for computing and mini's for laboratory automation and other dedicated applications. Although coercive standardization has little chance of success, standardization by enticement is possible. One form of enticement is for the computing center to provide software support for only one type of minicomputer. If maintenance of hardware is centrally supplied from the computing center that is a second form of enticement. This model presupposes a medium to large computer center that has outgrown its central computer and needs supplemental computing power. While the central computer should remain to support the broad range of languages and services provided in the past, routine computation (FORTRAN, BASIC) could readily run on auxiliary minicomputers. The model for a small university would, of course, emphasize other features.

Distributed computing on campus is not viable until a stong user-oriented staff has been assembled. Since a computer is a necessary nucleus for staff development, such a computer should be selected for its software support as well as hardware power.

Components

A slightly deeper preview of the future can be obtained by looking at the most recent components announced. Evaluating such components one can fairly accurately predict capabilities of systems which will emerge as the components are designed into new products.

Disc Drives. Since larger or faster discs enhance performance but cause no fundamental architectural changes predictions are relatively straight-forward. At least three manufacturers are making high performance discs using 3330 technology. Such discs cost approximately $6500 for 80 megabytes of storage. For 1976 extended performance drives storing 380 megabytes are projected to cost $13,000.

Memory. Integrated circuit memories are rapidly displacing core. In present integrated circuits which contain 1K and 4K bits, access times range from 80 nanoseconds to 1000 nanoseconds. Costs of integrated circuit memories range from $2 to $16 in small quantities. In early 1976 16K memories are slated for introduction with speeds projected to be 200-300 nanoseconds and costs less than $10 per integrated circuit.

To put this in perspective, a one megabyte memory would require 512 integrated circuits at a total parts cost of $5120. Power supplies, printed circuit boards and packaging will cost another $5000 to manufacture. Use any factor you wish to obtain selling price and it will still be very cheap.

CPU 'Bit Slices'. These components make the construction of modern CPU's almost trivial in comparison with older technologies. The fundamental idea is to construct a universal CPU building block which can be paralleled to form an arbitrary CPU. Using bit slices of either 2 or 4 bits, 4 slices would be used to form a 16 bit CPU. Expansion to a 32 bit CPU would require 8 slices.

Components like those described above simply allow the designer to provide more of the same computing capabilities for less cost. No fundamental architectural innovations result from their application. However, a final component, microcomputers, will change the way we design and build everything from cars to computers.

Microcomputers. These components are simply cheap small computer systems. The word micro implies only low cost and small size. In all other respects microcomputers are normal computers and are used and programmed as such. Although the field is so broad and changing so rapidly it deserves a separate paper, some special implications can be seen in a university.

- *Process control* has been a traditional justification for campus minicomputers. Many of these applications can be handled by microcomputers at far lower costs.

- *Dedicated computers for computer science departments* (minis) have been used to give students experience in operating systems, interrupt handling and input/output programming. Some of the newer microcomputers provide ideal hosts for such activities at a very low cost.

- *Microcomputer terminals* will provide the least expensive internal control logic, character generation, and screen refresh. Once there, the microcomputer can also do local editing and computation.

Advanced Laboratory Techniques

Although this area is difficult to probe because companies are secretive about their most promising projects, references do give some inkling about the state of the art. A rule of thumb is that parts like memory will double in size and halve in cost every two years. The years ahead promise to be exciting.

Bibliography

COMPUTER SYSTEMS

A) See reference manuals from minicomputer vendors
B) "Mini Makers Confront the Giants," Electronics Magazine (July 24, 1975), p. 65.

COMPONENTS

A) "The 16K Ram Is Coming," Electronics Magazine (June 12, 1975), p. 80.
B) "INTEL 4K RAM Speeding Up to 80-ns Access," Electronics Magazine (February 20, 1975), p. 29.
C) "More Complex Logic Tradeoffs Multiply Designers' Options," Electronics Magazine (February 21, 1974), p. 83.
D) "Charge Coupled Devices," by Gilbert F. Amelio, Scientific American (February 1974), p. 22.
E) "CCD Memory System Stores Megabits," Electronics Magazine (August 21, 1975), p. 109.
F) "Charge Coupled Devices Move in on Memories and Analog Signal Processing," Electronics Magazine (August 8, 1974), p. 91.
G) "Bubble Memory of 500,000 Bits Could Compete with Discs," Electronics Magazine (May 16, 1974), p. 29.
H) "Bubbles Are in the Air," Electronics Magazine (June 26, 1975), p. 68.
I) Microcomputer Manuals from the following vendors:
  1) Motorola 6800 u Computer
  2) Intel 8080 u Computer
  3) National Semiconductor PACE u Computer
  4) Intersil IM6100 u Computer

ADVANCED TECHNOLOGY

A) "Microcircuits by Electron Beam," by A.N. Broers and M. Hatzakis, Scientific American (September 1972), p. 34.

B) "Josephson Tunneling Shows Promise," Electronics Magazine (December 26, 1974), p. 55.
C) "I^2L Takes Bipolar Integration a Significant Step Forward," Electronics Magazine (February 6, 1975), p. 83.
D) "The New LSI," Electronics Magazine (July 10, 1975), p. 81.

CHAPTER 5

by CAROL M. NEWTON

Policy and Management Issues In Distributed Computing On Campus

Paradise*

Academic computing was accelerated into being by commercial and governmental subsidies that enabled us to recognize the computer's truly important and potentially pervasive role in the continuing advancement of academic pursuits. On most campuses, a central computing facility was organized to undertake the responsibility to provide computing supports to its academic community. Although minicomputers were acquired by some individuals for laboratory research, campus computing was primarily delivered by a relatively large central computer, and users' services and classroom instruction tended to orient to it. Growing sophistication in academic computing generally was associated with growing sophistication of the central computers and their associated systems and applied software.

It soon was apparent that outstanding computing supports in various specialties differed from one computer model to another, and from campus to campus for similar models. Academic computing obviously would be greatly enriched if each individual could be provided access to a variety of excellent computing resources. Hopes for such a networking capability grew as the ARPA network achieved technical success and as more modest regional consortia (2, 3) pioneered resource sharing. Meanwhile, in certain specialties such as hospital computing, distributed computing involving minicomputers was recommended (4) just prior to the recent minicomputer revolution, and the advantages of allying such local minicomputing with access to large specialized centers were discussed (1). Now, recent technological breakthroughs are dropping the prices of minicomputers and escalating their capabilities at an amazing rate.

*With apologies to Milton.

Although software and customer services are not keeping pace in the latter developments, and although more work remains to bring the EDUCOM network into being, it is safe to assume that advances in computer technology now beckon us toward a new era in distributed academic computing. Transition into this era requires an examination of academic computing strategies, and hence of policies that already have at times perturbed traditional precepts of academic governance. In some ways, the new technology offers alternatives that might restore important aspects of decentralized governance, of freedom of individaul choice. But in other ways, its richest promises may be realized and financial feasibility assured only if universities enter into binding agreements with one another.

Finally, another especially attractive aspect of distributed computing is emerging as virtues of wholesale/retail systems are being debated. Consultation in scientific computing and the development of high-quality applied software for education and research are being increasingly recognized as important elements of academic computing in their own right, and as being in many cases administratively separable from the centers providing hardware and basic systems support. Ideally, consultants expert in scientific computing for a given discipline might reside in departments, together with programmers serving them; general consultants and specialists in systems and communications might reside at the campus computing center; and leading experts might be available for occasional high-level consulting by way of the networks.

Clearly, if all of these objectives in distributed computing can be effectively implemented, if the required transition can be achieved with considerate attention to the needs and aspirations of all parties involved, there will indeed by a renaissance in academic computing. Its likely impacts on both educational and research programs are exciting to contemplate.

Paradise Lost

Unfortunately, our declining economy discourages the priming that would greatly help entry into this new era of academic computing, and it has set into motion forces that may very well oppose it.

BACKGROUND

As a declining economy and anti-trust badgering substantially reduced or eliminated subsidies upon which campus computing centers had come to rely, their efforts to protect other sources of income understandably tightened. Caught in other financial binds as well, many universities failed to adequately cover these losses plus increased expenditures required by the rapid growth of computing in academic pursuits. Recognition of the importance of extramurally funded researchers as sources for support for the campus computing center grew. In many cases, this posed no problem. However, in some cases it was clear to the investigator that his research mission would be best served if a portion of the computing for it were rendered by his own minicomputer or the purchase of services from an especially appropriate facility other than the campus computing center. Nationally-based peer-review groups, whose expertise would be difficult to fault, reviewed the requests for extramural funding that would have provided these alternatives.

On many campuses, review boards were formed to monitor diversions of computing revenues from the campus computing center. They tended to place upon extramurally funded researchers, who wished to acquire their own computing equipment or to purchase elsewhere services they believed to be more cost-effective or appropriate to their specialty, the burden of proof that they could not in fact use and therefore help finance the campus center. One realizes, especially in advanced research, that there can be a tremendous difference between struggling to make use of a marginally appropriate system and progressing rapidly in one's work by accessing more adequate specialty computing supports. Campus review boards have differed on where to draw the line in such decisions. Some have engendered a legacy of resentment because decisions appear to be based on administrative rather than the traditional academic priorities. Others, upon ascertaining that the applicant's plans were well thought out, have permitted a more pluralistic system to evolve for campus computing. The latter campuses seem to be in a better position to advance in distributed computing with less disruption of the campus center. They already have learned how to cope with such shifts, and an atmosphere of mutual trust permits constructive negotiations that are unhampered by compulsions on both sides to over-hedge one's bets.

THE PRESSURES OF OUR TIME

Financial support for research has fallen further at a time when many investigators have become convinced that the continuing advancement of their research depends on assurance of at least some minimum level of computer support. For the first time in their careers, many excellent investigators are experiencing substantial cuts in funding and, all too frequently, loss of funding. Because this often is not a question of research quality but, rather, of unpredictable shifting of priorities for funding certain areas of research in a drastically curtailed economy, the investigator understandably reacts with an unprecedented sense of insecurity. What is no longer highly and objectively dependent upon scientific quality is no longer under his or her control. Concurrently, the investigator encounters higher prices for computing services at the campus center, or endures limited or low-priority access for now unsupported research. He or she mentally extrapolates this rapid downward slope for computer availability and decides that survival as a researcher may very well depend on acquiring an individual computer, no matter how high the costs in other but dollars. These costs can be very high. When this is pointed out by a review committee whose motives are suspect, rightly or wrongly, a deaf ear and deepened drive toward "freedom" are likely responses. The more autocratic the system, the greater the reinforcement of the investigator's sense of powerlessness and hence the more intensified his or her drive for "survival".

The spiral of distrust and contention builds as more cases are added. All parties impelling it onward see themselves as pillars of the university, as standing for principles essential to its well-being. And this is true. When investigators assert their rights, with funds they have obtained, to acquire equipment they deem to be essential to their research or educational mission, they can see themselves as defending a cherished precept of academic freedom, as well as the mission for which their funds have been provided. When computer center directors accept a responsibility to guarantee basic computer supports to all members of the academic community, and believe that their capacity to do so is threatened by decentralization of financial support for computing, they can see themselves as defenders of the welfare of the majority. And so it goes.

Perhaps this picture is a bit extreme. But elements of it can be sensed on various campuses and in various individuals. As federal budgets tighten and prices of minicomputers fall, the drive toward such a spiral is likely to become more manifest. The polarizations thus engendered could become a major obstacle to overall advancement of computing capabilities. Bids to upgrade the center's computer are likely to be resisted by those fearing that further indebtedness for central hardware would elevate the barriers to legitimate bids for decentralization. Deprived of the interactive capabilities offered by more recently designed computers, the center is hard put to defend against claims of individuals who assert that their work requires interaction and hence acquisition of a minicomputer. In short, these human factors can have real and important consequences. In these days, three types of hurdle must be surmounted for us to realize our hopes for academic computing: technical; economical; and human. Of these, the latter, impelled by the second, may prove to be by far the most difficult to overcome.

EXAMINATION OF SOME ISSUES

Some rather divisive issues have arisen in the evolution of local policies for academic computing. Their frank discussion and thoughtful resolution is essential to attainment of the environment of mutual trust and constructive outlook required to advance academic computing.

The several examples that follow are encountered rather frequently.

Those seeking to legitimize campus controls on how all dollars should be spent for computing must contend with the fact that some are supplied by extramural sources for well-defined missions. They therefore seek justification for policies that are independent of funding sources. Investigators resisting controls challenge that it is inappropriate to demand reviews for the acquisition of minicomputers that cost less than uncontrolled equipment such as electron microscopes.

Relevance of Source of Funding to Choice of Computing Supports. Many of the arguments advanced to decouple the choice of computing supports from sources of funding sound plausible when initially heard. Typical examples are: (1) It's the people who ultimately are paying for all of this anyhow, whether federal or state budgets are involved. We are doing what is best for *them,* and distinctions on the basis of sources of funding shouldn't be allowed to obstuct that. (2) All funds accruing to this university are awarded to its (Board of Regents, Trustees, etc.) regardless of source, not to the individual faculty member. Therefore, policies for spending them should not have to recognize differences in sources of funding.

All such arguments must be held up to the light of proper accountability. As citizens in a pluralistic society, we direct our mandates to various branches of government and private agencies. We ask our state and private universities to educate our young people; we ask certain of our federal institutes and private foundations to support research for the eradication of cancer, solutions to the energy problem, etc. Each such program is individually accountable to the citizens supporting it for optimal use of funds for its defined mission. Our society has been deliberately founded on the principle that no one group shall presume to "know what is best" for the people.

It therefore is improper to hold that the fact that one is extramurally funded should be ignored when an investigator seeks to acquire a computer or computing services that best serve the mission for which they are being purchased. Assuredly the university can and should reject any projects it believes to be harmful to its own mission. But to routinely label as such all projects that decline to assent to its determination of how their computing funds shall be spent would be both artificial and potentially seriously damaging to the university's academic standing.

Whose Rights Come First? Traditionally, universities have stood firm to protect the rights of individual scholars to choose how to pursue their work, especially when they need not draw upon common university resources in order to do so. One must question the legitimacy of equating an individual's failure to subsidize a campus computing center with censurable harming of one's academic community. If this equivalence is granted, there seems to be little reason not to extend it to other academic pursuits. The consequences of doing so are disquieting to contemplate. Not only does it seem proper to restore traditional priorities that respect the individual, where such have been warped, but such may now be necesssary for restoration of a climate of accord essential to the entire campus' computing welfare.

Why Should Minicomputers Be Subjected to Controls Other Than Those Regulating the Purchase of Equipment of Equivalent or Greater Cost, Such as Ultracentrifuges and Electron Microscopes? This question often is raised by those resisting imposition of university controls on computing. Superficially it makes sense, especially if the controls are directed to discouraging alternatives to use of the campus computing center. However, setting aside the question of whether there also should be better protection of prospective buyers of other equipment, one notes that the complexities and often very poorly understood cost centers in scientific computing place it in a class by itself. The functions of ultracentrifuges and electron microscopes are few and relatively well understood. The minicomputer is functionally protean, and a number of its prospective purchasers, though knowledgeable in their own fields, do not appreciate the many considerations that should enter deliberations on choice of a system. The prospective purchaser may be oversold by manufacturers' representatives, in-house programmers envisioning the challenge of developing software on a machine of their own, junior faculty unaware of the extent and possible consequences of their own inexperience and eager to introduce computing into their department, or enthusiastic associates elsewhere whose successful use of a given computer for something rather similar might not in fact be readily transferable to the task at hand. Most often these importunings are well intentioned, but the results of an unwise choice can be disastrous regardless of intentions.

Results are what should concern us. If an ultacentrifuge won't work, it can be promptly repaired or replaced and the investigator wastes little time in the process. It is otherwise with computers. Instances of software problems are legion, and their resolution may drain even an experienced investigator's resources, energies, and patience. Results of this drain might very well fall out nearby in the academic community. Although it may be deemed paternalistic by some, a requirement for prospective purchasers of computing equipment to plan thoughtfully and knowledgeably for its acquisition would seem to be in the best interests of all. If the reviews and consulting required for this are carried out expeditiously and in an atmosphere of trust, there is little basis for valid objection. An essential emphasis must be attention to the purchaser's and project's own welfare. Hidden agendas that place first a concern about supporting campus computing are improper, counterproductive, and, at best, unlikely to substantially alleviate the campus computer center's financial woes.

THE REALITIES

Minicomputers are going to play an even greater and more pervasive role in academic computing than at present. It is only a matter of time. Falling prices will make it impossible to maintain restrictive polices. The outcome is certain. Many will be acquired by individuals with extamural support, and some of their computations may duplicate what might be provided by the central campus computer. If the campus is viewed as an isolated, zero-sum entity with respect to financial support for computing, consequent diminution of extramural revenues for the central computer is inevitable and the overall results could be serious. Attempts to repress this trend will at best only buy a little time, and their potential for triggering or intesifying a spiral of mistrust is great. The latter could be very harmful to all aspects of campus computing. Finally, with the principle of responsible free choice an established policy for minicomputers, it is difficult to justify denying researchers and students access to extramural services that are especially appropriate for their work. With consequent further diminution of support, viability of the campus computer center, as presently constituted, may be called into question.

With this, the issue of who then guarantees continuity and quality of basic computer supports for all members of the academic community is also called into question. since some fields are only beginning to realize the benefits of computers in their instruction and research, we cannot remand this responsibility to departmental or school levels. There can be no doubt that a campus computing center must be maintained. The only questions are, "How?", and, "In what form?".

Paradise Regained

STEPS ON THE WAY BACK

First, we must recognize and accept the realities. Academic computing inevitably will become distributed within and between campuses. The sooner we face this, the smoother and more generally constructive will be our transition toward the future.

Second, we each must recognize the essential strengths of all of our positions, and the importance of all to the academic community. Extramurally supported research tremendously enriches our academic programs. It brings to campus intellectually challenging problems together with the resources to pursue them, and contributes through overhead to other research and educational programs in the university.

No rational research-oriented university will continue to promote policies that compromise an investigator's ability to obtain the kind of computing one needs to maintain the productivity required to bid for continuing extramural support. Indeed, in these difficult times, the university should play an even more active role in strengthening the investigator's competitive advantage. On the other hand, the need for a campus computing center as guarantor of the continuity and quality of basic computing supports for all members of the academic community is altogether beyond debate. It is doubtful that campuses ever could have gotten along without one, but with the complexities of distributed computing upon us, it is certain that we should now have to invent expert campus computing centers did they not exist.

Finally, with knowledge of the future and an awareness of our strengths, let us begin right now on each campus to chart a thoughtful course that will bring to both its educational and research programs a rich variety of cost-effective computing resources to further their excellence. We can and must work together in the traditional spirit of collegiality that respects individuals and makes universities great. Erosion of collegiality by coercion is a hallmark of failure.

THE CAMPUS COMPUTING CENTER

Maintenance of a substantial hardware capability at the campus computing center in the face of inevitable trends to decentralize implies either substantially increased university support or escape from a zero-sum funding game. While advocating that universities themselves more adequately fund academic computing, one must suspect that in these tight financial times, the escape alternative will be preferred by some. This implies building a market of extramural users by accepting commercial or research institute contracts, providing standard services to other regional campuses lacking a major computer, or joining a national network. To become attractive on a national level, the development of outstanding capabilities in one or more areas should be considered; i.e. in addition to providing good basic services, the campus center might become a *specialized facility*. A combination of general regional services and specialized national services very likely will be the best solution for larger centers. The implications for overall upgrading of academic computing in this country are obvious.

But development and maintenance of a truly outstanding campus computing center need not be equated to maintenance of a substantial hardware capability. Instead, such a center may choose to develop high general expertise in modern scientific computing; in networking, minicomputing, sophisticated interfacing of computers to other systems, academic software development, expert counseling and instruction in strategies for scientific computing, etc. An adequate minicomputer or small standard computer might handle the great majority of routine local transactions. Being knowledgeable of computing throughout the country, advisors at the center could direct students and faculty to the most appropriate extramural services when capabilities beyond those obtainable locally are required.

Either approach would seem to bring us closer to what academic computing is all about, excellence in scientific computing that reaches above and beyond stewardship for a large machine. Many of our campus centers now exhibit this excellence and should be able to make the transition with little difficulty.

DISTRIBUTED COMPUTING ON CAMPUS

Distributed computing on campus probably should include both minicomputers and local departmental consultants and programmers. A prospective purchaser of computing equipment should be helped and required to plan knowledgeably with the assistance of University-supported staff and faculty. Other alternatives should also be carefully described and possibly recommended to the purchaser. However, if users provide evidence of having considered these suggestions competently and if those financially supporting the acquisition agree, they should be permitted to stay with their choice.

It would seem to be in their best longterm interest for most campus computing centers to assume an active, constructive role in developing high-quality supports to distributed computing on campus, and perhaps for extramural users as well. The development or maintenance of cross-assemblers for more commonly available minicomputers, provision of rechargeable expert custom programming and interfacing services, maintenance of a pool of minicomputers for rental, the development of systems for communicating some minicomputers with the central campus computer as intelligent terminals, might be suggested. Consider the latter. After the novelty of reinventing statistical and other established software has worn off, new minicomputer users may more fully appreciate the great wealth of expertly developed, long-tested software available on larger machines. If they then can use their minicomputer both stand-alone for appropriate local transactions and as an intelligent terminal that can tap the campus computer's major applied software, their financial support and advocacy for the campus center are likely to rise substantially.

SUPPORTS TO DISTRIBUTED COMPUTING FROM MULTICAMPUS CONSORTIA

Individual campuses may fall short of the volume of activity required to achieve important economies of scale in minicomputing, which come within reach for consortia of campuses. Economical group purchases of minicomputers and their associated commercial software are obvious ventures for a consortium. In fact EDUCOM has arranged for discounts with two computer component vendors for all members. The larger the number of members, the more likely that the required number of prospective purchasers can be attracted for a given transaction without pressuring other purchasers who really prefer something else. Spare-parts depots and highly cost-effective maintenance services for the more widely used minicomputers also should be considered. Although founded for more positive goals, a newsletter can bring pressure on manufacturers and software houses by making known commonly encountered problems.

One of the most valuable products of sharing and collaboration within a consortium is likely to be software. Inadequacies in some applied and systems software in minicomputers constitute one of the major reasons for preferring large computers for certain applications. However, much of the latter's software constitutes a major investment, involving teams of experts, substantial documentation, continuing maintenance, and numerous corrections and refinements accruing over a large number of years. There is no way for this quality to be duplicated instantly for minicomputers. However, if universities believe that minicomputing is important to their future, now is the time to begin deliberate, well-planned collaborative programs to place minicomputer software on a sound basis. The desultory offerings of informal users' groups will not suffice. There must be a solid, longterm commitment for both development and continuing maintenance. While one university might undertake such a commitment in a limited area, perhaps as part of its role as a specialized center, the need for group action is clear.

Finally, local consortia enable sharing of equipment that is required only occasionally and hence unlikely to be well represented on all campuses. Consider especially the equipment that is required to translate data from one machine-readable form to another. A specialized minicomputer may perform only one part of a larger job. Its output may not be readable by the next processor to be used. Considering the possible combinations in such incompatibilities, it would not be surprising to find that all of the data-conversion equipment desired on a given campus might not be found on that campus. Again, the local consortium's potentially broader equipment base is one answer.

THE ROLE OF STANDARDIZATION

An obvious dilemma arises from the foregoing considerations. One of the most attractive advantages of minicomputers is their ability to introduce at relatively low cost a rich diversity of local computing supports that are specialized to different areas of application. Unfortunately, these specialized software systems associate with different minicomputers and often are not readily transferable to others. In addition, very promising new minicomputers are being offered by less well entrenched companies. We can expect a broad industrial frontier of innovations in the coming years. All of this militates against restricting academic minicomputer acquisitions to a few models of manufacturers.

On the other hand, it is clear that many of the advantages that can be realized from central campus support and collaboration in consortia require focusing attention on a few computers Group buying and shared support of software are obvious examples requiring volume to be cost-effective, but the development of interface devices and protocols for accessing networks might prove to be even more important Clearly, a pluralistic system is best one that offers substantial advantages to those acquiring standard systems while permitting freedom of choice to those whose academic missions would be better served by other systems

One would anticipate little contention where the better established standardized systems are concerned The advantages already achieved by collaboration should be quite visible for such, and wide preference for them would be expected to create a comfortably adequate user community without active recruitment It may be otherwise for systems on the borderline, whose proponents have much to gain by pressuring others to join them. A spirit of collegiality that favors the great majority of users, adherents to popular standard or to non-standard systems, is essential to a healthy academic computing environment, and hence computing policies should be designed to discourage undue pressures to standardize, while making available the undeniable advantages of some standardization. Again, *the need to coerce is evidence for failure.*

Yet another dilemma: The larger the collaborative base, the larger the number of standard systems that can be cost-effectively, comfortably accommodated, and hence the wider the choice for individuals. Large consortia are one answer. However, responsiveness to the particular needs of users on one campus is likely to be lessened if decisions concerning priorities for collaborative efforts must be made on the basis of what is best for a larger group of campuses Pluralism should apply here, too A campus should partition its investments between local and consortial activities. One further notes that specialized extramural software collaboration often has been, and is likely to be, by professions rather than campuses The minicomputers or microprocessors chosen for extramural collaboration may not be the same as those preferred by a majority of campus users. All the more reason for a pluralistic approach and respect for what serves the individual best.

University of California Advisory Panel on Minicomputer Policies

BACKGROUND AND GENERAL CONCLUSIONS

An Office of the Executive Director of Computing has been created for the University of California system. Since the Director reports directly to the President of the University, the University apparently appreciates the important, pervasive role of computing throughout its various branches. Since being appointed to that office, Melvin Peisakoff has initiated a number of committees to investigate various aspects of the University's computing needs. For instance, a task force on communications has investigated both microwave and common carrier communications for linking computers among the nine campuses. The panel on minicomputing has based its policy recommendations on intensive deliberations on academic needs. Since campuses have, to different extents, permitted or welcomed minicomputers and other aspects of decentralized computing, the panel does not foresee serious difficulties in advancing into a new era of distributed academic computing. Indeed, that is what much current planning is all about.

It would be difficult and perhaps not worthwhile to summarize all of the panel's deliberations. Some of the more important general observations were

In minicomputing software tends to be a greater concern than hardware. For instance, it might at times be a very false economy to require two nearby people to share purchase of a single minicomputer if their disparate software needs are adequately met only by two quite different machines.

Although one would like to, *it may be difficult to obtain purchase contracts for minicomputers* and their associated software that enable acceptance to be *contingent upon demonstrated system performance given specifications.* The minicomputer market is quite different from the established, large computer market. Low prices reflect to a large extent more modest services, guarantees, and general hand-holding. This is an important reason for recommending that minicomputer purchases be aided by knowledgeable advisory panels.

Minicomputing should be viewed as part of a total capability for distributed computing. Both on-line and off-line intercommunication among computers should be enabled. Software optimal for several portions of one job may reside on different machines; large computer backup for the mini is only one example of this need.

All of these considerations point to the advantages realizable in consortia. The University of California system is an excellent testing ground for what may be accomplished by consortia for minicomputing, and the panel on minicomputing recommends that it actively and creatively explore what can be achieved in this dimension.

AN OPINION SURVEY

Two opinion surveys concerning minicomputer policies were conducted by panel members. In the briefer survey questionnaires were sent to department chairmen and directors of major research units. In a few cases, faculty designated to respond for them, or deans, replied. A preliminary analysis of some general questions indicates the following results:

Q: Do you believe that permission to acquire a minicomputer should be by the traditional procedures for other equipment of comparable cost?

A: 78 yes
18 no
3 very qualified

Along with "yes" were some comments that computers should not be treated differently from mass spectrometers, etc., but others perceived that some different considerations might be appropriate in reviews of their purchases. The primary consensus was that channels of governance should be the same. Along with "no" were comments that minicomputers were less well known or well defined to some than were ultracentrifuges, etc., and that decisions concerning minicomputers are likely to have greater educational impact.

Q: Who should review minicomputer purchases, if it is decided to do so?

A: 62 traditional local channels
11 local, with university technical support
6 university-wide
18 strong anti-review sentiment
6 want only some technical advice

Q: To aid university planning for cost-effective computer supports, do you object to some regular reporting on minicomputer use?

A: 72 acceptable
30 object

Of those to whom some regular reporting on minicomputer use would be "acceptable", 25 urged that reports not be too frequent or too long. This generally favorable attitude suggests the earnestness of the respondents. They are willing to invest the effort required to make a good system work.

Q: What are your reactions to required technical review that addresses questions of importance to purchaser, that are answerable by any reasonably knowledgeable buyer.

A: 41 O.K., with some qualifications
15 O.K., with firm assurances that it is purely advisory
34 negative (18 emphatic)

Q: Should applicant be required to accept a recommended alternative?

A: 15 yes
51 no
5 depends on funds

Q: Whose considerations should come first? With this question a ranking was requested among the first four items, and the top two choices were scored when more than one check was made.

A: 29 purchaser, faculty
13 department
10 campus
3 university
37 depends on source of funds
5 depends on use
11 depends on circumstances

Q: Should applicant be free to choose, so long as all people funding the acquisition are satisfied and he has considered the proposed alternatives?

A: 73 yes
4 qualified
5 no

Q: Should all minicomputers acquired for educational purposes be administered by the campus computing center?

A: 19 agreeable
55 against (15 vehement)
7 favor pluralistic systems

Although only seven respondents volunteered that they would recommend a system where some were administered by the center and some were not, it is likely that more people would have been agreeable to this had it been an explicit alternative in the question. Some voting "against" noted that one of the purposes of minicomputers is to decentralize computing.

Before drawing conclusions from the foregoing response, one must be mindful that it is only a casual survey, with obvious liabilities to bias with respect to nonrespondents. Also, it was sent to academic administrators at the department-chairman level, not to individual faculty and students. (The larger, two-pass questionnaire seeks to reach these people as well.) However, certain of the findings are so clear that, at least for this category of respondent, it seems unlikely that a more systematic survey will reverse them.

What might one anticipate about this group of respondents? They probably orient to academic interests while appreciating administrative necessities required for the welfare of the department or university. The preference for adherence to traditional channels of academic governance is not surprising. Any controls might be resisted more uncompromisingly by the faculty whom they would most directly affect. Evidence corroborating a sense of administrative responsibility is found in the willingness to report on computer usage, together with the awareness that this could entail an administrative burden (i.e. the requests to keep reporting simple).

In view of this, quite strong sentiments that the preferences of informed purchasers and their sources of funding must be respected, cannot be ignored. Ambivalence with respect to a required technical review probably reflects concern, some of it openly expressed, that such might cease to be purely advisory.

As remarked earlier, most University of California campuses have tended to welcome, or at least tolerate, minicomputer acquisitions in the past. One therefore might expect phobias against controls, or opposition to the computer center's administration of educational minicomputers, to be less adamant for the University of California than for campuses harboring resentment of more authoritarian systems.

It seems rather safe to conclude that any enduring policy, while requiring and technically supporting a responsible pre-purchase review of alternatives, must allow the applicant's choice of a system so long as all people funding its acquisition and maintenance are satisfied and the user provides evidence of having seriously considered all proposed alternatives. It also seems desirable to adhere to the traditional channels of academic governance as closely as possible. More detailed policy and program recommendations recently released by the University of California minicomputer panel are available from the author.

PROPOSED UNIVERSITY-WIDE SUPPORTS TO MINICOMPUTING

As mentioned earlier, the advantages realizable by a consortium of campuses can be substantial. While it might be easier for the University of California system to mobilize the administrative vehicles for consortial activities, it is unlikely that the activities themselves would differ markedly from those which other consortia might adopt. University-wide activities to support minicomputing might include:

Basic Technical Supports

- Bargaining power for group purchases or good service should respond to expressed needs rather than risking overestimation of future requests for a system.

- Jointly supported custom programming may enable cheaper machines.
- Contracts or grants to faculty to develop innovative systems to advance research or education.
- Selective software maintenance, documentation, and distribution.
- Selective contracting for hardware maintenance.
- Depot of spare parts, or computerized inventory of what is available on various campuses, whom to contact.
- Investigation and development of regional communications hardware and software systems, to link minicomputers to large computers and to each other.
- Development of shared resources for converting machine-readable information will allow a diversity of data formats. Specialized minis may do only part of a job.
- Basic professional full-time staff will be necessary to manage support activities and to consult with users and prospective purchasers.

Academic Resource Sharing

- Shared expert consultants.
- Shared instructional resources can be facilitated by mutual listing of computer courses, permission to enroll, and sharing of teaching aids.
- Workshops, symposia, demonstrations, "road shows".
- Users group.
- Joint studies and evaluations.
- Shared support for representatives to appropriate professional committees.

Newsletter

- Announce new shared technical support
- Request bids for new software.
- Announce newly available software.
- Advertise for participants in a group purchase or for support for custom software.
- Announce workshops, new courses.
- Reports from representatives to national meetings, committees.
- Report manufacturer support deficiencies, frequent hardware or software problems.

This is all very promising, but how do we pay for it? How do we set priorities? How do we attract and compensate substantial investments of time by top academic talent? How do we ensure longterm commitments, that justify major investments in communications? How do we achieve a healthy balance of resource allocation between individually owned minis and shared large computers? How do we accomplish all of this with minimal invasion of the informed individual's freedom to choose?

Starting with simple programs requiring little capitalization, we can gradually work toward more ambitious goals, learning as we go.

Conclusion

Distributed computing within and between campuses is virtually certain as we move toward a new, exciting era in academic computing. Concomitant with this, decentralized funding is likely to erode support for large campus computing centers, if each campus is regarded as an isolated, zero-sum funding entity, and if the centers adhere to their traditional forms. However, the very situation that poses this problem also points a way to its solution. With the complexities of distributed computing upon us, the need to support an expert campus computing center becomes even greater than before. Centers that prepare for active leadership in fulfilling this role are essential to the university's academic mission and hence in little danger of being denied financial support. Revenues from services will increasingly supplement those from use of the large computer. Campus centers can exercise and be esteemed for their expertise in scientific computing, earning respect well beyond what they might once have been accorded for possessing a large piece of hardware. Those who wish to retain the latter can break the bonds of a zero-sum game by developing specialized supports whose excellence can attract users from a nation-wide base, while also providing high-quality computing supports to smaller nearby academic institutions. Intelligent planning for such transitions with respect for the rights and needs of all involved, should begin right now.

On the other hand, while distributed computing is to be welcomed, requirements that prospective minicomputer purchasers make well-informed choices are not unreasonable. As the market rapidly broadens, as hardware prices fall, and as fears for continued funding for their computer-dependent research force some to desperate measures, a number of proposed purchases may be ill-considered. Many newly attracted purchasers may be far less well informed about minicomputers than about other equipment of comparable cost that they might buy, and the impact on them and their work due to struggling with an inadequate minicomputer system can affect others in the nearby academic community. However, any review should provide helpful technical consultation and be oriented to the user's needs. After requiring a knowledgeable consideration of alternatives, a review committee should permit the purchaser and those supporting the purchase and system maintenance to make the final choice.

Finally, multi-campus consortia can contribute tremendously to the cost-effectiveness and excellence of distributed computing systems. Beginning with simple programs requiring little capitalization, they can advance carefully toward more ambitious goals.

References

1. P.M. Britt and C. M. Newton, "A Case for Functional Specialization of Large Computing Centers", *Proceedings of the ACM National Conference*, Association for Computing Machinery, New York, N.Y., 1971, pp.357-358.
2. R.W. Cornew and P. M. Morse, "Distributive Computer Networking: Making It Work On a Regional Basis", *Science* 189, 1975, pp. 523-531.
3. M. Greenberger, J. Aronofsky, J. L. McKenny, W. F. Massy, Eds., *Networks for Reasearch and Education: Sharing Computer and Information Resources Nationwide*, MIT Press, Cambridge, Mass., 1974.
4. Theodore H. Kehl, Chairman, "A Reexamination: Centralized versus Decentralized Computers in Biomedical Environments", *Proceedings of the ACM National Conference*, Association for Computing Machinery, New York, N.Y., 1971, pp.357-366.

CHAPTER 6

by Clinton DeGabrielle

Legislative Perspective On Distributed Computing On Campus

Introduction

I have never been a legislator, but I do receive a considerable amount of direction from the Washington state legislature and have a very direct interface with them. It is on the basis of this environment that I address the subject, "A Legislative Perspective on Distributed Computing on Campus".

First, it is necessary to define "Distributed Computing." At the Washington State Data Processing Authority we use the definition, "providing a functional capability to a user at the location or locations where the user would most usually perform the function." There are probably many who feel this is a cop-out devised to establish a broad generalization which can be applied to any situation with any solution that has been pre-ordained. However, we found many more specific sets of language to be restrictive and to tend to describe parochial interests.

While setting a frame of reference, it is only fair to reflect also some assumptions regarding legislative bodies that you may find completely unacceptable. Assume that your legislature has a strong desire to understand your need for computing resources and an equally strong desire to satisfy those needs within the bounds of an equitable assignment of fiscal resources. Further, assume that your legislature has experienced a frustration in dealing with several dozen individual requests for data processing resources which on the surface appear to duplicate themselves, to a large extent. As a final assumption, accept that your legislature does not have the wisdom of Solomon, the patience of Job, nor the luxury of infinite financial resources.

To combat this frustration, to overcome the lack of understanding and to make some order out of the chaos which they felt, legislatures have resorted to a number of schemes in dealing with data processing resources. Commissions have been established, departments of data processing have been created and data processing advisory committees instituted. All this attention to better control from a half of one per cent to 1.5% of a total state budget. As in many instances, it isn't the magnitude of dollars, but rather the visibility and glamour of computers that attracts this attention.

Computers get attention because the media like to report on computer activities, and politicians will attach themselves to any focus that the media develops. Computers have consistently received a great deal of notoriety. Their cost, their applications, their acquisition and their mistakes are all newsworthy and at the same time they are suspect by the general public. All of this adds up to sufficient reason for the legislature to have a high level of interest in computers. Throw in the security and privacy issue and the big brother image, and you have created an ideal situation for legislative interest and involvement.

The Legislative Perspective

With this background, let's try to examine the legislative perspective of computing. There has been a good deal of emphasis in a number of states on consolidation and it is normal to expect that such a direction or such an attitude precludes consideration of distributed computing. Although we have had a major thrust toward consolidation, in the State of Washington, this is not the case.

I sincerely believe that most legislators are interested in providing an optimum return on the investment of any resource. They are not really interested in being involved in decisions of what computing resources are appropriate for a specific function. They are getting involved and they are making those decisions because, in a great many cases, they just do not feel comfortable with the stories they are getting. Seldom are they presented with a request that deals with a multi-campus or multi-purpose computer. Rather, most requests are for resources to serve an individual campus, an individual department or a single user. Thus, over time a lack of credibility develops between the requesting schools and the legislature, and the legislators cast about for a way to develop a set of controls.

Most academic computer users might say, "that doesn't apply to me; I share *my* resources and I am willing to cooperate in use of *my* computers. I have lots of examples of people who are not on our campus using *my* computer." They may be right, but how many have taken a mature objective approach to any statewide planning of data processing resources and how many have ever consulted with the legislature to try to understand their concerns? How many have voluntarily used someone else's computer or contributed to the development and implementation of a system on someone else's campus. In so many cases, any solution is all right as long as it happens to someone else. Maybe the legislature has some small grounds for feeling that more cooperation is possible.

In a great many cases a campus or a user makes a case for a particular approach based solely on the biased analysis of a local situation. A desired resource is chosen and then elaborate steps are taken to prove that this is the most cost effective way to meet the need. In many instances the needs are not truly representative and the solution to meet the needs has not been selected from a set of viable alternatives. Rather a desired solution is compared to one or more alternatives which have been proposed because they present the desired solution in a good light. Requestors show that they can't afford to use another schools resources because the communication costs and cost of service on the other schools computer exceed the cost of their own solution. How can one school be penalized by asking them to pay more than they need to with the handy dandy solution they desire? It is strange that in over thirty requests for equipment over the past two years from universities, colleges, community colleges and state agencies the Washington State Data Processing Authority has not seen a single set of supporting documentation that examined the costs in light of costs to the state or cost to the taxpayer. The green dollars required to support the desired equipment are blithely compared to the grey dollars represented by the estimated costs of using an existing state resource. The argument is made that both costs represent real charges against the requesting schools budget, and this is probably true. However, if as much effort were directed to solving this bookkeeping problem as justifying a position, perhaps a more equitable solution for all parties concerned could be arranged.

Legislative Strategies

To induce cooperation, each legislature seems to attack the problem a little differently and to be looking for different results. In Washington, the legislature created a Data Processing Authority to establish policy and standards and to control the acquisition of hardware. A major thrust of the legislation was the consolidation of hardware and the development of appropriate common systems.

Some basic principles have been developed as the Washington State Data Processing Authority has implemented legislative strategies. A first principle is that, wherever practical, computer resources should be part of a network that provides the user with a variety of means to serve his or her needs. When implemented according to this principle a system would provide a user with access to any of the hardware or software resources in the state. Thus, a user with a terminal primarily being served by an on-campus mini with BASIC, would also, through the mini, have access to other computer resources on another campus or in Olympia to solve problems that do not lend themselves to BASIC.

Another of our principles is the establishment of centers of expertise at various campuses. One campus becomes the leader in research and development of C.A.I. They try the new hardware and software in support of C.A.I. and become the introduction facility for other schools to begin to use C.A.I. As other schools develop a high level of demand, using the center's resources, an on-campus facility is installed and the center continues to be used for libraries and development. In this manner, a time-sharing center of expertise, a simulation center, a text-editing center, a storage and retrieval center, a vocational training center and centers in specific disciplines, such as nuclear physics, business, language, medicine, and so on are established. Some do not proliferate to other campuses and others spawn multiple campus facilities. In this manner, the state is providing distributed computing. Some resources are minibased, while others are special purpose and still others are larger scale general purpose machines.

The Washington State Network

To make this concept work, there is need for an extensive telecommunications network. At present, the state has some 300 terminals in a variety of communication links. A plan is now being completed to develop an integrated network based on a hierarchy of dedicated circuits, polled circuits, multiplex, concentrators, switching centers and intelligent communication pre-processor front ends. The legislature seeks to create an environment that will permit the user to access any computer or any other terminal in the state. The network will serve terminals on thirty-three campuses as well as terminals in the K-12 school system, the state and local police, statewide driver licensing stations, district highway engineers, a statewide library network, welfare offices, forest protection sites, the state's liquor stores, employment security offices, and more than a hundred other users of communication based information systems.

That is one state's approach to distributed computing — an integration of computing and communication resources being developed with a measure of cooperative planning and intended to provide a pick and choose super market of resources for the user. Along with this manner of providing hardware resources goes hand in hand a program of common application systems development, a statewide common payroll/personnel system, a common library network system providing bibliographic, acquisition, circulation, serials, and locater functions, a standard accounting system, a common student record system for the twenty-seven community colleges, a common budget and budget monitoring system, a common purchasing system, a common inventory system, a common business identifier system and a common financial information system for the community colleges.

Common integrated data bases are also a main element in the plan. Where appropriate, data management systems are used to make the data available for access and use by a variety of applications. The residency of these data bases is not important but the common data element definition and maintenance is significant. Data bases are under development to provide student records, human resources data, fiscal data and information on agency and institution missions. In the on-line library system presently in the pilot test stage, a single bibliographic data base is being constructed to serve as a central reservoir for the author, title, subject and other details needed to describe a particular work. Thus, there will be only a single record for any book with holding, acquisition and circulation systems pointing to the record in the data base.

It would be inappropriate to represent all of these items as accomplished fact, but for every single item some work has been completed. In some cases such as the student record system, the accounting systems, the library system and the payroll/personnel system, production modules are in operation. In other areas, we are doing the requirements analysis; in still others, we are in the design phase and in some we are in final stages of programming and testing.

In some cases, there has been a reasonable acceptance of the progam and there is a sincere cooperative effort underway to produce the product. In some cases, there has been cautious recognition of the program and a good deal of setting on the sidelines waiting to see what happens to others. In other areas there has been strong opposition and considerable attention to protecting one's turf. Some things are working well; others are not. But, at least at present, we do not have a wholesale catastrophe or revolution on our hands.

How does the Washington State Legislature feel about all of this? I may be biased, but I sincerely believe that the Data Processing Authority and a large segment of the state's data processing community are developing a high degree of credibility with the Legislature. Neither a user nor a provider of computer services can slip on the statewide network of computing resources as comfortable. All must build an increasingly solid image of mature, objective planning and implementation. Further, if an individual, a department, a school or a group of schools is willing to approach any request for resources in terms of a cooperative planning and implementation, with a sound analysis of the costs to the state, then the chances of the legislature responding in a positive fashion increase with each instance.

Limits of Revenue

The great majority of governmental units have reached the practical limits of generating revenue yet are faced with every-increasing demands for services and support. In the State of Washington, voters in local elections turned down over 150 million dollars in local school levies, and higher education had its budget request trimmed by nearly 50 million dollars. A state income tax has failed three times in the last nine years and other proposed tax increases have met similar fates. The message seems to be pretty clear "the taxpayer even with representation has had enough." The pie from which you receive funds for computing has been frozen in size and you are going to receive a smaller and smaller percentage of the total. Because many other things share the same pie and have more people involved, as people costs keep increasing, less will be left for your computer budget. At the same time, since most of your computing budget is people costs and your cost of people keeps going up, you need more money. The financial squeeze is very real. The simple truth is there isn't enough additional revenue available to support the increased cost of the people presently on the total state payroll.

How does this all tie into the question of how does the Legislature look at distributed computing? It ties in very directly. Two years ago, the Washington State Legislature could support a program that had a four or five-year payoff. Today, the Legislature can support only programs that pay for themselves during the current fiscal period because there isn't any reservoir of revenue. This is certainly not a popular view of funding for computing, for education or for any other governmental service, but it is fact.

Perhaps, we all need to take a look at our priorities and reorder them in light of today's realities. If, with distributed computing, you can do your job better with the same dollars, then the legislature will look on distributed computing favorably. But perhaps you should really get involved and play a part in looking at the overall use of funds on your campus, not to see how you can get more, but to become a positive factor in the determination of how best to apply available resources. If you can't see yourself in a total campus involvement, how about a statewide or a regional involvement in computing planning? Not a study for studies' sake or a study to delay an action, but rather a real contribution to as broad a program as you can mount. In this environment, distributed computing will find its own place and you will have made a contribution to the solution of a broader problem.

CHAPTER 7

by Thomas E. Kurtz

Management and Policy Issues In A Regional Network

As networks of all types accumulate experience, it is clear that fundamental differences are few and that common problems are many. The NERComP experience is fundamentally no different from that of other networks. Minor differences arise from these facts:

1. NERComP got started earlier than most.
2. The disparity of equipment is greater than in pre-planned networks.
3. Historically, there has been less central planning and control.

With respect to the third fact, we recall the motto of New Hampshire ("Live Free or Die"), of Dartmouth ("Vox Clamantis in Deserto"), and of Harvard ("Every Tub on its Own Bottom").

NERComP Begins

NERComP is historically one of the oldest regional consortia devoted to sharing computer resources. Its ancestor began at MIT in 1957 when a grant from IBM to MIT specified that computer resources on the 704 be made available (free of charge) to New England colleges and universities. The arrangement lasted ten years, and gave a strong incentive for the development of computing resources at a number of New England colleges and universities.

In 1967 this activity, which for ten years provided service only on the MIT computer, expanded to include computer services from other institutions. In 1970 NERComP became a not-for-profit corporation with forty institutions of higher education in New England as its members (owners).

Until recently, NERComP and its ancestor served as marketing agents for first MIT alone, and after 1967 up to six or eight other supplier institutions. The services it provided were obtained from computer "haves" and delivered to "have-nots." In many cases the have-nots were departments, individuals, or projects at institutions which possessed some computer capability but were not able to provide the exact service needed.

Around 1972 NERComP recognized several problems inherent in its style of operation. First, it marketed time sharing services which could be duplicated on relatively inexpensive mini time sharing systems. Second, its marketing efforts were sometimes in direct competition with those of its suppliers, some of whom maintained de-facto marketing efforts of their own. Third, NERComP was doing little to promote the *exchange* of computer resources between supplier institutions. In fact, at that time its member institutions could be divided into two mutually exclusive subsets, suppliers, and users.

NERComP Changes

NERComP perceived that two major changes were needed: First, the *kind* of communications in use had a strong influence on the nature of the services. Communications technology was multi-drop frequency-division multiplexing in almost all cases. Although this technology is well suited to retail distribution of time-sharing services, an alternate technology offers greater flexibility in dealing with RJE as well as direct computer to computer communication. While there are technical problems still to be resolved (some of which will be mentioned later,) the message switching technology (sometimes called packet switching) currently under construction will make computer-computer communication between suppliers relatively simple. It is true that the technology does not guarantee one particular type of service nor preclude another, but it has a strong influence. For many years we used computers remotely by carrying boxes of cards to the distant center, and carrying back the printer output or having it mailed. This is still possible, and relatively inexpensive, but hardly anyone does it.

The other change needed was a major shift in the organization, the image, and the style of NERComP. It needed to change from a retail marketing organization to a facilitating and cooperating group, with the retail marketing being handled in part by the ten or more existing university star networks. To assist the reorganization, NERComP sought and received a second grant from the National Science Foundation (NSF). A first grant had been received in the days just prior to its incorporation.

The history and background of NERComP have been documented elsewhere. The reader who desires additional information is referred to previous EDUCOM conference proceedings and articles (1, 3, 4, 5).

A Digression

Although this paper is supposed to concentrate on policy issues, all defenders of the faith and dogma, bear witness. I am about to utter a heresy. The EDUCOM dogma, principal number one, is that the chief stumbling blocks to networking are not technical, but organizational and sociological. The Council of Arlie in 1972 formalized this dogma, and inscribed it in stone in the good book *Networks for Education and Research* as interpreted by the prophets Greenberger, et al. So, prepare yourselves, ye inquisitors!

I believe that the chief stumbling block to networking is, at the moment, not political nor organizational, but technological. Since the technical theory is well established, the technological gap can be measured in dollars. To purchase or construct the technology needed for widespread networking is still very expensive. The major expense exists over and above, well over and above, the raw cost of data transmission itself, at least at the moment. I have four theses:

The high cost of alternatives to standard voice communications. To allow general networks to flourish, speed-independent message switching in some form is needed. Such services can be obtained commercially, but prices are high and services limited to certain urban areas. Neither Telenet nor Tymnenet serve Hanover, New Hampshire, for instance. Nor have they any plans for local service to the nearby towns of Lebanon, Norwich, Lyme, or Etna. Similar technology can be built, but much effort spread over a period of years is needed. NERComP is developing its own message switching equipment in an effort that is both costly and time consuming but for which there is no immediate alternative. National networks need link only major population centers, but regional networks must serve the hinterlands.

The high cost of connecting existing communications front end processors to networks more general than a phone line or FDM circuit. Most front end processors must be reprogrammed in order to connect to general networks, but in some cases they cannot be reporgrammed. Since institutions use their own software for front end processors, a large number of different revisions exist. Programming costs have been estimated at between ten and fifty thousand dollars per processor. Whether or not institutions with similiar machines can share costs remains to be seen. It is one matter to build changes in your own system, and quite another to design *and* maintain changes from a group of similar machines. NERComP is approaching this problem by designing its network to replace existing front-end processors, if necessary.

The high cost of changes to operating systems. Most operating systems now in existence are not equipped to handle computer-initiated file to file transfers. Further, most operating systems lack detailed access control mechanisms necessary to carefully delineate who may use which network and for what services. Lacking as well are the requirements for essentially instantaneous billing and accounting. Finally, most systems are not secure enough to permit connection to general networks and to user groups of unknown constitution and inclinations. In short, operating systems are not yet ready for networks. The costs which will be incurred to make them so are substantial. In NERComP this situation will be remedied only gradually.

The high cost of high quality software products. There is already enough software of reasonable quality to justify networking. But universities now realize how expensive it is to provide a well designed and debugged software package with documentation and user support. Computer center managers will have to spend time and money rendering their software fit for networking. Among NERComP members efforts have already begun, since they have had to face this problem for five years.

Management Issues

One trouble with trying to solve the management issues is the difficulty of discussing them in the abstract. With only part of the eventual network operating, it is difficult to know which problems are important and which do not matter. For instance, if a new statistical system is to be offerred by the network, how does one decide where to mount it? The question may be moot, or it may be severe. Once a full network is available, the problems may be resolved as they arise. Techniques for decision making that do not work will be discarded and replaced by ones that do.

With NSF support, NERComP has organized three advisory committees to discuss management issues and to devise solutions and policies. Each committee has a staff coordinator to help carry out its work and to carve it deliberations into stone. The three areas are:

- Organization and Governance (OGAC)
- User Services (USAC)
- Technical (TAC)

Since each advisory committee is composed of persons from member institutions, the schools are closely involved in setting policies and procedures.

To illustrate management and policy issues, concentrate on the activities of the OGAC whose deliberations will be included in a policy handbook. The first activities of the OGAC were to define the responsibilities of each person or entity in the networking chain of relationships. It identified four roles: Central Coordinator, Supplier, Distributor and User (See Figure 1).

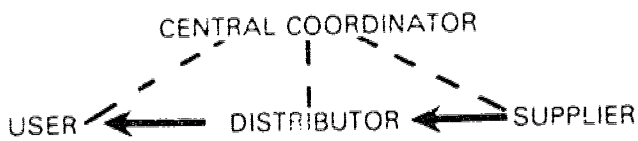

FIGURE 1 — Networking Chain of Relationships

The arrows indicate the direction of computer services. The user is the *end* user [illegible]s in direct contact with the distributor, which may be his local campus computer center. The supplier is the site of the hardware [illegible] software being provided.

The committee next identified eight areas where responsibilities might exist [illegible]y include:

- Network management
- Provision of computer power
- Network operation and maintenance
- Accounting and validation
- User services
- Marketing
- Coordinating
- Extra network activity

The next step was to devise a matrix of responsibilities, with entries for most of the eight areas. For example (since the full 4 x 4 x 8 matrix is too large to include in detail) the responsibilities of a *supplier* to a *distributor* in the area of *user services* are to provide

- Seminars and support materials
- Consultation
- Documentation
- Training
- Other general support

Details like the amounts of these services that are obligated for various levels of support will be specified by the OGAC in further deliberations.

In the *resource chaining* model, NERComP is concerned primarily with the supplier-distributor relationship. Contracts that specify obligations are now in preparation by the OGAC for NERComP / supplier and NERComP/distributor

The details of the user distributor relationship will be determined on a case by case basis. Many users are currently served by NERComP member suppliers, and their present policies will carry over into the future. Only one requirement is common to all user distributor relationships. Every end user must be a NERComP member (if an institution), or be on the staff at a member institution.

Users do have responsibilities, however. In addition to paying their network dues, they should participate in user group activities and refrain from dealing directly with anyone except their own distributor.

Some of the principles which the OGAC has developed are

- Only distributors can authorize network access
- Distributors assume financial responsibilities for their users
- A usage recovery pool should exist.
- Charges should be independent of network access point
- Suppliers are responsible for [illegible]ing and reporting usage

The OGAC continues to work on rate structures, contracts, and to recommend ways to support the network initially while traffic is lower.

In the related user services area, the USAC has developed standard forms for suppliers to use in describing their software offerings. Items covered include

- Software item description
- Training aids and support
- Documentation
- Consultation
- Level of Maintenance

Unanswered Questions

While progress has been made and continues to be made, even in advance of true network operation, there are a number of important questions not yet answered. Some answers will have to wait until several years of operating experience have accumulated, but others can be addressed now.

What organizational structure best suits the networking goals in a region? NERComP is a non-profit, tax exempt corporation with institutions as its members. It has trustees, an annual meeting of institutional representatives, and several advisory committees. Is this the best structure?

How can financial viability be provided to the central networking organization? If it controls the network medium, it can support its activities by extracting a tax on revenue. If it does *not* control the network medium, the central networking organization must depend upon its members honoring certain agreements of support. Further, how does the networking organization obtain capital funds?

How should network offerings be determined? Initially the network will offer whatever is available. Later it will have to face such issues as how to evaluate quality, whether to establish quality limits; consumer protection; how to decide on new services; how much to be influenced by members' wish lists; and whether to join outside networks.

How should software services be stablized? What procedures are to used for making changes in software? How far should the supplier go to insure that a particular system always works? Obviously, suppliers will have to make long range committments regarding stability, availability, reliability, and so on. But what are the definitions and limits on these? With most computer applications users need assurances of stability. It takes several years for a new product to catch on.

Clearly some form of contract to insure a reliable revenue flow is highly desirable for planning purposes. But how stringent need they be? Do we anticipate a large number of users? Do we encourage long range contracts at lower cost?

Once a network is running smoothly within a region, how is the network protected from its members bypassing their network connection and seeking bilateral arrangements? In some cases, members may be able to optimize locally in this way, but only to the long range detriment of the network organization and to the region as a whole. As James Emery put it, "How do we charge for facilitating sevices? Dues? Taxes?"

How far will individual institutions go in entering agreements? If there are cash flow problems, how will institutions deal with accounts receivable? If they make concessions what will they want in return? And how much direct control of resources and billing procedures will member institutions insist upon?

How does a network organization reconcile differences between institutions with respect to charging, use of certain proprietary materials, problems or perceived problems with inconsistent auditing practices? The list of problems and potential problems is long.

Regarding the Future

I hesitate to predict 15 - 20% of campus computer center work processed through networking in the 3 - 5 year time period immediately ahead as Joe Wyatt does. I would be extremely pleased at - 10% taking place on networks. Even this modest amount should have a profound effect on the quality of instruction and research. Above that there is the chance of serendipitous events. Perhaps successful networking can be a force to counter the almost Luddite attitude toward educational technology now common in the agencies of the Federal Government.

References

1. Cornew and Morse, "Distributive Computer Networking: Making It Work on a Regional Basis," *Science*, Vol. 189, No. 4202, 15 August 1975, pp. 523 - 531.
2. Greenberger, et al, eds., *Networks for Research and Education*, (MIT Press, Cambridge, MA.) 1974.
3. Kurtz, T.E., "The NERComP Network," in *Networks for Research and Education*, Greenberger, et al, eds., (MIT Press, Cambridge, MA.) 1974, p. 282.
4. ———, "Regional Networks as a Basis for National Nets, *Planning for National Networking*," (EDUCOM, Princeton, NJ) 1973, p. 111 - 115.
5. ——— "Regional Networks and Instruction," *Networks for Higher Education* (EDUCOM, Princeton, NJ) 1972, p. 70 - 75.

CHAPTER 8

by W. E. Walden

Statewide Sharing Experiences In Washington State Higher Education

Introduction

This paper is restr[illegible]ed to statewide hardware and software resource sharing as it relate[illegible] Higher Education in the [illegible]shington. Although a cons[illegible]rable amount of resource sh[illegible] between Higher Educa[illegible]nd State Agencies, and betwe[illegible]ate Agencies, these activiti[illegible]not described here. Since the sharing of computer related reso[illegible] the State of Washington is somewhat confusing to insiders, it [illegible] quite baffling to outsiders. Many diverse act[illegible]es are going on [illegible] yet Higher Education seems to be slowly developing a sense of dire[illegible]tion rel[illegible]ive to statewide sharing of computer related resources

For a very brief description of Higher Education in the State of Washington refer to Figure 1. In Washington there are two universities,

Institutions	Location	Enrollment
University of Washington	Seattle	34,504
Washington State University	Pullman	15,613
Central Wash. State College	Ellensburg	6,965
Eastern Wash. State College	Cheney	6,390
The Evergreen State College	Olympia	2,446
Western Wash. State College	Bellingham	8,601
Community Colleges *Twenty-seven, Coordinated by the State Board for Community College Education*		141,000

FIGURE 1 — Washington State Higher Education

four state colleges, and twenty seven community colleges which are coordinated by a State Board for Community College Education. Although the community colleges are located throughout the State, a majority of them lie in the densely populated Seattle-Tacoma area. Figure 2 shows the locations of the two universities and four state colleges, and the major equipment on each campus.

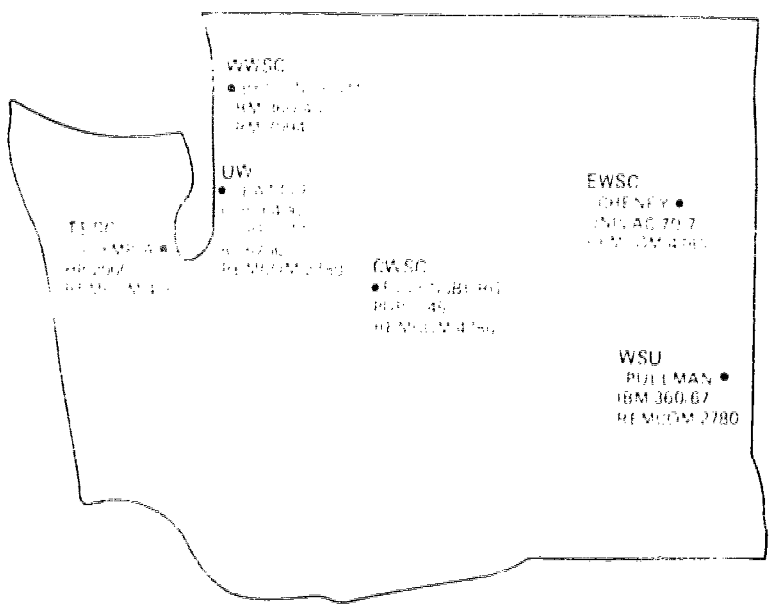

FIGURE 2 — College and University Locations and Equipment

Higher Education Computing Consortium

In January, 1975, the Higher Education Computing Consortium was formed. Despite the fact that the term Higher Education is used, this Consortium consists only of representatives from each four year college and university, primarily at the level of Vice President. Thus, the Community Colleges are not included although a representative from the State Board for Community College Education is invited to attend meetings of the Consortium Board. The group has a full-time Coordinator located in Olympia, the State Capital. Figure 3 shows the structure of the Consortium.

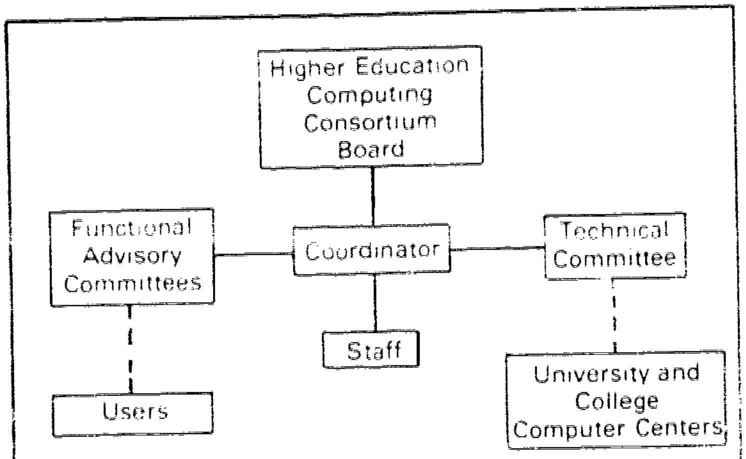

FIGURE 3 Higher Education Computing Consortium

The Higher Education Computing Consortium has developed a plan which adopts several conceptual approaches.

1. In the academic area the conceptual approach is to make a *substantially wider range of services* available to each institution by providing access to off-campus resources, as an addition to local resources, to take advantage of specialized expertise and services. In effect, a heterogeneous network would be established.

2. *Academic batch computing* will be performed at local or at major centers depending on the size of the job, and on the availability of hardware and software resources.

3. The distinction between batch and interactive is becoming blurred so that some applications may use *both batch and interactive capabilities* on the same equipment.

4. *Interactive and instructional time sharing* computing will be performed primarily on mini-computers.

5. *Secondary centers* will provide those resources (or access to resources) necessary to meet the particular needs of an institution. The resources will include systems analysts and programmers to support unique institutional requirements as well as intermediate scale hardware to provide access to a major center in support of local needs or to support other institutions.

6. *In the administrative data processing area,* the conceptual approach to providing additional resources cost effectively, involves the use of university service center computers accessed from each state

college. Each college would provide its own systems analysis and programming capability, as well as support for common systems.

Figure 4 shows the basic commitments of the colleges and universities. Figure 5 displays the amount of activity now taking place to meet these commitments.

Subject	Institution From	Institution To	Target Date
Large Academic Batch Computing	UW	WSU	9 75
	WSU	UW	9 75
	WWSC	UW WSU	9 75
	CWSC	UW WSU	6 75
	EWSC	UW WSU	7/75
	TESC	UW WSU	8 75
Administrative Data	WWSC	UW (Phase 1)	6 77
		(Phase 2)	6/79
	EWSC	[illegible] (Phase 1)	3/75
		[illegible]	6/77
	CWSC	WSU [illegible]	7/75
	TESC	WSU [illegible]	Done
Large Academic Interactive Time Sharing	WSU	EWSC	6/75
	TESC	EWSC	6 75
	WWSC	EWSC	6 75
	CWSC	UW	3 75

FIGURE 4 Basic Commitments by Colleges and Universities

Sharing through Specialized Centers

Central Washington State College has released a UNIVAC Spectra 45 computer and replaced it with a DEC PDP 11 45 minicomputer and a [illegible]COM card reader printer terminal. Both of these devices are used [illegible] to Washington State University and the University of Washington. While most of their administrative data processing is done at Washington State University, most of their academic computing is done at the University of Washington.

At Eastern Washington State College, which has been designated as a center for large interactive time-sharing, they have a UNIVAC Spectra 46 which is being replaced during October 1975 by a UNIVAC 70/7

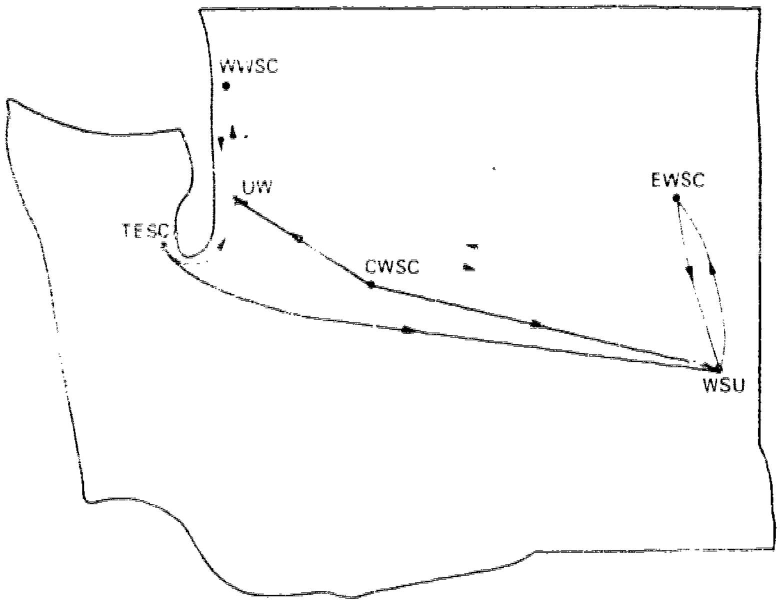

FIGURE 5 — College and University Equipment Sharing

Washington State University is acquiring its interactive services from Eastern Washington State College. In turn, Eastern Washington State College has started conversion of administrative programs and will install a REMCOM 4780 card reader/printer terminal on November 1, 1975 in order to start submitting administrative jobs to the Washington State University Center.

The Evergreen State College has a Hewlett-Packard 2000 which is used to provide interactive BASIC on campus. They do most of their administrative data processing at Washington State University by using a REMCOM 4780 card reader/printer terminal, and submit some academic jobs to the centers at Washington State University and the University of Washington.

At Western Washington State College, which has an IBM 360/40 and an IBM 7094, some users access the University of Washington academic center for large or specialized academic jobs.

Washington State University faculty and graduate students submit some jobs to the University of Washington academic computer. To date, most have run already developed programs on the CDC 6400 to avoid conversion to the IBM 360 at Washington State University. For interactive BASIC, FORTRAN, and COBOL, faculty, graduate students, and staff access the Eastern Washington State College computer center.

At the university of Washington, the Academic Computer Center has an integrated system consisting of a CDC 6400 and a CDC CYBER 73. The Administrative Computer Center has a Burroughs B6700 with two central processing units. To avoid conversion faculty and graduate students submit some jobs to Washington State University, primarily previously developed programs which run on the IBM 360. Some faculty in the Medical School also utilize CAI facilities at Western Washington State College.

Although Washington state colleges and universities have made a start toward the sharing of hardware resources, much less has been accomplished relative to common systems. To my knowledge, there is no computerized common system shared by all public colleges and universities although some bilateral transfer has occured. The Evergreen State College Financial System is installed and being used at Central Washington State College. The Washington State University Facilities Inventory System was transferred for use by The Evergreen State College, and a Research Grant Tracking System at the University of Washington has been adapted for use by Washington State University.

Community Colleges Sharing

In Washington state the community colleges have formed two consortia to utilize computing equipment located at Seattle and Spokane. The Seattle Center, with a UNIVAC 90/60, and the Spokane Center, with a UNIVAC 9480, each run two major administrative systems. The Financial Information System and the Student Information System are both on-line systems which utilize a separate Data Base Management System. Figure 6 displays the locations of community colleges accessing these two centers.

The State Board for Community College Education has developed an extensive plan for computing and data processing in the community colleges. Under the aegis of the board a number of committees address nearly every aspect of community college computing and data processing. In 1975 there appears to be good cooperation among the community colleges in implementing this plan which would have the community colleges use the Eastern Washington State College Interactive Center for interactive processing, the Washington State University Service Center for remote batch processing, and the Spokane and Seattle Centers for major common on-line systems.

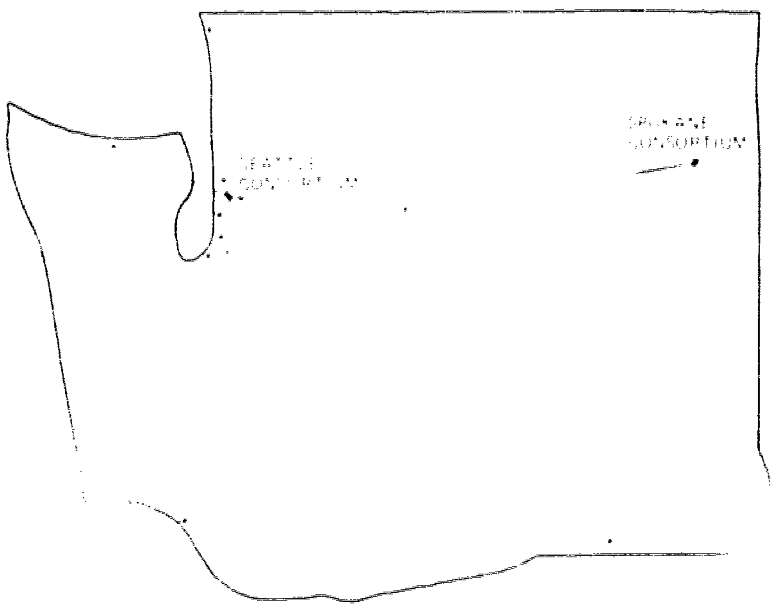

FIGURE 6 Community College Consortia Patterns of Computer Use

Cross System Resource Sharing

Some sharing does occur between the community college system and the four year colleges and universities in the state system. Nearly fourteen community colleges acquire interative BASIC from The Evergreen State College. At the same time two community colleges utilize the Eastern Washington State College Center for interactive computing, and twelve community colleges access the Washington State University center via terminals. Some of these are low-speed terminals in order to supplement their local academic computing capability. However, many of the community colleges have highspeed card reader printer terminals or mini-computers to do all batch academic and administrative processing remotely. Figure 7 displays the community college usage of colleges and universities.

As in the four year college system, a small amount of system transfer has also occurred. The Financial System of The Evergreen State College has been installed by Fort Steilacoom Community College, Olympic Community College, and Lower Columbia Community College. Fort

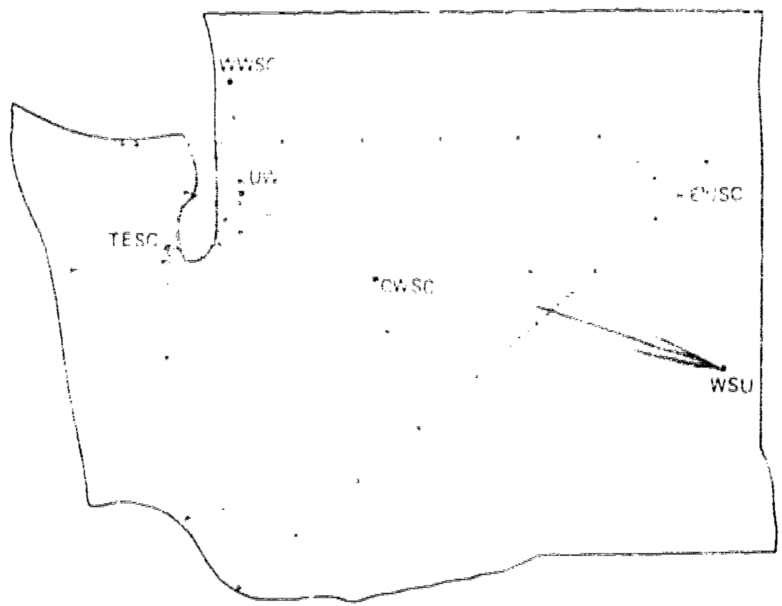

FIGURE 7 – Communit· College Use of College and University Facilities

Steila·oom Community College is using the University of Washington's system for financial modeling and forecasting

Related Statewide Systems

In the State of Washington an on line Library System is being developed for all libraries including academic libraries Planned to include bibliographic search acquisitions, and circulation subsystems for all holdings in the State Library, the University of Washington Library, and the Washington State University Library, this will be a common system for sharing resources in Higher Education, and will also be used by the state city and county libraries

A common Personnel Payroll System is also being developed for statewide use By attempting to incorporate the requirements of all state agencies and institutions into the new system, state designers may not be able to develop a system which will be acceptable to institutions of higher education However, fewer systems will be in operation than at present Higher Education may well be using one, or at most two version of the system now being developed

CHAPTER 9

by Melvin P. Peisakoff

Experiences in State-Wide Sharing In California — The University of California

Introduction

The California Master Plan for Higher Education, adopted in 1959, assigned specialized functions to each of the three segments of higher education in the state. The University of California would emphasize graduate and professional education, research, and medicine and law, in addition to an appropriate undergraduate program. The state colleges (now the California State University and Colleges) would emphasize undergraduate and master's level education, with a limited graduate operation. the community colleges would provide vocational programs for those who did not wish to go further, and preparatory programs for those who wished to continue their higher education.

Each of the segments has developed an organizational structure and supportive activities appropriate to its functions. As a consequence, the computing activities of each segment have significant dissimilarities relative to the activities of the others. This paper reviews the approach to computing within the University of California. This may be compared with the approach within California State University and Colleges described by Dr. Baker in his paper which appears in this volume as chapter 10.

Computing Within The University

Within the University, past emphasis has been on campus computer centers supplemented as necessary by specialized computer facilities. Intercampus sharing of computing capabilities has been relatively minor. In contrast, future emphasis is expected to be on networking to more fully share existing and new capabilities, and on more and smaller minicomputers to take advantage of the substantial advances in cost effectiveness which are occurring at this end of the computer scale. This new emphasis is reflected in a statement of *Goals, Policies, and Plan of Implementation for Computing in the University of California* adopted in late 1975. This paper describes some of the background and ideas on which the University statement is based.

Governance of computing in the University, as in most activities, is shared by Systemwide Administration and the campuses. Specific responsibilities are assigned to the level where they are most appropriately carried out to support the goals of the University. At the systemwide level there is a Computer Policy Board which advises the President on all policy matters concerning computing in the University. The Board is composed of a senior operating official from each campus, Lawrence Berkeley Laboratory, Lawrence Livermore Laboratory, the Chairman of the Academic Senate Committee on Computer Policy, the Vice President — Business and Finance, and the Executive Director of Computing. The two California ERDA laboratories are represented because of the significant interaction in computing, both current and proposed, between the campuses and the laboratories which are operated by the University for ERDA. As the President establishes computer policies, the Board is responsible for monitoring their operation and providing advice on necessary changes. The Executive Director of Computing is responsible for implementing Presidential computer policies at the system wide level. His office also provides staff support to the Board. Each campus also has an advisory mechanism to advise its Chancellor, and the campus computer center director, on campus computing matters, and to provide an effective interface for implementing systemwide policies and standards on the campus.

Proposals for large equipment and software acquisitions (those over $100,000 in cost) are reviewed and approved at the systemwide level in addition to required campus level actions. All computing in the University is surveyed annually by the Executive Director of Computing. Based on that survey and on interim equipment change proposals, the Board reviews not only the appropriateness of equipment, efficiency of operations, and adequacy of service, but also considers and recommends assignment of responsibility for providing required services.

The available organizational options include the following:

- *Campus Computer Centers* which report to campus management and provide services primarily to a single campus. They provide services to other campuses either on an "as required, as available" basis, or under a charter obtained from the Computer Policy Board specifying terms and conditions of certain services to be offered on a systemwide basis, available to all University users regardless of location without price or service discrimination.
- *Systemwide Computer Centers* which provide services on a systemwide basis.
- *Specialized Computer Facilities* which perform specialized

services for a limited class of users. Examples of specialized computing facilities include not only computers associated with academic departments, research units, and projects, but also larger facilities such as those at the University hospitals and Systemwide Administration.

- *Laboratory Computer Centers* at the ERDA laboratories which are available to campus users under specific terms and conditions mutually developed by ERDA, laboratory management, and Systemwide Administration.

The University currently has approximately 460 computers on its nine campuses and in Systemwide Administration representing annual expenditures of approximately $2.1 million including an allowance for equipment amortization. This does not include the ERDA laboratory computers. Approximately 55% of University expenditures for computing are incurred at the campus computer centers and Systemwide Administrative Data Processing (ADP) computer facilities. The remaining 45% are expenditures for use of other specialized computers. Functionally, approximately 15% of the total expenditures are for instructional computing, 25% for systemwide and campus administrative computing, and 60% for research. Intercampus use represents about 3% of campus computer center revenues. In addition to ERDA work run on the laboratory computers by campus personnel with a joint appointment, approximately $650,000 of other campus computing is run annually at the laboratories.

The main computers at the campus and ADP centers are listed in Figure 1.

Location	Computer
Berkeley	CDC 6400
Davis	Burroughs B6700
Irvine	Xerox Sigma 7, DEC PDP-10
Los Angeles	IBM 360/91
Riverside	IBM 360/50
San Diego	Burroughs B6700, CDC 3600
San Francisco	IBM 360/50
Santa Barbara	IBM 360/75
Santa Cruz	IBM 360/40
Systemwide ADP	IBM 360/65, IBM 360/40

FIGURE 1 — Main Campus and Systemwide Computers at The University of California, 1975

The main computers at the ERDA labs are all CDC. Computers available at Lawrence Berkeley Laboratory, Lawrence Livermore Laboratory and Los Alamos Scientific Laboratory are listed in Figure 2.

Labs	CDC Computers 6600	7600	Cyber 73	Cyber 76	STAR
LBL	1	1	—	—	—
LLL	1	3	1	1	2
LASL	2	3	2	1	—

FIGURE 2 —Computers at University of California ERDA Laboratories.

The University's computing plans recognize the increasing importance of networking and minicomputers the former as a means of utilizing and sharing current facilities, both intramurally and extramurally, and the latter as a means of capitalizing on technological advances.

Data Communications

Data communications in the University are carried out in the context of other University communications requirements, particularly for telephone and television traffic. The Intercampus Telephone System which connects all campuses, Systemwide Administration offices, and other selected locations via dial-up is currently available for data communications, as well as voice traffic. The public telephone system is available as back-up and for off-network connections. In addition, there are specific leased lines dedicated to data communications including a 50KB wide band line between the North and South Administrative Data Processing Centers and ten additional intercampus narrow band leased lines. It is expected that the number of dedicated lines will increase as intercenter usage, both interactive and batch, grows. Such increase will be significant in all application areas: instructional, research, and administrative. However, from the standpoint of bandwidth, the most dramatic future increase in requirements will probably arise from traffic generated by shared administrative data bases throughout the University. Consideration will be given to implementing a University microwave network multiplexed to accommodate some combination of data, voice, and television traffic. Packet-switching will be considered in lieu of multiplexed circuits for narrow bandwidth inter-campus data traffic if service becomes available which is more cost-effective and more transparent to both host and user than currently available packet-switching services. One such possibility may be the ATSS-DS network being developed by PT&T for the California Department of General Services, Communications Division.

In addition to its internal data communications capabilities, the University plans to participate in EDUNET as both a user and supplier, as well as to continue to participate in ARPANET. Extramural dialup traffic on the telephone and value-added networks also will continue at a level commensurate with requirements.

Minicomputers

In 1975 approximately 87% of the University's computers cost under $100,000. Their associated annual costs represent approximately 26% of the total annual costs for all computers. As the cost of minicomputers decreases, they are becoming cost-effective for many computer applications in the University that previously were appropriate only for multiprogrammed large computers. This is, of course, not foreseen for all applications. For example, large data bases and extensive analytic calculations will generally not be appropriate for minicomputers. Nevertheless, it is expected that an increasing portion of the University's computing will be done on minicomputers. Many of these will be portable computers, some costing as little as $5,000 to $10,000 each in quantity purchases, but capable enough for many instructional, research, laboratory, and administrative applications. These "personal" minicomputers will also serve as interactive and batch terminals for accessing larger minicomputers and the computer centers, and are expected to exert a strong influence on the future structure of computing in the University.

Systemwide standards for future minicomputer acquisitions will stress software compatibility and sharing, fast and low cost maintenance, flexibility for terminal use, and transferability among users. While there will be substantial operational and cost advantages associated with standardized systems, in the University environment it is especially important that standards not preclude use of more cost-effective or necessary systems for particular applications, including providing varied instructional, research, and operational experience with different computers. Some of the campuses are expected to maintain pools of minicomputers for short-term loan to users and for recirculating items no longer required by their previous users. The first systemwide contracts for standardized systems are expected to be negotiated during FY 1976-77 based on industry replies to a request for information to be put out by the University in 1976.

Additional factors in the University's approach to minicomputers are described in detail by Dr. Newton in Chapter 5.

The University's evolving computing policies place it in a posture to capitalize on the opportunities presented by minicomputers and networking. Funds are allocated to individual campuses, and each Chancellor, in turn, allocates them within the campus. Users then seek the most effective source of supply. Embargoes are discouraged as a matter of policy, and sharing of resources is encouraged. These policies, in the context of increased availability of minicomputers and networking, should have a substantial impact on the role of each computer center. Computer centers normally recharge their services on a full cost recovery, services-rendered basis. Therefore, if income and expenses are to balance, each center must specialize in what it does well and be sized to the requirements for those services. As this occurs, the role of the minicomputer and the network will be further enhanced.

In order to avoid a conflict of interest, it is especially important that a center director's performance be evaluated not only on the efficient operation of the campus computer center, but more importantly, on how well the campus' overall computing requirements are satisfied from available sources with available funds. A center director should not only be charged with the efficient operation of an on-going enterprise, but should be expected to recommend and arrange for other, sometimes competing, sources of computing from among other centers or minicomputers. As campus computer center directors step into this broader role, it is expected that they will perceive the new framework as a welcome opportunity. A positive supportive attitude by all participants, including users, as well as directors and their staff, is a key element in maximizing the benefits afforded by the evolving changes

CHAPTER 10

by LAURENCE H. BAKER

CSUC Computer Resource Alternatives

Background

The California Administrative Code states.

> 'The primary function of the California State University and Colleges (CSUC) is the provision of instruction for undergraduate students and graduate students through the Master's degree, in the liberal arts and sciences, in applied fields and the professions, including the teaching profession.'

The California State University and Colleges which includes nineteen campuses distributed over one thousand miles and a central administration, is governed by a Board of Trustees. In 1975 there are over 290,000 students enrolled and close to 20,000 faculty.

During the 1974-75 academic year, The California State University and Colleges graduated 48,000 students and awarded 8,708 Masters' degrees. During the same period, the University enrolled 225,797 (FTE) undergraduates and 39,319 graduate students. Six degree programs involving 73,762 students require particularly heavy computing support. In addition, faculty has determined that all majors in the following degree programs require considerable computer skills.

- *Business Management* (15,725 students) 66% moderate exposure, 34% intensive exposure.
- *Computer Science* (1,275 students) 100% extensive and intensive exposure.
- *Engineering* (11,985 students) 30% moderate exposure, 70% intensive exposure.
- *Mathematics* (4,831 students) 28% moderate exposure, 60% intensive exposure.
- *Physical Sciences* (5,489 students) 33% moderate exposure 58% intensive exposure.

- *Social Sciences* (34,448 students) 56% moderate exposure 17% intensive exposure

In nearly all other areas of the University some degree of computer utilization is essential for some students in order to be trained in the appropriate tools of their academic major. For example, 60% of the education population (36,407 students), require some exposure to the computer, while 9% require intensive computer training.

As agreed upon by both faculty and administration, the role of computing in The California State University and Colleges is to satisfy the instructional requirements described and to support those kinds of administrative processing necessary to properly manage the individual campuses and the system.

It is fully recognized that increasing enrollment in disciplines requiring intensive computing support and increasing computer usage in most every other academic discipline (e.g., Biology, Agriculture, Graphic Communications and Urban Planning) will result in rapidly increasing demands upon our computing resources. Although we will provide the tools necessary to support quality and competitive education, we do not intend to be at the forefront of information processing technology and affect the state of the art in this field. The Office of Information Systems will select these ways of satisfying our computing requirements which are most cost-effective consistent with reasonable service to our users.

Strategy for Exploring Resource Alternatives

The central administration includes a Division of Information Systems (DIS) charged with coordinating budget preparation, policy and procurement concerns relative to computing. This division interfaces with the community of users in the CSUC which can be classified in four groups:

- Instructional Faculty
- Academic Administration
- General Administration
- Faculty Research

Through an advisory committee which includes campus representatives from these groups as well as campus computer center directors, policy changes, budget recommendations and procurement plans are reviewed. In addition, a variety of informal communications exist with each group; individual contacts, special interest groups, ad hoc committees formed to satisfy specific functions, and user surveys designed to examine trends in user requirements.

Representatives from each group play an important role in helping define and quantify short- and long-run systemwide computing requirements. For example, as a result of cooperative efforts by campus representatives and the Division of Information Systems, we have a planning model to project instructional computing workload. Using the model, instructional computing workload is projected as a function of number of students by major, computing skill levels expected by major, and number of problems required of a student in order to reach a specified skill level.

To augment this model, the Division has also surveyed a cross section of employers in California to get an estimate of their needs for manpower in computer related skills.

The Division of Information Systems has taken three steps to be sure we have considered all the alternative ways of satisfying CSUC computing requirements.

First a document describing existing computing facilities and present and projected demand for computing support was released to computer vendors with a request for information. Each vendor was asked to describe how CSUC should satisfy projected computing requirements. This request motivated vendor interest.

Second, a draft of the Electronic Data Processing (EDP) Master Plan was released to campuses asking for their comments. Responding to proposed plans and priorities, campus replies outlined concerns, and made alternative suggestions and proposals for changes in priorities.

Finally, CSUC became a member of the EDUCOM Planning Council on Computing in Education and Research.

As a result of these exercises, the alternatives CSUC has considered include:

- *One large general purpose consolidated computing facility* serving all instructional and administrative users via a Communications Network.
- *A distributed general purpose network* of campus and one systemwide data center supported by a communications facility.
- *Eight limited general purpose regional centers* supporting two or three campuses each.
- *Decentralized general purpose campus centers.*
- *A distributed hierarchical network* of campus and systemwide data centers including a hierarchy of computing resources supported by a communications facility.
- *Commercial services* to support specialized requirements.
- *Contract services* from other universities.

General cost categories have been included where alternatives are considered: hardware, software and maintenance; communications; personnel; site; travel; and utilities.

The levels of computing hardware resources considered have included

- Large general purpose systems
- Medium scale systems designed to support general purpose but more specialized operations. (e.g., Batch and on-line systems as distinct from timesharing).
- Medium-to-large minicomputers
- Intelligent terminals and personal computers (microcomputers and minicomputers).

Effect of Institution Size on Strategy

After extensive consultation the CSUC Division of Information Systems develops objective specifications and contract terms and conditions for all systems and services to be obtained. Because the practice is required by law, all systems and services are procured on a competitive bid basis. This practice has some desirable features, the most important of which is cost savings. In addition, through this practice industry has at times been motivated to consider changes to meet CSUC requirements.

Although most smaller institutions are not devoting the same resources toward planning and management functions, many smaller institutions may still be able to benefit from paying more attention to these areas. Smaller colleges and universities may also find substantial benefit in the discounts for computing equipment and consulting support now available through EDUCOM.

Institution Policies Affected by New Resources

In The California State University and Colleges, all program areas contend for limited dollars. The desirability of improving budget support for computing is considered along with requests for improvement in all areas. Through consultation with the Presidents of all nineteen campuses, priorities for program improvements are identified which then must be supported before the Board of Trustees, state agencies and the state legislature to obtain improved levels of financial support.

I believe that the majority of CSUC requirements can be satisfied by a hierarchy of computing resources internal to the system. At the same time it may be desirable to satisfy spe ..ized administrative or instructional requirements through contracts with commercial services, other universities or consortia designed to offer specific services. Such specialized requirements include:

- A Financial Aid billing and collection service
- Shared library cataloging
- Access to diverse vendor hardware and software not installed.

Some policies concerning computing in The California State University and Colleges may have to be changed to make it possible to consider these alternatives. Steps are being taken to enable CSUC users to access specialized computing services and to make the hierarchy of computing resources within The California State University and Colleges available beyond institutional boundaries.

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APPENDIX B

Conference Workshops

1. The impact of advances in computer and communications technology
David Winkel, director of Computer Services, University of Wyoming
Development of themes raised in Session II. Informal discussion with emphasis on experience at the University of Wyoming and institutions represented by registrants

2. Management and policy issues in distributed computing
Carol Newton, Associate Director Health Sciences Computation Facility
University of California, Los Angeles

Clinton DeGabrielle, Executive Director Washington State Data Processing Authority
Development of themes raised in Session III with emphasis on experience in the New England Regional Computer Network Informal Discussion to draw on the experience of registrants

3. Experience with state-wide networks
Thomas Kurtz, Director of Academic Computing, Dartmouth College
Development of themes raised in Session III with emphasis on experience in the New England Regional Computer Network Informal Discussion to draw on the experience of registrants

4. Distributed computing in health sciences and services
Don Martin, Director of Health Sciences Comp Activities
University of Washington
Special problems associated with health sciences applications for computer networks. Informal discussion of activities of the Health Education Network Users Group. Constraints of organizing to make more effective use of numerous mini-computers on campus

5. Distributed computing in administration services
Alan L. Eliason, Director, Computer Center, University of Oregon

John Gwynn, Manager Data Processing, University of Wyoming

Michael A. Jennings, Director, Administrative Systems
Oregon State System of Higher Education
Implementing distributed administrative computing in a university setting with emphasis on changing requirements, concepts and results. Computer technology presently features an adaptive approach to administrative computing. Informal discussion

6. Mini to maxi computer networks
Art Pohm, Professor of Electrical Engineering, Iowa State University

James W. Fryklund, Manager of Systems Hardware Computer Center
Oregon State University

Lee Shope, Manager of Developmental Projects, Computing Center
University of Iowa
Building a network of computer communications to draw on the strengths of mini-computers located in specific departments and large scale central computers. Organization, economic, and political problems to be overcome. Emphasis on experience in Iowa and Oregon

7. Bibliographic resources
Ralph Franklin, Bibliographic Systems Consultant
Washington State Library
A description of the plans in progress on the Washington State Library Automation Project. Informal discussion of these plans and progress on other library bibliographic automation approaches

8. Discipline-oriented computer network users groups
Richard Hughes
Professor of Chemical Engineering
University of Wisconsin, Madison
CACHE (Computer Aids for Chemical Engineering Education) Committee experience utilizing the United Computing System Network for sharing computer software. Twenty-five schools have participated in using the FLOWTRAN program during the Spring of 1975. This experience will be compared with that of other user groups

Informal reports of these workshops were prepared following the conference. Copies of the reports are available from the EDUCOM office, P.O. Box 364, Princeton, New Jersey 08540 at the cost of reproduction (10¢ per page) and postage. Report length ranges from 3 to 8 pages.