Athena Plans

Three Year Plan for Project Athena

July 13, 1988

MISSION STATEMENT

Athena exists to create a computing environment that fosters significant and long-lasting improvement in the overall quality of education at MIT.

Commentary on Mission Statement

Athena's role is in MIT's primary educational mission, with a goal of contributing to the quality of the educational process, including instruction, research, and activities outside the laboratory and classroom. Athena is *not* an effort to reduce the amount of direct faculty/student contact, the amount of time devoted by students to learning, or an effort to reduce the overall cost of education.

The computing environment includes hardware, data communications, physical facilities, systems software, documentation, user support, applications software, and information resources such as the libraries and outside databases.

To contribute successfully to a long-lasting improvement in the overall quality of education, Athena must work with faculty and students to integrate meaningful use of computing into the fabric of MIT.

BACKGROUND

In June, 1988 Project Athena will have reached the endpoint of its originally envisioned five year life. Athena was originally conceived of as an experiment (or perhaps more appropriately, an exploration) of the potential uses of a network of high performance, graphics workstations in the MIT curriculum.

The project's original goals can be usefully divided into three categories:

1. fostering educational innovation - Athena has provided funding and computational resources to faculty interested in exploring the innovative uses of computing in the MIT curriculum;
2. development of a coherent computing system from heterogeneous workstation hardware - Athena has created a computing environment that makes available an array of networked-based services and which provides a high degree of source code portability across disparate machine architectures;
3. installation and operation of computational facilities - Athena has installed workstation servers throughout the campus. This hardware is used by faculty, students and staff as a general educational computing utility.

The original vision of the five year experiment was that MIT would gain sufficient understanding of the value and costs of a distributed computing environment to allow it to make a long term strategic decision about educational computing. This vision assumed that three things would be completed during the first five years:

1. a large base of workstation hardware would be installed and operated for at least two years before June, 1988;
2. the systems software would be largely developed and available for the same period;
3. the faculty-based projects would have accumulated enough useful experience by June, 1988 to adequately assess the value of using computation in the curriculum.

The reality is that none of these three preconditions have been fully met. Academic Year 1988 represents the first time Athena has been able to provide the full set of distributed computing resources originally envisioned. Even now, because of the relatively high cost of workstations and the unexpected delays in installing equipment, the base of equipment falls short of what was originally hoped for. The relative newness of the computing environment and the series of software changes needed to migrate the computing system from older, time-sharing services to workstations have reduced the amount of useful experience with distributing computing.

For the above reasons, the proposed plan for Athena calls for a three year period during which MIT should continue Project Athena without making a longer term strategic commitment. We should use this three year period to acquire a better understanding of the costs and benefits of the educational computing environment so that a longer term, strategic decision can be reached in 1991.

Athena's continuation should be undertaken with modifications of the original project goals to reflect both what we have learned to date and what has happened in the personal computer industry.

GOALS FOR THE NEXT THREE YEARS

Listed below are seven major goals necessary for Project Athena's success during its continuation period, 1988 - 1991.

- **Educational Success**. By 1991, a signficant number of subjects across a broad spectrum of disciplines should be able to show that use of Athena-based services (including a broader array of hardware, software, utilities, and support) demonstrably improves the quality of an MIT education. Toward that end, Athena should develop its role as a catalyst for encouraging intellectual efforts among faculty to qualitatively assess, discuss, demonstrate, and exchange information about curriculum-based software.

- **Service and Reliability**. Project Athena must provide a reliable, affordable, easy-to-use educational computing infrastructure, maintained by staff who recognize the importance of service-orientation in support of faculty and student users. Users should expect Athena to provide "one-stop shopping" for hardware, software, and network connectivity.

- **Accessibility**. Computation and print facilities should be available in sufficient quantitities to allow the entire student community (including graduate students) access to the Athena system within a five minute walk from any location on campus; further, waiting time for available workstations should generally be negligible, with exceptions confined to periods of peak load. Additional deployment opportunities must be explored thoroughly, with particular emphasis on faculty offices, departmental facilities, libraries, living groups, new construction, and existing classrooms. Private ownership models should be considered seriously, with timing dependent upon external market developments.

- **Faculty Focus**. Planning, and execution of plans, must involve a broad representation of faculty to ensure their teaching (and research) needs are met. The goal should be to ensure a solid foundation of vigorous faculty support for Athena activities post-1991.

- **Hardware/Software Heterogeneity, Coherence, Integration, Export/Import**. Athena systems must be as accessible as possible to various classes of hardware and software without sacrificing a desirable level of coherence and compatibility across the network. Athena should also foster faculty efforts to import and export useful applications from other educational institutions and industry. Finally, Athena must thoughtfully renew its infrastructure while being mindful of evolving industrial software and hardware standards.

- **Cost Awareness**. MIT should be prepared to consider assumption of yearly costs of some $6-million for continuation of centralized academic computing support in Academic Year 1992. Goals and tactics for Project Athena should be developed and executed with cost-efficiency as a major objective.

- **Organizational Migration and Integration**. MIT should be prepared to consider the integration of academic computing responsibilities into Institute administrative structures by June, 1991. This goal suggests the need for initiation of discussions and prototype cooperative projects between Athena and other administrative and academic units of MIT during the first year of the continuation.

PLAN FOR NEXT THREE YEARS

Project Athena's plans for attaining the goals listed above in the next three years can be divided into four broad categories:

- fostering continued innovation in educational uses of computing,
- operations of the computing environment and deployment of new hardware,
- continued evolution of the distributed computing environment, and
- expansion of the computing environment to include a larger base of users, particularly graduate students and researchers.

The subsections below are organized around this division.

Continued Educational Innovation

Athena will operate under conditions that both permit and require a changing stance toward its activities. Because centrally available funds for curriculum development will be drastically cut, there will be far greater reliance on departmentally based, externally sponsored curriculum development projects. The weight of institutional initiative and responsibility must shift toward the departments, with whom Project Athena should work out new forms of partnership.

In the next three years and beyond, we envision a far more stable computing infrastructure, a condition essential to Athena's success as an educational experiment. Moreover, Athena will devote far more attention than in the past to stimulating and supporting faculty inquiry into the hard educational questions associated with the development of new software.

Assessment of the curriculum development projects Athena has supported to date suggests a number of important directions for change:

- There are examples of projects with exciting educational impact, not only in providing more efficient ways of performing familiar educational tasks, but also in helping students to see things in new ways. Among these examples are computer environments for design, visualization of complicated mathematical models, the design and implementation of electronic seminar rooms for teaching subjects across the curriculum, and uses of the computer for processing and analysing laboratory data.
- Among faculty, there is a significant potential for involvement in educational computing, as yet only partially realized.
- Educational computing is not an exercise that can be accomplished without a major investment. Costs in money and faculty time are high; development cycles are long. Flaws in programs or the computing system have a negative educational impact. The most interesting projects are the work of faculty who have long been, or have more recently become, champions of educational computing. Often, senior faculty champions have paired with junior faculty colleagues.
- Grassroots activity in educational computing using PCs and Macintoshes has developed alongside Athena and represents an important source of innovation.

Given the above insights, we propose to create an Educational Computing Initiatives Group within the Athena staff. This group will a charter to do the following:

1. Focus on departments as the basic institutional units for development and use of educational computing in the curriculum with provision for school-wide or Institute-wide initiatives. This will require new forms of partnership between the project and the

departments, making use of a range of models for the provision of technical and educational support for faculty initiatives.

The two most successful models for this is what we have termed "triangles" and "special interest groups". A "triangle" is a team consisting of faculty members in a department, an Athena applications programmer and a departmental staff member responsible for software design and implementation. A "special interest group" combines a number of Athena technical staff with specialized technical knowledge and a group of faculty members from different departments who are using the staff resources as the foundation of their educational applications. Athena's work with the Aeronautics and Astronautics Department is an example of a triangle, and the Visual Computing Group is an example of a special interest group.

2. Expand the umbrella of Athena to include faculty using less technically sophisticated computing systems. Athena should be perceived as the logical intellectual home for faculty interested in educational computing as broadly defined, whether or not they use the hardware and software base Athena now provides.

3. Increase the visibility of applications software developed and used within MIT and elsewhere by assisting faculty in importing and exporting educational software. This should include sponsorship of seminars and other forms of faculty-to-faculty communication that cut across departmental boundaries. Examples include computer environments for design and computer processing of laboratory data.

4. Foster improvements in the match between faculty members' needs for educational computing and Athena's technical directions, including specification of software development tools and user interfaces. The review and implementation of those tools will primarily be done by the Athena Systems Development Group.

5. Assist faculty in formulating curriculum development proposals and locating external funding for them. This should include use of Athena's hardware grants as a form of co-funding that will improve the probability of outside agencies and foundations accepting MIT-based proposals. An excellent example of this is the Foreign Languages Project funded by the Annenberg/CPB project.

6. Provide support for faculty interested in conducting "self studies" for the planning, monitoring and evaluation of educational computing initiatives. Examples include projects carried out in Architecture and Planning, Civil Engineering, Aeronautics and Astronautics and the Music Section.

7. Maintain a repository for software in use at MIT to reduce the burden on faculty.

The funding for this group should consist of a core of support directly from the Athena operating budget. In addition, we expect to seek external support for development of crucial software tools and to work with departments and schools at MIT to urge use of curriculum development funds for educational computing projects.

Operations, Deployment and User Support

Project Athena now operates over 700 workstations and nearly 70 servers of various types. This large scale computing system requires ongoing operational support services that are provided with an relatively small staff. Athena was initially an early prototype computing system that was clearly experimental in nature; users generally understood this and adjusted their expectations accordingly. This period has long since passed, and the Athena system is viewed much more as a campus utility, with corresponding expectations of high availability and predictable performance. We expect that the user community will expand over time, and that assumptions about the service role of Athena will be even more strongly held within the MIT community.

Listed below are major goals necessary for the success of Athena Operational Support.

Deployment - Project Athena should continue aggressive efforts to deploy additional hardware, with a target rate of approximately 250 additional workstations per year (750 workstations in the continuation period). This deployment target would enable Athena to expand its services to graduate students and faculty while increasing the number of workstations in users' hands by some 150%. This target also would allow the Operations and Systems Development Groups to observe the effects of increased scale across the network.

- Opportunities for large clusters (~15-20 or more workstations in roughly contiguous space) are likely to be limited to W20, the MIT Libraries, a few departments, and newly constructed or renovated space. About 50% of the total deployment goal may be met through such large clusters.
- Small clusters (~5-10 workstations in roughly contiguous space) may be developed in departments, laboratories, libraries, and living groups. About 30% of the total deployment goal may be met in this manner.
- Individual workstations (~3 or fewer in a single location) may be tightly or loosely coupled to the network and will operate in the private mode. About 20% (150 workstations) of the total deployment goal may be met in this manner. The primary target for this type of deployment will be faculty offices.
- Developments in vendor product lines may dictate that Athena radically alter this deployment strategy to include a much larger percentage of privately-owned computers.
- Hardcopy output policy must ensure 24-hour-access, high-volume, high-quality output devices are available at a reasonable cost to the end-user, and low-volume devices are readily available.
- A variety of new and emerging hardware and software options must be supported.

Reliability, Availability and Predictability of Service - Operations must ensure that deployed hardware and software performs reliably and predictably as a general utility for community use. Critical remote files on servers such as the system libraries are already replicated to provide a high degree of service availability. Individual users' files are not now replicated, and the costs of doing so may be prohibitive. We expect to study the availability for these files and assess whether we can improve it at reasonable cost.

Renewal of Server Infrastructure - Renewal of the current hardware base is essential to provision of computing service. This is particularly true for the aging VAX 11/750s that serve as the core of the server system. A significant fraction of the hardware grants scheduled for the first year of the continuation will be allocated to new servers; new disk drives be a part of this replacement. The server infrastructure should begin to be replaced in the first year, with consolidation of machine rooms where possible to increase cost-effectiveness.

Long Term Costs and Expenditures for Academic Computing - Strategies such as shifting to more cost-effective server hardware and relying more on vendor-supplied operating systems will in the long run reduce the costs of running an Athena-style computing system. We also foresee continued declines of hardware prices in the next three years. In the last three years, the price of a typical Athena workstation has declined from nearly $25,000 to approximately $6,000. In the next academic year, further declines to the $4,000-5,000 range are virtually certain.

We will also continue our close working relationship with key hardware vendors to urge product strategies targeted towards reducing the costs of workstations. We have worked with Digital, IBM and at least two other workstation vendors to define what product characteristics are essential for universities, and what other characteristics can be foregone in the interests of cost reduction.

We also will experiment with increased reliance on privately owned workstations. More widespread private ownership of computers will reduce the need for MIT to purchase, operate and maintain a large base of public workstations scattered around the campus.

The last part of the plan for reducing computing costs is for MIT to establish a maintenance center for workstations. Part of MIT Information Services now does this for IBM PCs. We will continue discussion among Athena, Information Systems, Digital and IBM to define a more cost-effective way to support workstations on campus.

Systems Development

Ease of Use - One of the most widely voiced concerns about Athena's technical strategy is that UNIX, the underlying operating system, is extremely difficult for new users to learn. We need to address this problem by working directly with faculty and students who are using the system to understand what aspects present the greatest difficulty to both users and programmers. It is essential that a group of faculty be directly involved in defining the specific tools they need to make software development easier and more cost-effective. We envision the formation of a faculty-based advisory committee to provide a coherent statement of functional requirements.

Given how difficult remedying this long standing deficiency of UNIX has proven, it is unlikely that a *de novo* effort on our part will be successful. Our strategy will be to build upon and adapt already existing work by private industry and other universities.

Several companies have approached Athena with the idea of a collaborative arrangement to improve the user interface to the UNIX system. Some of these organizations have what they believe are appropriate solutions either available now or under development. It is not in MIT's interest to duplicate their efforts. Rather, we plan to pick one of these interface systems, adapt it to our needs, and make it generally available. The systems we have seen emerging are largely based on ideas from the Xerox STAR system, a precursor to the Macintosh software. The recently announced efforts of AT&T and Sun Microsystems to produce a new UNIX shell called "Open Look" layered on the X Window System may be the most prominent development in this area.

A far more difficult problem is making the UNIX environment upon which Athena is based easier to program in. Currently, faculty report that they make a very large investment of their own time and that of programmers to create a single piece of software that is educationally useful. Two major areas that take enormous time and considerable technical expertise are the development of an effective user interface to their software and the extensive use of presentation graphics (both two and three dimensional) in their applications. Both of these areas are central to the creation of effective software, and each need must be addressed if a large base of Athena applications software is to become available.

MIT is working now with vendors and other universities to develop programmers toolkits layered on top of the X Window System. This provides a set of "objects" that can be used by programmers, including menus, editable text, scroll bars and other user interface components. We expect that while these toolkits

will make development of sophisticated user interfaces easier, they may also be viewed by many applications developers as too difficult to learn and use. Further development work will be essential to resolve the underlying problem.

Stabilization of System Software - Sometime in 1988, Athena should document a programming interface that will remain substantially stable for the next three years. All system development plans from that point forward should ensure compatibility with that documented interface.

The key components of that interface are already well-defined. The UNIX system call interface, Version 11 of X, the C language, FORTRAN 77, Common Lisp, the Kerberos authentication protocol and associated client library and the Network File System (modified for Kerberos authentication) are all likely elements of that defined standard. Still unresolved areas include application development toolkits, specialized authoring environments, three dimensional graphics, and the specific form of certain UNIX system calls now being debated in the national standards community.

Note that the commitment to stability being planned here does not imply stagnation. We see new, upwards compatible software being made available to the Athena user community more or less continuously.

Athena as Layered Software - The Athena computing environment is currently built using Berkeley 4.3 UNIX. Since we began the project in 1983, a number of vendors have enhanced AT&T's System V UNIX, and in the next few years virtually all the functionality that was originally only available in the Berkeley version should be present in a variety of proprietary systems. Athena should focus its resources on the incremental software needed for these vendor-supported implementations of UNIX to be used at MIT.

Specific goals for layered software include ability to:

- run binary applications that were orginally developed for vendor supplied software;
- offload support cost of software maintenance;
- run Athena-developed applications on vendor-supplied hardware and software.

Widespread Adoption of Athena Software - For the same reasons which motivate our migration towards industrially-supported operating systems, we plan to encourage adoption of key parts of the Athena software system by industry. This has already been successfully done with the X Window System, and we see no reason similar strategies won't work for other Athena-generated software. We have just begun release of the Athena authentication server (Kerberos). The same strategy will be used for distributing our name server (Hesiod) and any other major software systems with potential for widespread adoption.

This overall strategy depends on three critical components. First, the software must fill a need already perceived by the industry. We have systematically avoided software development in areas where a critical need is unlikely to exist. Second, the work we do must be fully tested at large scale for a sustained period before it is released publicly. Third, MIT must be willing to provide the software to all interested parties at reasonable cost using the same approach as we did with the X Window System.

Integration with Lower End Computing - Athena must adopt a much more accommodating position with respect to PCs and Macintoshes. Our general strategy will be to import or develop software that allows

PCs and Macs to take advantage of some of the network-based services we now provide to workstations.

Lower end computers will be able to obtain computational services in three distinct ways, each corresponding to a different technology used to connect the PC or Macintosh to the campus network: dial-in using modems over standard analog phone lines, use of digital phone service (via the ISDN service available in MIT's new phone system), and direct connection to the MIT Campus Network. These three methods have different costs and different capabilities. Modem-based service is universally available and relatively slow(300-9600 bits per second). ISDN service at 64,000 bits per second will be available only within the MIT campus and the few Boston communities where it happens to be installed in the next few years. Direct connectivity to the MIT campus network (at speeds from 4 to 10 million bits per second) will be relatively expensive and limited to the campus for the forseeable future.

The key services in approximate order of their relative priority to Athena users include:

- print service - particularly for access to sophisticated laser printers.
- mail service - the ability to receive mail from an Athena post office server and send it from a personal computer;
- file transfer - to move files to and from personal computers;
- remote login service - to connect to other systems around MIT that are on the campus-wide network;
- file service - connection to file servers.

Development of Improved Tools to Support Athena Operations - There are a range of technical projects which will contribute to better service. Development must work toward a system maintainable beyond three years by a normal operational group.

Research and Graduate Student Use

Research and education are inextricably intertwined at MIT; many Athena users are involved in both. Over the next three years, Athena should extend its value and usefulness to those research users for whom distributed computing and workstations make sense.

To meet the needs of researchers and graduate students, Athena must undertake initiatives along three broad lines:

- state clearly the scope of hardware, software, and services to be provided;
- develop operational plans to ensure useful hardware, software, and services can be provided in a timely and cost-effective way; and,
- ensure that anyone in the MIT community who wants an Athena workstation will be encouraged to acquire it without reference to intended use.

One barrier faculty and research staff face in adopting the Athena computing model in their research is the lack of a single organization which can coordinate the purchase, networking, physical installation and software licensing and installation. Currently, the user would have to deal with the Telecommunications Office, Athena, the hardware vendor and several software companies. To reduce these formidable barriers, MIT (either through Athena or Information Systems) must provide "one stop shopping" for members of the MIT community. This service should include:

- timely delivery and installation, coordinating physical and logical networking needs, and appropriate workstation hardware, software, and peripherals for access by the user within 30

working days of receipt and confirmation of an order;

- network services including file storage and access, printing, communications, authentication, name service, and notification;
- user services, including training, documentation, consulting, and maintenance arrangements; and,
- system support, including software development and system operation environments, a system library, and purchased software.

There are several related issues which need to be resolved in order to make this service possible. In particular, some combination of Athena and other organizations at MIT must work towards resolving the following:

1. Workstation Types - Users should be able to obtain workstations from any source (including Athena) and receive Athena services, provided the workstation conforms to Athena specifications.
2. Network Installation and Activation - Athena should coordinate closely with Telecommunications to ensure timely availability of network services.
3. Licensing - Athena must work with other Institute organizations to renegotiate software site licenses and extend access beyond the narrowly-defined educational environment.
4. Maintenance - In the long term, MIT must have a low cost means of maintaining workstations on campus. Given the relatively high cost of vendor-supplied maintenance services, most campuses (including MIT) have created PC repair and service organizations. This same approach needs to be extended to workstations before the end of the Athena grants which now support the maintenance costs.
5. Cost Recovery - Athena must establish a cost-recovery plan to successfully provide "one stop shopping."
6. Definition of Projected Use - Athena must work closely and carefully with departments and individual faculty to meet their evolving needs. Additional data must be collected to define:
    - what additional software or services would be desired;
    - how much network storage is required;
    - needed print facilities; and,
    - the extent to which users wish to procure other systems for research (as opposed to Athena workstations and systems as they presently exist or are envisioned).

FINANCIAL PLAN FOR NEXT THREE YEARS

The strategies described above can not be met without significant commitments of financial resources. The staff-related costs and expenses of Athena are approximately $2.8 million this Academic Year. This does not include $400,000 in curriculum development funds allocated this year to support the group of programmers that works directly with faculty development projects and $200,000 of special funding provided by IBM in support of the group helping faculty use video imaging as part of educational applications. This figure also does not include the curriculum development grants to the faculty. Even more significantly, the above costs do not include equipment maintenance or new hardware acquisitions, both of which are provided by Digital and IBM as part of the Athena grants.

As shown in Table 1, without continued maintenance and hardware grants, Athena would cost MIT $5-6 million dollars per year not including curriculum development funds or renewal of the hardware. Replacing the hardware on a four year cycle would cost approximately $3 million per year more. MIT is simply not in a position to absorb all these costs in its Academic Year 1989 budget, and it is extremely unlikely that MIT will be able to find other donors willing to provide sufficient unrestricted funds for Athena's continuation. It is therefore crucial that in the short term MIT continue its mutually beneficial relationship with key industrial companies to fund a major component of its educational computing strategy.

Support Organization	$3.0 million
Hardware Maintenance	
workstations	.90
servers	1.70
other	.20
TOTAL(without hardware renewal)	$5.80 million
Hardware Renewal	
workstations	$1.25 million
servers	1.20
other	.20
TOTAL(with hardware renewal)	$8.45 million

Notes: Assumes 1000 workstations with four year average life
Assumes workstation cost of $5,000
Assumes industry field service with 25% discount

Table 1: Actual Annual Costs of Athena

Athena has received approval of continued support from both IBM and Digital for the next three years. They have each committed continued hardware and maintenance grants and $500,000 per year in cash for the next three years. These resources, combined with a commitment of approximately $2 million per year in Institute general funds in Academic Year 1989, should be adequate to meet the above goals with the exception of sustaining support of curriculum development. Table 2 below summarizes the expected allocation of this budget in this plan. Note that all costs in the budget are net of any cost recovery for printing or documentation.

Category	Percent of Budget
Networking/Operations	31%
Systems Software	21%
Educational Computing Initiatives	12%
User Services	21%
Office	6%
Other(Software licenses,management)	10%

Table 2: Budget Allocation for Academic Year '89

This budget will support a core group of applications development staff. We expect this to be augmented by additional funding from outside sources, particularly in the video imaging area. Proposals have already been submitted to Bellcore and Sony. We also expect that many faculty-based curriculum development proposals will have included in them support for help from the applications development staff programmers, and that further growth within that staff will depend on such funding.

Athena may also undertake technical projects that require external funding. The key criterion for these projects should be whether they are important to Athena's overall mission.

PLANS BEYOND THE THREE YEAR HORIZON

In planning for the period beyond the three year continuation of support from Digital and IBM, Athena must deal with a complex set of issues that revolve around the cost, functionality and availability of computing resources. Formulation of a complete plan for the post-1991 period is a task that should be a major part of Athena's charter during the next three years. The subsections below highlight the most crucial issues this plan must eventually address.

Financial Support for Educational Computing

The most critical issue MIT must face is putting academic computing on a stable, affordable basis. It is unlikely that the level of computing we provide to our students and the commitment of financial resources can continue to be so disparate in perpetuity.

Given how rapidly the costs of computing change, an accurate budget for Athena beyond Academic Year 1991 must be viewed as speculative. The figures given in Table 3 below should be viewed in that context.

Category	Costs
Operating Budget	$3.8 million
Server Maintenance	.8
Workstation Maintenance	.6
Hardware renewal	1.5
TOTAL	$6.7 million

Notes: All costs in 1992 dollars.
Staff costs assumed to inflate at 6% per year.
Server maintenance assumes $8 million in capital maintained at annual cost of 10% per year.
Workstation maintenance costs assume 600 public workstations at $1,000 per year.

Table 3: Annual Budget After Three Year Extension

Academic Computing as a Utility

The expansion of Athena to provide universal graduate student access and to support a range of research uses is part of the larger strategy of making computing a utility on the MIT campus. The key characteristics required for this are universal availability, relatively low charges and the availability of a wide range of useful resources over the network in ways that are straightforward to use.

Creating such a utility will require the following:

1. The Institute should provide campus-wide data communications as a general utility. A single, campus-wide network protocol should be supported. The costs of the network utility service should either be incorporated into overhead (as we do with electricity) or paid by user charges (as we do with telephone service). This utility should be available in virtually all MIT facilities, including classrooms, offices, laboratories and dormitories with only a minimal setup time. The extra wiring now being installed as part of the new phone switch will make this approach feasible without major new expenditures. Special accommodations

for connecting to this network (most likely at lower communications rates) from outside MIT should be provided for off-campus residents.

2. Plans for various organizations at MIT such as the libraries must include strategies for providing services to workstations over the data network. MIT is still behind most of its peer institutions in this area. In the short term, the current catalog and circulation services should be accessible over the network. In the longer term, materials that are published electronically (such as reference works) and working paper collections should be available to the entire MIT community.
3. A large fraction of the faculty, and virtually all faculty teaching subjects with large enrollments, should have workstations in their offices. This will make participation in electronic bulletin boards, electronic circulation of class notes, and response to electronic mail a routine part of running a subject.
4. Most of the charges for use of the computing utility should be fixed costs rather than charges per use. This reflects the fact that the incremental costs of providing data communications and computing vary little whether the facilities are heavily used or idle, and that we maximize the benefits of our computing investment by encouraging rather than discouraging use. We currently apply this philosophy for internal phone use. Exceptions should include printing or specialized services such as tape loading and backup.
5. We need to link academic computing to the planning of other facilities. We should adopt design standards for new buildings and major renovations that will make future data communications easier to install and operate.
6. The provision of computation and projection of output in a number of classrooms is a growing need. Faculty should be able to schedule classrooms with workstations at students' desks and should be able to request the setup of workstation and projection system in most classrooms with mininal advance notice and planning, much in the same way overhead projectors are now available.

Division Between Private and MIT-owned Computation

MIT should operate a general server system based around the Athena servers. These servers should be provided for academic use to all faculty and students, including all graduate students. The costs of this system (operating, maintenance and capital) should become part of the Institute's operating budget.

MIT would provide a relatively small set of public workstations; most computing should be done on privately owned equipment purchased in volume by MIT (under substantial discount arrangements) and resold to students and faculty. The small number of public workstations (perhaps a few hundred) would be intended for use by students who can not afford their own computers, specialized applications that required hardware not normally available on private workstations because of its relatively high cost, and students who need access to computational services when they are out of their residences. These workstations may also be in classrooms and used as part of the instructional process.

Hardcopy output would be created by privately owned printers (attached directly to workstations) or campus print servers which were operated on a fee-for-service basis.

MIT would provide a base software system that runs on some limited number of workstation types. This software would be licensed MIT-wide, with the costs recovered as part of the sales price of workstations. Additional software might also be available under a volume discount arrangement with software companies.

Evaluation of Athena

The question of how to evaluate the educational benefits of Athena has remained unresolved since the project's inception. MIT does not have a long history of assessing its own educational programs, and many faculty are doubtful of the value of such assessments. We do not evaluate the educational effectiveness of our libraries, administrative offices or academic departments in any systematic way, and efforts to impose such evaluations are likely to fail.

The formal assessments of Athena to date include two studies fostered by the Project Athena Study Group and a series of surveys and interviews conducted by Athena staff. Each of these efforts sheds some light on various aspects of Athena's value, but none has provided a complete assessment of all aspects of Athena.

The primary factor that will determine MIT's long term decision about Athena is faculty and student perceptions of the value of the campus-wide computing utility Athena provides. The best measures of this are whether use of computing grows for both instructional and general purposes, and whether Athena is perceived as providing a powerful and stable computing environment that enhances learning. The factors that determine each individual's decision about Athena will continue to be very varied and complex.

The process of evaluating the effectiveness of Athena as part of MIT's educational and research support system must eventually lead to concrete institutional decisions. The extent to which we require an integrated computing environment, the appropriate level of commitment of funds to computing and the allocation of those costs among users are all difficult questions. Nevertheless, at the end of the Athena extension period the Institute must have in place a set goals and plans for educational and research computing on campus.

It is recommended that the Provost appoint a committee to begin work no later than September, 1989, chartered to identify the goals for educational and research computing at MIT. The committee should broadly represent the Institute's academic and research communities as well as the newly-constituted Athena Executive Committee. This committee should not be limited to evaluating Athena. Rather it should use the Athena experience and staff as resources to formulate a long term strategy for computing resources for the future. The Committee should use the first six months of its effort to review Project Athena as well as computational environments provided by other institutions. It should then formulate recommendations and implementation plans (including forecasts of expenses and revenues) by January, 1991.