Computer Planning Board
Educational Subcommittee
Implementation Plan

Electronic Studio Plan

for

Engineering

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A Five Year Plan for Educational Computing in the Engineering School

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1 Educational Computing in Engineering

The Engineering School is committed to offering an undergraduate program in engineering that is among the best in the nation. In recent years, advanced computer systems, most notably high performance scientific workstations, have become essential tools in all branches of engineering. For this reason, the Engineering School is creating a modern computer laboratory, called OwlNet, with sufficient resources to give every student and staff member convenient access to a comprehensive collection of computational tools for solving mathematical problems, simulating and analyzing physical systems, creating graphics and documents, and designing physical devices and other engineering products.

The OwlNet computer laboratory is intended to meld the engineering student body, faculty, and staff into a computational community that regularly uses a common collection of computational tools. Every student, faculty member, and staff member will have ready access to a high performance graphics workstation linked by a high-speed network to a pool of shared servers that store, file, print documents, and perform large calculations that are beyond the capabilities of a workstation.

The laboratory is designed to function as an electronic “studio” analogous to the studios commonly used in professional programs in art and architecture, Every engineering student will be assigned an electronic "carrel" that he maintains for the duration of career as a student. The studio will support a wide array of tools including scientific programming systems, text editors and document formatters, electronic mail systems, computer-

aided design systems, and mathematical modeling and statistical analysis tools.

To acquaint students with the facility, all engineering students will be strongly encouraged to take a common introductory course in scientific computation by the middle of the sophomore year. This course will focus on the principles of scientific computation including

- the elements of scientific programming including both symbolic and numerical computation,
- abstraction as a mechanism for managing complexity,
- the properties of floating point arithmetic,
- basic numerical algorithms,
- graphics standards and numerical libraries.

In the process, it will expose students to the basic tools provided by OwlNet including the UNIX shell, text editors, language processors, and debuggers. After this introduction, engineering students will be prepared to use the computer laboratory on a regular basis in their courses. The introductory course will be supplemented by a collection of 1 credit short courses on specific topics to provide additional background for particular advanced topics, such as: the C programming language, MATLAB, symbolic algebra systems (such as MAPLE and Mathematica) expert systems, specific graphics standards, networking, parallel and vector computation, and numerical simulation.

2 Specific Requirements

To support the electronic studio concept, the Engineering School must create an educational computer system with four major components:

- public facilities designed primarily for student use,
- private facilities in faculty offices,'
- private facilities for the operations and maintenance staff, and
- a demonstration facility for a classroom.

AU these facilities must be linked by a high-speed network so that each machine can function as a gateway for accessing any other machine in the system.

2.1 **Public facilities**

To support student usage, OwlNet must provide

- 104 b/w workstations and 16 color workstations with high-resolution bit-mapped graphics located in laboratory rooms that are accessible 24 hours a day,
- 8 large file servers (3/280 equivalent) and 9 small file servers (3/80 equivalent), each equipped with at least 2 gigabytes of disk space,
- a high-performance computational server with an order of magnitude more computing power (in both execution speed and memory) than individual workstations, and
- an array of public peripheral devices for printing and scanning documents including 10 laser printers (one for every physical cluster of workstations), 2 line printers, and a large color plotter.

We also need to plan on upgrading our current networking facilities.

2.2 Private facilities for faculty

Every full-time tenure track faculty member in the Engineering School should have access to OwlNet from his/her office. There are approximately 90 full time tenure-track faculty members in the Engineering School today; we expect that figure to increase to over 100 by 1994.

We project that more than half of these faculty members will acquire workstations for research purposes that are suitable for accessing OwlNet. The University must provide the remaining faculty members with workstations or graphics terminals (X-terminals) suitable for accessing OwlNet. Consequently, we will need

- 40 workstations or graphics terminals (X-terminals) for faculty offices, and
- 5 servers (one for 8 workstations/terminals), each equipped with 2 gigabytes of disk space, to provide file service for workstations and file and computational service for terminals.

2.3 Private facilities for OwlNet Staff

To support the OwlNet staff, OwlNet must provide:

- 8 workstations for OwlNet staff offices, and
- 1 file server equipped with 2 gigabytes of disk space.

2.4 Other facilities

To present and discuss OwlNet tools in the classroom, the Engineering faculty needs at least one computer demonstration facility consisting of

- a large screen, high-resolution projection system, and
- 4 demonstration workstations representing each major workstation type in OwlNet.

2.5 Personnel Requirements

To operate the existing network of 60 machines, OwlNet employs two full-time staff members and 8 undergraduates working 10 hours a week, yielding a total staff of 4 full-time equivalents. This staff is too small to run the existing configuration smoothly and effectively. To help address this problem, OwlNet was recently authorized to hire a full-time executive deputy to manage the system. To support the system,described in this plan, which is more than twice the size of the existing system, OwlNet will have to double it staff. The projected staff consists of:

- an deputy director,
- 4 full-time systems members,
- 10 part-time undergraduates working 10 hours per week during the academic year,
- 8 full-time students during summer months, and
- 1 secretary.

2.6 Software requirements

The existing complement of software on OwlNet is grossly inadequate. Many kinds of computational tools that are routinely used in industry are not yet available on OwlNet because of funding limitations. To assemble a credible collection **of** software tools, OwlNet will need a budget of at least $50,000 for software acquisition and maintenance fees. This figure is conservative: It is only slightly more than twice the existing budget of 320,000, and many licensing fees are proportional to the size of network.

2.7 Space requirements

Each public workstation in OwlNet requires approximately 40-50 square feet of space including space for walkways and associated peripherals **(such** as printers). Hence the total space requirement for the OwlNet public laboratories is approximately 5,000 square feet organized in rooms suitable for housing clusters of 8 or 16 machines (we currently have about 3,500 square feet). The associated file servers and computational servers require machine room space (which is air-conditioned and inaccessible to students). Since this equipment is typically very compact, 500 square feet of machine room space should suffice (we currently have about 200 square feet). The machine room space can probably be found in the machine rooms in Mudd and Abercrombie that OwlNet shares with the Departments of Computer Science, Mathematical Sciences, and Electrical and Computer Engineering. It is possible that the installation of more servers in existing machine rooms may require an increase in sir-conditioning and power capacity.

The space required to accommodate the OwlNet staff amounts to 5 offices (4 full-time staff and a deputy director) 120 square fet per office, for a total of 600 square feet (OwlNet currently has not office space).

3 Coordination with Other Divisions

Although the Engineering faculty designed OwlNet specifically for the Engineering School, the design is well-suited to many departments in the School of Natural Sciences and to selected departments, such as Linguistics, in other schools on campus. OwlNet could be easily expanded to include the School of Natural Sciences as the plan for Natural Sciences suggest. In the process, some significant economies of scale could be realized. In particular, the expansion of OwlNet to accommodate other schools and departments

will require less additional staff and equipment than establishing new independent laboratories would. The plan for Natural Sciences has already included these projected savings in its proposed budget. The corresponding budget to create a comparable independent facility would be much larger because the proposed number **of** workstations is insufficient to meet the peak computing demand within Natural Sciences. Similarly, the proposed staff is insuflicient to operate and maintain an independent laboratory; the bulk of the operations and maintenance responsibilities for the Natural Sciences laboratory will be borne by the ongoing OwlNet staff. A few extra staff members will be required to handle the increase volume of machines and to help acquire and install the particular software systems required by Natural Sciences.

4 Cost Estimates

A. One-Time Costs for Purchases

	1990	1991	1992	1993	1994	Total (5 years)
Computers and Related Hardware for Public Facilities						
Workstations+file servers	200	130	180	150	180	920
Laser printers	8	8	8	8	8	40
Plotter	---	---	10	---	---	10
Compute server	---	150	---	---	---	160
Compute server amort.	---	--	37.6	37.6	37.5	112.6
Subtotal	288	288	236.6	196.6	226.6	1,232.6
Computers and Related Hardware for Offices (workstations and servers)						
Workstations + file srvrs	100	60	60	60	60	300
Educational Software	30	30	30	30	30	160
Total One-Time Costs	418	368	316.6	276.6	306.6	1,682.6

B. Annual Costs for Maintenence. Supplies and Personnel

	1990	1991	1992	1993	1994	Total (6 years)
Maintenance						
Hardware	79	116	134	140	146	614
Software	6	6	6	6	5	26
Subtotal	84	120	139	146	161	639
Supplies	4	4	6	6	6	23
Personnel						
Full-time staff	60	90	90	90	90	410
Students	10	20	30	30	30	120
Secretary	20	20	20	20	20	100
Subtotal	80	130	140	140	140	630
Total Annual Costs	168	264	264	290	296	1,292

All numbers are in thousands of dollars

Notes : The above calculations are based in large part one numbers given elsewhere in this report, some of which are repeated below.

1. Cost of workstations + file servers assumes the following purchases:

1990	48 workstations, 1 large & 6 small file servers
1991	16 workstations, 1 large & 2 small file servers
1992	32 workstations (inc. 8 color workstations), 4 small file servers
1993	32 workstations, 4 small file servers
1994	32 workstations (inc. 8 color workstations), 4 small file servers

The cost for a b&w workstation cluster (8 workstations and one small file server) is estimated at $50K. Color clusters are estimated at $80K.

Beginning in 1992, OwlNet will begin replacing obsolete workstations and file servers, and the net increase will be three clusters in 1992 and one each in 1993 and 1994.

Given the projected purchases and retirements of machines, we expect OwlNet to have the following configuration in each of the next five years:

	workstations	large F.S.	small F.S.	laser.	plot.	C.S.
1990:	116	7	9	6	1	0
1991:	130	8	11	8	1	1
1992:	156	8	12	10	1	1
1993:	164	8	13	10	1	1
1994:	172	8	14	10	1	1

(F.S. = file server, C.S. = compute server.) The current numbers in each of the above 5 categories are 68,6,3,4, 1 and 0, respectively.

Of the-workstations/X terminals mentioned above, 1 cluster per year will be for faculty use, and 1 cluster is planned in 1990 for OwlNet staff.

The number of workstations available for student use in 1994 is thus 172 - 48 - 124, moving toward an equilibrium number of 120. This number is based on the following calculation:

1 workstation * 12 hours/day * 7 days/week = 84 hours/workstation

(this assumes that a workstation will be unoccupied during part of each day, and that equipment or other failures will also limit its availability)

1000 OwlNet accounts (this may be low) * 2.5 courses/account (this may be high) * 4 hours/week/course = 10,000 hours of workstation access that will be required per week

10,000 hours/84 hours per workstation = 119 workstations.

4 hours/week/course is likely to be too much for many courses, but there will be some courses, especially in CS and ECE, that will go far over this amount.

2. Amortization

OwlNet is in a somewhat different position from the other divisions in that it already has a large installed base of machines, and the machines currently installed will be gradually replaced over the next five years. A yearly equipment budget similar to those for 1993 and 1994 will allow us to continue to retire obsolete equipment on a five-year cycle. The amortization of workstations, file servers, and peripherals is in effect already built into the budget.

The compute server is different, because it is a large purchase made once every few years. OwlNet does not currently have a compute server. We propose purchasing a compute server in 1991 and project that it will last for four years. After the initial purchase in 1991, the compute server is amortized at $37.5K a year (for a $150K purchase price).

3. Hardware maintenance

The maintenance cost estimates are based on the following annual costs (including the current yearly budget of approximately $60,000):

b&w workstation	$ 500
color workstation	1000
large file server	8000
small file server	2000
laser printer	325
plotter	1000
compute server	15000

The numbers of b&w workstations during each of the five years is estimated at 108,124,140,148 and 156, respectively. The numbers of color workstations is thus 8,8,16,16 and 16.

The numbers for larger file servers are probably not accurate. It is likely that these will be replaced with small file servers if a compute server is purchased. However, there may be other reasons for maintaining a balance of large and small file servers in OwlNet.

4. supplies

Sam Davis, OwlNet director, estimates that OwlNet is currently spending about $4K a year for supplies, in&ding manuals.

5. Personnel

The assumptions are:

(a) a deputy director will be hired for 1990 (already budgeted)

(b) one new full-time staff member will be hired for 1990 and one for 1991 (current budget $70,000)

(c) the number of students employed by OwlNet will increase substantially in 1990 from the present level, and then continue to increase at a slower pace until its maximum in 1992 (current budget $25,000)

The numbers entered in the table all include fringe benefits.

5 Impact on Curriculum

Course curricula in the Engineering School must be continually revised in response to changes in technology. In most engineering enterprises, modern computer systems are the principal tools used to design, simulate, and evaluate new devices and products. These computer systems dramatically increase the size and complexity of the problems that engineers can solve - while simultaneously reducing the time to produce a solution. The computer plays a critical role in all phases of engineering including design, prototyping, simulation, design analysis, documentation, and maintenance. Rice cannot educate engineering students well unless it teaches them contemporary approaches to engineering problem-solving. These approaches all require modern interactive computing equipment.

The pace of change in engineering computer technology is so rapid that hardware and software systems become obsolete within a period of 3 to 5 years. To maintain a strong engineering curriculum, Rice must continually revise the content of courses and update the computer systems used as tools in the engineering process. In Computer Science, for example, there is not a single course in the curriculum that was taught in a similar form at Rice (or anywhere else) ten years ago.

If Rice fails to upgrade and improve OwlNet on an annual basis along the lines described in this plan, the faculty will not be able to teach a contemporary engineering curriculum. The quality and quantity of computing resources provided by OwlNet will determine to what extent the Engineering faculty is able to revise the curriculum in response to the relentless pace of technological change.