The economic impact of network affiliation upon institutions of higher learning

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INTRODUCTION

Educational and research institutions are increasingly becoming concerned with determining the best means by which their computing requirements can be satisfied, since these needs are becoming increasingly varied and are continuing to expand. Simply installing more processor power is no longer a solution. More types of software support, ranging from languages to specialized applications packages, are needed. Various types of data bases must be made available. Each of these entails the development of the necessary facilities as well as continuing maintenance. While technological developments are continuing to reduce the cost of raw computing power, the cost of software is continuing to rise relentlessly. Accordingly, it is becoming economically impossible for many institutions to support the breadth and variety of software that their users desire.

One oft-talked-about solution to these growing problems is the computer network. For example, by linking institutions together it would be possible to share the development and maintenance costs of software and specialized data bases over a much broader user base. Clearly, it is unlikely that there would always be a nice fit between the services economically supplied locally and the services available over a network. On the other hand, it is clear that a national educational and research computing network would contribute toward the solution of the escalating support costs being encountered. It would also address the problem of nonlocal availability of unique or specialized resources.

There are obviously drawbacks to such a national network. Yet, the potential is so great that considerable interest exists. For example, EDUCOM (a consortium consisting of more than 250 colleges, universities, and nonprofit organizations and dedicated to helping its members make the most effective use of computer and communications technology), with the financial support of the National Science Foundation, organized a series of General Working Seminars on the subject of computer networking in higher education and research. Invited participants were drawn from the ranks of university administrators, computer center directors, users from key disciplines, and computer scientists.

The results of the General Working Seminars have been set forth in a very readable book\(^1\) and shall not be repeated here. However, a general observation concerning the participants' conclusions is pertinent. Regardless of their professional role, all participants agreed that it is now technically feasible to create a national network linking computer facilities at colleges, universities, and research institutions. While technological problems do remain to be overcome, these were viewed as minor in relation to the non-technical difficulties confronting such a network, difficulties involving economic, political, and organizational considerations. Accordingly, it was believed critical to obtain a clear understanding of these factors before embarking upon any large-scale network development.

A variety of projects have been conducted to examine various aspects of networking. For example, a study by Weingarten, Nielsen, Whiteley and Weeg\(^2\) examined the effects which the National Science Foundation's Regional Networking programs have had upon institutional computing activities. Berg\(^3\) has examined the exchange of computing services in relation to comparative advantage and international trade concepts from economics. Heller\(^4\) studied the relative price differentials between institutions for processing different types of standardized jobs. This represents an empirical study of the comparative cost advantages of different computing facilities, independent of the advantages of greater service offering availability.

No one project, however, has taken a comprehensive look at the overall impact of a national network linking institutions of higher education and research. The concerns voiced at the General Working Seminars, coupled with the networking interests of many institutions, led to the formation of a comprehensive three-year investigatory project funded by the NSF and conducted by EDUCOM.

Experimentation on a national basis with a prototype network was rejected for a number of reasons. Such an effort would be very costly, would severely restrict the alternatives that could be investigated, would disrupt the normal operations of the affiliated institutions, and would require a significant commitment of energy and personal time from many key individuals.

Accordingly, a simulation approach was taken to investigate the non-technical issues confronting a national edu-
cation and research computing network. This paper reports upon just one aspect of the overall study, namely the economic impact which affiliation with such a network might have upon member institutions.

THE NETWORK SIMULATION PROJECT

The network simulation project conducted by EDUCOM was divided into three phases. The first phase consisted of basic data collection. Eighteen education and research institutions participated in the project, each contributing a voluminous amount of data with respect to the computing resources which they maintained and operated (hardware and software facilities), as well as data with respect to current operations (pricing schedules, priorities, demand levels by service type, and turnaround times as a function of demand levels). In addition, data was collected on user profiles. A network simulation model to operate upon this data was constructed. The results of this project phase have been reported previously.

Phase two expanded and updated the accumulated data base. Visiting teams interviewed administrators, users, and computer center personnel at each institution. Computing policies, practices, and decision rules, as well as institutional computing goals, were deduced from the interview data, confirmed with each institution, and added to the data base.

Phase three enhanced the basic simulation model, so that it could be operated in three modes:

- As a basic simulation model, with all decisions at each institution being reflected by programmed decision rules.
- As a "straw network" game, with the player making decisions for his institution but with pre-programmed decision rules making all other decisions.
- As a full network game, with all decisions being made in parallel by institutional representatives.

The basic simulation model was used to investigate a number of issues such as network stability to induced shocks; traffic flows as a function of price, service levels, and policy decisions; and migration and usage patterns. The straw network game was used by each of the participating institutions to learn about the possible effects of network membership and to experiment with alternative policy decisions. The full game was employed during a three-day session held at EDUCOM with representatives attending from each of the participating institutions. In addition, these attendees participated in a number of workshops. Project findings are summarized in Reference 12.

Although institutions have a variety of reasons for seeking to join and participate in a national computer network, all share a common concern—namely, the likely economic impact of participation. Economics is the glue that binds all portions of the institution together, and the economic impact of national network membership is something that would be felt indirectly if not directly by all members of the institution. Accordingly, it is important to consider in some detail the possible economic consequences of network membership.

CASH FLOWS

When "cash flow" is mentioned in connection with a network, the associated thought is often "unplanned cash flow imbalances." It is very likely that there will be a net cash flow (either inflow or outflow) between any one institution and the other institutions on the network, for it is very unlikely that an institution's exports of computing services would exactly match its imports. Further, because of the variations in demand and supply, the net cash flows are very likely to differ from the desired or budgeted level.

Cash flow imbalances

Whether a net cash flow will or will not pose a problem for a specific institution is a function of three characteristics—the size of the net cash flow (relative to the total computing budget and to the budgeted level of net cash flow for that institution), the size of the cash inflow and outflow individually relative to the total computing budget, and the rate at which the magnitude of the net cash flow is changing.

Relative size of net cash flow

A net cash inflow or outflow will have little impact if it totals only a small percentage of an institution's total computing expenditures or of an institution's budgeted level of net cash flow. An institution may plan to run a small surplus to relieve budget problems or to run a large deficit because it chooses to purchase services externally rather than maintaining a larger on-campus computing capacity. In either case, so long as the difference between planned and actual is relatively small, the net cash inflow or outflow is not likely to impact the institution significantly.

A large net cash flow, relative to budget, may have a significant impact. If steps were not taken to increase (decrease) capacity or to restrict the purchase (sale) of services, there would necessarily be an effect upon an institution. An unexpected net cash outflow would require funds to be diverted from other activities or would require deficit financing on the part of the institution. An unexpected net cash inflow may be used to support other activities (or it may by law flow to another organization, e.g., the state treasurer). It may also impact the service received by internal computer users and may cause other side effects (e.g., tax implications, violation of restrictions on unrelated income or source of income).

Size of the cash flow components

Independent of whether cash inflows match cash outflows, there should be a concern for the size of the cash inflows and outflows relative to the institution's overall com-
puting expenditures. For example, a high level of external service purchases should raise questions concerning continued availability of these services to the institution’s members and the possibility of negotiating volume discounts from volume suppliers. On the other hand, a high level of sales to external users should raise questions concerning the likelihood of continued demand for these services. In either case there should be a concern about possible contractual arrangements, quantity discounts, volume guarantees, and the like. The sudden termination of a major supply source could seriously impact the continuation of the users’ educational and research computing while the termination of a major demand source could remove revenue needed to support relatively high fixed costs of the computing facility. In either case, there is a potentially significant economic impact upon the institution, and the risk must be recognized and dealt with accordingly.

However, unless an institution happens to offer a very popular specialized service, it is expected that the cash flows will be relatively small. Even in those cases where the cash flow is intended to be relatively large, there are mechanisms to protect against the increased risk. Thus, risks previously described should not discourage economically sound arrangements. It is just that the importance of proper contractual arrangements to protect the interests of both buyer and seller becomes much greater in these circumstances.

Rate of change of net cash flow

The fixed costs associated with the operation of a computing facility are relatively large. Thus, in the short run, a rapid change toward greater cash inflow would result in deteriorating service or response time, while a change toward lesser cash inflow would result in operational losses (or reduced surpluses) with such budgetary shortfalls having to be met with other institutional funds. Because of the relative inflexibility of short term cost/capacity adjustments in a computing facility, a rapid change in net cash flow can have potentially serious consequences.

On the other hand, more slowly evolving changes offer the potential for lesser impact, since there is more time for the institution to make appropriate adjustments in purchase/supply levels.

Areas improved by differential cash flows

There are a number of impacts which may stem from the above-described factors. These impacts are controllable in the sense that cash flows can be controlled with management attention. The key is to make sure that proper and timely control is exercised.

Minimum acceptable central facility

Most institutions feel for reasons of control, local service, prestige, and so forth that there is a minimum size and capability level below which they would not want to reduce their central computing facility. (Often, this minimum size is not very far below current capacity.) Such a capacity floor introduces a number of complications into network membership.

For example, the existence of a minimum capacity target implies that the central facility should operate at greater than or equal to the specified minimum capacity. Otherwise, the institution would be paying more than it should for computing, representing a direct drain on the institution’s budget. The only alternative to an outright subsidy (paying for the operating deficit) is to attempt to increase net income through price adjustments. However, higher prices may encourage additional business to flow to the network (thereby decreasing revenues and requiring that prices be raised again in a continuing cycle) and lower prices may not generate sufficient additional demand to overcome the reduced revenue from existing business.

A minimum capacity level may also result in a number of institutional goals being overridden. For example, an institution may desire to provide its entire user community with ready access to a national network so as to enhance the effectiveness of teaching and research. However, if this results in insufficient business being directed to the institution’s own computing facility, then pressures will develop to restrict network access. Network access may be rationed, outside usage may be taxed (to make internal use look economically more attractive to the user), or network use may be prohibited for certain types of computing (or for certain types of users such as students).

Hard versus soft funding for computer services

Many institutions fund internal computing with so-called soft money. That is, the institution directly supports the computing facility’s budget and then allocates or rations usage by distributing time or “funny money” credits to users. The “funds” so distributed to users have no value for anything other than local computing, hence the term “soft.” In contrast, all network computing will involve “hard” or real dollar expenditures. Thus, institutions must find additional hard money to fund those network services that are utilized, as additional cash outflows will be triggered.

The funds to support network usage may come from four sources. They may come from hard dollars earned from the sale of computing services to the network (analogous to earning foreign exchange in international trade), or they may come from a reduction in support for the institution’s own computing facility. Additional hard funding may be obtained from reductions in other programs or activities at the institution, or it may be obtained from new funding sources. However, in pursuing new sources of funding, network usage would potentially have to compete with all other institutional programs seeking additional funding support.

Network sales viewed as an asset exchange

An institution that is selling computer services to network users is in essence performing an asset exchange, exchang-
ing a portion of its computing facility for dollars. Whether or not this is advantageous depends upon the institution. For example, many state universities currently receive a fixed allocation from the state legislature to support computer operations; in turn, all revenues from services go to the state. Computing service sales to the network under these conditions would be disadvantageous, for the institution would essentially be losing part of its computing capability without receiving any benefit in exchange.

Revenue source

Membership in a network is often looked upon as a revenue source. There is a widespread belief that institutions can "make a profit" by selling computer services. (Clearly, not all institutions can be net sellers of services, although obviously some will be.) However, even for net sellers of service, the opportunity to generate net income is not without cost.

First, if capacity is expanded to support outside service sales, then increased capital and operating costs must be considered along with the investment risk (users may switch to another facility at a later date, leaving the institution with excess capacity). Second, if capacity is not expanded proportionately, the institution's own users will be "paying" for the outside usage in terms of longer turnaround times and increased congestion. In fact, if the institution offers a priority surcharge scheme, internal users may literally subsidize outside usage through the priority charges required to maintain the same turnaround time.

BUDGETING PROCESS

The budgeting process will also undergo change in a networking environment. At the present time most institutions make an estimate of sponsored research computing (based upon research contracts in-house and upon proposals outstanding) and an estimate of the appropriate level of educational, administrative, and unsponsored computing. These figures are compared with the budget requirements of the computing facility in order to serve the aggregate workload, and a final budget is established for each type of computing. Funds for these activities are then allocated to the prospective users, using either soft or hard dollars, depending upon the policy of the institution.

With a national networking environment, two new factors appear—use of the local computing facility by external users and use of external computing services by local users. The former is a source of hard dollars, while the latter consumes hard dollars. The budgeting process still goes through the estimation phase as before. However, estimates must also be made of external use of the local facility. This estimate is more difficult to make, since an institution will generally have little knowledge of the computing plans of external users for the forthcoming budget period. (This is another reason why service guarantee/minimum volume agreements can be advantageous.) Since less is known about the volume and timing of external demands, there is likely to be a greater error surrounding their estimate. Hence, the institution should be prepared to accept a greater shortfall of revenue or a greater excess of demand at its computing facility than customary.

The budget preparation process must also address the needs of internal users for outside services. The use of network services by internally-funded users can be tightly controlled, since the institution is in a position to dictate limits on the amounts that can be spent. The real risk arises if the institution ties the level of external use by these users to the level of service supplied to external users over too short a time span, so that fluctuations in external sales would disrupt the educational and research process.

PRICING PRESSURES

Most institutions present!y operate their computing facilities as a quasi-monopoly. A variety of constraints (both funding and administrative) are established to restrict users to the local facility. However, participation in a national network implies much greater freedom for users to move to external computing sources to satisfy their computing needs, and institutions will be subject to a number of new pressures—pressures that will constrain some of the ways in which they might seek to price their computing services.

Specialization

As one would expect, different types of computers have different relative advantages in processing a specified workload. As the study of Heller showed, no one installation was least expensive for all types of work. Each had a relative advantage for some types and a relative disadvantage for others. Thus, no matter how well an institution is operating its local computer facility, there will be external services that will likely be more cost-effective for certain types of work.

As a result there is likely to be a trend toward specialization of the services offered by different facilities. As various segments of one facility's business are drained off by other facilities having a comparative advantage, the institution is forced to compete in those areas in which it has a comparative advantage. Thus, there will be pressures to specialize. This may or may not be in keeping with the institution's objectives.

Price structure

Differences between facilities are not limited to computer power alone. Many installations operate in a bundled fashion, with service and support factored into the computer rate. Accordingly, by shopping around, a user can select one service offering good support for program development and another service offering "cheap cycles" for those occasions when turnaround and support are not important.
Thus, pressures will develop to move each member institution toward a common, unbundled pricing structure (though not toward the same prices). To the extent that an institution fails to price some component of a service, there is a significant loss potential. Business that does not take advantage of the favored resource (but pays for it) will be lost, and business that does use the favored resource (but doesn’t pay for it) will be gained. Revenue is likely to be lost, unless the institution adjusts toward an unbundled price structure. Such a change may or may not be in keeping with an installation’s operating philosophy.

Cost-recovery disparities

No two institutions are exactly alike, and their accounting systems are likely to be even more dissimilar. Thus, the costs that are included in the rate-setting process will vary. Even if two institutions have identical computing equipment, staff salaries, and rate structures, the values calculated for those rates are likely to differ due to differences in the cost bases or cost-calculation procedures used. Even among the eighteen participating institutions in this project, we found wide variations in reported costs in environments that would appear similar or comparable. Thus, many institutions are likely to feel there is “unfair competition” from institutions whose accounting systems might yield a lower cost base for budget and rate purposes.

Local service advantages

To place the previous factors in perspective, it must be remembered that every institution has many significant competitive advantages with respect to its local user population. For example, there is the general desire of users to “do it here” where things are more familiar and where they may have greater control or can obtain better responsiveness from the “establishment.” There is also the inertia factor. Computing is not a uniform commodity, and there are significant conversion barriers to switching sites and services. Consulting and other user assistance can be provided better locally. There is also a cost associated with using a network (e.g., transmission costs), so each institution can offer a built-in cost advantage to its local user community. Thus, there will always be room for an institution “to do its own thing” without fearing the immediate departure of most of its local users.

CONTRAINTS ON A FREE-MARKET NETWORK

In theory, the national network should be a competitive market place that permits competition between facilities to squeeze out operational inefficiencies and to encourage new entries when service offerings are inadequate. Users in such an environment would shop for the facility offering the greatest comparative advantage for their computing needs. As a result, more computing would be performed for the same cost, and everyone would be a winner. In practice, however, this may not happen. The stage is set, but there are a number of constraints which may preclude such competition.

Non-comparable services

Many of the computing services to be made available over the network are expected to be unique or specialized services. By their very nature these services will not be offered by many institutions. Hence, a competitive market for those services is unlikely to develop.

Legal

A variety of legal constraints, ranging from prohibitions on serving commercial organizations to prohibitions on serving out-of-state organizations, may restrict the ability of a computer facility to sell its services externally over a national network. The constraints will vary, depending upon educational discount contracts, state laws, and institutional charters.

Tax

Most educational institutions are exempted from property and income taxes with respect to their educational facilities and activities. To the degree that various taxing jurisdictions declare network service activities and revenue to be a non-educational use of facilities, an institution’s ability to participate in the network may be sharply curtailed. Whether any commercial work will be tolerated and whether the provision of services to other educational institutions will be viewed as an educational or a business enterprise will depend upon the local taxing authorities’ interpretations of their laws and regulations. However, the economic impact upon an institution could be significant, as could the constraints upon network affiliation.

Federal

An internal computing facility serving federally-funded computing users is required to share its costs fairly among the various users. There is an elaborate body of procedures associated with the definition of “fair costs.” Normally, so long as the federal government pays these “fair” rates and other users, internal or external, pay no lower rate, the institution may charge whatever rate it desires. However, will federally-funded network users from other institutions still be considered outsiders on whom surcharges may be levied, or must these users be considered part of the internal federal sharing community which must be charged the lowest rate? Also, the importing and exporting of computer services by an institution may be viewed simply as an exchange of services, in which case an institution would have to make representations to its auditors about the fair-
ness of another institution’s charges. (Under the exchange interpretation, the computing charges of the external computing facility would have to be included in the local computing facility’s cost base.)

One of the features often mentioned in connection with a national network is a provision for software royalties. This would enable the developer of a program or routine to establish a usage fee, providing an incentive to individuals to develop and share high quality software. It is anticipated that an individual could specify any royalty level he wished, depending upon his perception of the quality of his work and its value to others. However, arbitrarily established surcharges for internal users are not likely to be acceptable to government auditors, and the consequences could be severe if a broad set of external users (e.g., those with federal funding) were to be considered “internal users” for rate purposes. Thus, federal regulations may have a significant impact upon one of the planned mechanisms to stimulate the development and sharing of quality software.

Loss of freedom

The decision to supply service to external users may result in a loss of freedom for the supplying institution. If the supplier were to see itself as offering a full-fledged service rather than temporarily selling excess capacity, it would lose the freedom to modify network service availability unilaterally in order to accommodate local needs.

By the same token, unless the user of an external service has some form of service availability agreement, he may be giving up control over his computing supply. Thus, some other organization, with which he is not affiliated, would have the power to change the availability or conditions of his access.

Growth

Even if an institution were able to compete freely in a national computing marketplace, there are a number of constraints upon growth (both upwards and downwards) of its computing facilities that may limit network participation.

- Institutional charter—The institution may not be able to operate an auxiliary, revenue generating enterprise, so that external business would have to be minimal.
- Desired facility size—The institution’s goals for a local facility may prevent the facility from being reduced to its economically optimal size.
- Entrepreneurial risk—The institution may not be willing to accept the entrepreneurial risk associated with installation of additional computing capacity and the sale of computing services to an external market.
- Capital investment—An institution may not be able to expand facilities to serve external users because of an inability to obtain capital funds.

EVOLUTION OF NETWORK COMPUTING FACILITIES

All of the factors discussed above appear to dictate against a significant change in the size of an institution’s computing facility. However, there are ways around these problems. The following subsections suggest ways in which network computing facilities might evolve.

Evolution of major network suppliers

The establishment of a separate, wholly-owned corporation to serve network demands (when business exceeds the institution’s growth limitations) is a likely mechanism for providing popular computer services to a national marketplace. Many institutions have indicated a desire to make their services available to other educational and research users. However, should these services prove very popular and demand exceed what can conveniently be served, we have observed a willingness of institutions to consider setting up a separate organization to serve a national network community.

This mode of network facility development has already been observed in practice. For example, library cataloging services started out as small offerings on the host institution’s computer facility. However, in the case of BALLOTS and OCLC, as the volumes of these services grew, they were spun off by their host institutions into separate service-providing organizations. Thus, the national network could evolve to a number of institutions providing minimum service volumes and a number of commercial organizations providing larger volumes of specialized services.

Evolution of major network buyers

The facility that is a successful network service buyer is likely to have evolved along one of two paths. On the one hand, it may have become a smoothly-operating, specialized facility that provides a limited range of services and imports the bulk of its requirements. The computing facility (hardware, software, and staff) would have become oriented toward providing a selective number of high quality, specialized services. Other services would be supplied to users via network purchases. The facility itself might be large or small, depending upon the volume of those specialized services it might sell to others.

On the other hand, the network buyer may have become a very small, limited computing facility. The institution may have reached this point either via a conscious decision to install limited local hardware capability, or by a decision to reduce the hardware configuration and scale of operation of an earlier facility. In either case network services would be used to enhance the breadth and cost-effectiveness of the computing services offered to the local user community.
COST CONSIDERATIONS

The availability of a wide array of computer services will have a number of cost-related impacts upon an institution and its internal user community. In particular, the benefits (costs) will accrue to (will be borne by) different portions of the institution. The following represent a sample of the considerations which an institution should evaluate in reaching a decision on network participation.

User cost savings

The previously-mentioned study by Heller⁴ indicated that the total cost to run a standard benchmark job at each of a number of institutions spanned a wide range. Variations of more than 10:1 were observed in job cost from one institution to another. This variation provides a significant opportunity for a user to 'shop around' and obtain meaningful cost savings for his particular type of work.

On the other hand, if an institution has the capability and the capacity to do the work locally but the user takes his work elsewhere for processing, the total amount spent externally will be a direct loss of income for the institution. Note that the loss to the institution will exceed the user's savings. In order to maintain the same 'net income' position, the institution must reduce the size of its own computing facility (e.g., hardware, software, staffing level reduction) and/or obtain a compensating volume of business from other external network sources. Thus, when evaluating the user benefits that might accrue, an institution must also consider the actions that it will have to take to compensate.

User cost increases

Computing is not a uniform commodity, so one cannot substitute 'Brand A' for 'Brand B' effortlessly. Therefore, in order to obtain the savings indicated by the job processing-cost differentials described above, it will be necessary for the user to investigate the relative costs and advantages/disadvantages of different facilities. In addition, when he makes a decision to use 'Facility X,' the user must learn the command language and control statements for that facility and learn to work with a remote user consulting organization.

All of these activities require an expenditure of the user's resources. The institution or the network may provide some assistance. For example, data on processing costs for common benchmark programs at all facilities might be provided, so that the user would have information on which to limit his field of investigation. However, learning to operate with a new facility is a cost the user must always bear. Even if this did not involve an accounting charge, there would still be the cost of lost time, personal effort, and energy. Thus, the potential cost savings must be reduced by these added costs.

Facility cost savings

The availability of network revenues may permit an institution's computer facility to expand to a more economic size and take advantage of economies of scale. This would permit unit cost savings to be passed on to all users, internal and external alike. Usage growth may also permit the facility to upgrade its support levels for certain services, or to support new services which were not economic at lower usage levels.

Similarly, the availability via the network of external service suppliers may also permit an institution's computer facility to obtain cost savings by not expanding (or by actually contracting) its scale of operation or its offerings. For example, a facility may be able to avoid a costly upgrade to new hardware by off-loading some of its growing local demand to outside service suppliers. Or a facility may be able to reduce its support costs by dropping services whose support is very costly or difficult to provide or whose use is infrequent. Such services can be eliminated locally, since they could still be obtained remotely via the network. Thus, a network connection offers a variety of cost saving alternatives.

Institutional benefits

The availability of specialized computer services via a network connection may enable an institution's research community to be more competitive in obtaining external research funding. That is, researchers might be able to undertake activities that had been foreclosed to them previously due to lack of proper computational facilities. Greater research breadth and facilities' availability may also enhance the institution's educational program, aid student and faculty recruitment, and enhance the institution's reputation. Further, to the degree that researchers are successful in attracting additional external research support, the indirect or overhead charges against these research contracts will make a positive contribution to the support of the institution's facilities and general operations.

PERSPECTIVES

The various types of economic impacts that have been discussed must be characterized as potential impacts; they might or might not occur. Their significance will depend upon the particular institution, the type of network, and the operating environment. However, each impact can potentially occur, so it needs to be considered explicitly.

On the other hand, reading the list of potential impacts gives an overall negative impression, for there are many things that can go wrong. Yet, many of these negative events are not likely to occur. Consider, for example, the long list of things that could go wrong with a jet airplane. Fortunately, most of the possibilities on that list never occur, and we continue to use commercial air transport safely. Therefore, let us consider what types of networking situations are
likely to occur, based upon the data provided by the participating institutions.

Initial network usage is likely to involve specialized services that are not available locally. (Such specialized services would include application packages, data bases, as well as "cheap raw cycles.") There is little expectation that major portions of an institution's internal users' workloads would be processed externally. Likewise, there is little expectation that any supplier would capture a major portion of another institution's processing load. There will, of course, be exceptions. For example, Harvard not too long ago gave up a major portion of its local computing capability, choosing to rely instead upon service purchased remotely from MIT. However, it is expected that network flows for exports and imports of computer services will be in the range of five percent to 15 percent of an institution's overall processing budget.

At this level of interaction, many of the potential funds flow problems discussed above become manageable. At worst, an institution might face a 15 percent reduction in business due to internal users going out on the network for service and no external users choosing to make use of the facility. While no one looks forward to a 15 percent budget cut, it is not likely to cause severe dislocations. The impact may be further softened, since many institution's workloads are growing and since network utilization is expected to phase in gradually.

Similarly, the other worst case (no internal users make use of network services but network users add 15 percent to the processing load on the facility) does not pose a significant danger. Most facilities either have some excess capacity available or have planned various small enhancements that will increase capacity at moderate cost. Thus, the increased demand should be accommodated without undue service deterioration, expense, or risk.

Pressures stemming from service-level comparisons (e.g., turnaround time, software quality) are likely to be present but muted due to the high conversion costs between facilities and the existence of user inertia. As long as these pressures remain moderate, they will exert a healthy influence on operations. However, unlike the other areas, this one has a much greater potential to become serious. If an institution is not operating close enough to the "customary" service levels, or if it is operating old, inefficient equipment, it might well be placed under rather severe competitive pressures.

The various constraints on a free-market network represent very real issues. Many institutions believe that these issues will not become serious so long as network business represents a "small enough" proportion of their business. On the other hand, network business amounting to 15 percent of revenues may not be "in the noise level," especially for facilities with multi-million dollar annual budgets. It is impossible to speculate as to the likely outcome. Impacts of some of these issues will depend upon the rulings and interpretations of local governmental jurisdictions; thus an inconsistent pattern of effects may be seen across the country. In other cases, similar situations have not arisen previously, so there are no precedents from which to extrapolate.

The constraints upon facility growth, while formidable sounding, are not expected to be a severe limitation on network development. Most facilities are not expected to face significant growth problems. The few that might face very high external demand levels are likely to be those with a pre-existing entrepreneurial disposition, sites that would be willing to create a new business enterprise to provide the demanded services to the network user community. This has been an observed growth pattern in university computing operations, and administrators generally expect analogous behavior in a networking situation.

The cost savings and other benefits that have been described appear for the most part to be real. That is, it appears that users will be able to gain the benefits described within the bounds of a reasonable expenditure of effort. Thus, the promise of a national network in many respects appears realizable.

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