Request for Proposals for Implementation of an Undergraduate Computing Environment in the School of Engineering

September 21, 1987

1 Introduction

1.1 Statement of Purpose

The School of Engineering at North Carolina State University is beginning the first phase of a multi-year plan to put into place a state-of-the-art computing environment for use in the Engineering undergraduate curricula. This environment is to be based on CPU per terminal type clusters of networked workstations with centralized file servers, print servers, and similar resources. Detailed requirements of the hardware, software, and networking of this system are provided in Section 2. The purpose of this document is to request proposed solutions to the needs described herein from vendors of such computing equipment and software. A request for bids, based on our evaluation of the proposed solutions, will be issued following evaluation of the responses to the current request. The bid request will call for one complete cluster to be implemented during the current fiscal year (87-88). It is to be understood that this is the first phase of a multi-year equipment acquisition plan that will likely span five years.

1.2 Summary of Proposed Environment

The computing environment to be installed in the School of Engineering will be organized in departmental clusters, with on the order of thirty to fifty workstations per cluster. Each cluster will be served by one or more central file servers. User files must reside on the server, such that a student may come in and sit down at any terminal, log in to the cluster, and have transparent access to his files. A *single system image* per cluster is desirable, so that the cluster has the appearance of a single, large system from the user's point of view. This

model is also important for system management purposes, in that an entire cluster may be monitored and controlled from a single point.

1.3 Instructions for Responding

Vendors responding to this request for proposals should prepare a document describing a *complete system* according to the guidelines listed herein. A *complete system* is defined here as all of the hardware and software required to satisfy the functional specifications for the first cluster of student workstations as described in this document. Vendors offering more than one configuration which satisfies these requirements should prepare separate responses for each such configuration. Pricing information should be included where applicable. It should be understood that this request for proposals will be followed by a request for bids, which will include more detailed specifications than those listed here. It is also important to understand that deviations from the specifications listed in section 2 will not preclude the consideration of proposals not meeting the stated requirements; however, significant deviations from those specifications are not likely to be considered favorably.

Questions regarding this document should be addressed to Dr. Thomas K. Miller, Box 7911, North Carolina State University, Raleigh, NC 27695, telephone (919)737-2336, or to Dr. William E. Willis, telephone (919)737-2458. Responses to this document should be addressed to NCSU Purchasing, Box 7212, Raleigh, NC 27695-7212.

2 Target System Requirements

2.1 Overview

The following is extracted from the School of Engineering Computer Committee's annual report dated May 6, 1987. This extract gives a high level description of the proposed undergraduate computing environment More specific requirements regarding hardware, networking, and software are addressed in sections 2.2, 2.3, and 2.4, respectively.

1. Hardware requirements.
   (a) system should be composed of CPU-per-terminal type computers (i.e., single-user workstations) with *transparent, high speed file access* to a centralized server via a local area network (Ethernet).
   (b) support for medium to high resolution *interactive graphics*.
   (c) system architecture should be *incrementally expandable* to a level which will support the entire SOE student population at a ratio of one workstation per ten students.
   (d) system should be robust and should exhibit *graceful degradation* in the event of equipment faults.
2. Software requirements.
   (a) must support a sufficient array of *compilers and engineering application packages* to satisfy virtually all undergraduate computing needs.
   (b) user interface must be "friendly" and oriented towards *interactive computing*.
   (c) must allow easy *migration of software* from all major systems currently in use in the SOE.
   (d) must support a large number of externally developed *engineering applications*, as well as general purpose applications such as *word processing, spread sheet*, etc.
3. Access.
   (a) easily accessible to both faculty and students.
   (b) faculty should be able to access the system from their individual offices.
   (c) some form of off campus access, such as modem lines, should be available.

While it is logistically desirable to have a homogeneous computing environment which meets all of the above criteria, this may not be a realistic goal. The diversity of the application domains and individual requirements of the departments and curricula within the School of Engineering seem to preclude an environment based on a single machine architecture and a single operating system. For example, MAE may have an essential application package which runs only on the IBM PC under MS-DOS, while CHE may have packages which require VAX/VMS, and ECE may have VLSI CAD tools which run only under UNIX and require 8-plane color graphics. The apparent solution is to provide an environment which is sufficiently flexible to allow for some level of integration of these existing (and future) heterogeneous subsystems to accommodate specialized needs. To this end, it is recommended that the hardware and software components of the environment should adhere to inter-vendor standards in the following areas:

Networking. The School of Engineering has a large investment in Ethernet as a physical medium for high speed computer communications. Ethernet is currently supported by all of the major vendors of engineering and scientific workstations and therefore should continue as our backbone medium. We must also consider inter-vendor standards for network access protocols. Currently, TCP/IP is the predominant inter-vendor standard on the SOE network. Recent vendor presentations have demonstrated that all of the major vendors are planning to support Open Systems Interconnection (OSI) as defined by the International Standards Organization (ISO), and it is recommended that any facilities that we put in place should look toward OSI as an eventual standard.

Languages. The predominant general purpose computing languages in the SOE are FORTRAN, Pascal, and C. Full standard implementations of all of these languages is recommended to facilitate software portability among heterogeneous systems.

Graphics. A commitment by the vendor to adhere to inter-vendor graphics standards is recommended.

Windows. Multiple window environments have emerged as a standard feature of high performance engineering workstations. Standards for windowing have begun to emerge, most notably the X-windows system developed at MIT. It is recommended that adherence to windowing standards be required for the systems in our environment which support multiple windows.

2.2 Hardware Requirements

2.2.1 Workstation

The workstation hardware proposed must conform to the following requirements.

1. The workstation must be based on a 32-bit CPU with the necessary hardware to support a multitasking, virtual memory operating system.
2. The workstation must include a floating point processor.
3. The workstation must include a bit-mapped graphics display with a pixel resolution of at least 1000 horizontal by 800 vertical. It is desirable that the pixel aspect ratio is 1:1. A single bit-plane graphics display is adequate; however, the availability of upwards compatible graphics displays with multiple bit-planes is a desirable attribute.
4. The workstation must include a mouse device with at least two buttons.
5. The workstation must have a standard keyboard layout. It is desirable that the keyboard provide spatially separated groups of keys including typewriter keys, function keys, cursor keys, and numeric keypad.
6. It is not required that the workstation include a local disk; however, based on the number of workstations per cluster (30 to 50) it is expected that feasible configurations will include a local disk for the operating system kernel and virtual memory swap space.
7. The workstation should contain no less than 2MB main memory. Larger amounts of memory as a standard configuration will be considered a desirable attribute. In any case, the main memory should be expandable to at least 4MB without requiring additional enclosures, back planes, or power supplies.

It is desirable that the workstation proposed by the vendor to meet these requirements is a member of a family of software compatible workstation products with a wide range of price/performance. Each vendor responding to this request for proposals should address this issue by briefly summarizing the family of which the proposed workstation is a member, including ranges of prices and performance.

Another hardware issue of concern is open architecture. While this is not a requirement, it will be considered a desirable attribute that third party components such as disk drives, memory cards, etc., are available. Responses should address this concern, citing specific third party products if applicable.

2.2.2 File Server

The primary function of the file server will be to store user files and globally accessible programs and data, and to provide transparent access to them from the workstations. It is expected that this machine (or machines) will provide other centralized services as well, such as printing, plotting, and communications. The server machine must conform to the following requirements.

1. The server should include at least 750MB on-line disk storage.
2. The server should support on the order of thirty to fifty of the above described workstations with no *significant performance degradation.* (*Significant performance degradation* can be interpreted here roughly as less than 80% of the throughput of a workstation with its own dedicated hard disk.)
3. The server should support asynchronous RS232 ports with full modem control. At least 8 such ports should be included on the server, expandable to 32. These ports must be capable of providing interactive access via dial-up modems and "dumb" ASCII terminals.
4. The server should support industry standard dot matrix and laser printers. (RS232 interfaces to these devices are acceptable.) Responses to this request for proposals should include recommendations for one dot matrix printer and one laser printer with high resolution graphics support to be attached to the proposed server. (It is expected that more than one printer per cluster will probably be required; in which case some capability to automatically distribute print queues to multiple printers would be desirable.)
5. The server must provide connection to the campus ethernet. (More details will be provided in the networking section.)
6. The server must contain enough main memory to meet the above stated performance requirements. It is expected that this will require at least 8-16MB memory.
7. The server must include a backup device (tape drive) for periodic system backups.

In addition to the above requirement, flexibility in configuring the server machine is a highly desirable attribute. The objective is to facilitate minimum cost tailoring of the server to meet evolving system requirements. Examples include CPU upgrade path (without replacing the entire machine), memory expandability, fixed disk expandability, I/O expandability,

and the range of vendor supplied and third party add-on devices available. The ability to incrementally add server machines while maintaining a single system image would definitely be considered a desirable attribute. Responses should include comments on these concerns, and specific examples where applicable.

2.3 Networking Requirements

Two levels of networking must be considered for the proposed system. The first is the intra-cluster network which connects the workstations to the server, or servers. The second level is the inter-cluster networking, which includes connection to the campus wide ethernet.

2.3.1 Intra-cluster Networking

The purpose of the intra-cluster network is to provide a high speed data path between the workstations and the server machines. The physical medium and communication protocols of this component may be vendor specific, but ethernet-based solutions will be looked upon favorably due to existing in-house facilities and expertise. Responses which propose non-ethernet solutions for intra-cluster networking should therefore include strong justification. The protocols which run on the intra-cluster network must provide transparent access to user files and global programs and data residing on the server or servers. Also, file ownership and protection mechanisms supported on traditional multi-user systems must also be supported by the intra-cluster networking. As stated previously, the concept of a *single system image* for the entire cluster is highly desirable.

2.3.2 Inter-cluster Networking

The inter-cluster networking component must be ethernet-based for compatibility with existing School of Engineering facilities, and must support industry standard networking protocols. As a baseline, the IP/TCP standard must be supported. In addition, responses must indicate vendor commitment to conform to the ISO-OSI standards as they evolve. Responses to this request for proposals should also include a list of other network protocols supported which may be of interest in the School of Engineering. Examples include Sun NFS and DECnet.

2.4 Software Requirements

The key system software issue for the proposed computing environment is adherence to industry standards in the areas of compilers, network communications, and user interface. The key application software issue is the availability of a broad array of engineering application packages, as well as more general applications such as text processing and spread sheets. It is strongly desired that all of the components considered as part of the system software be directly vendor supported. By contrast, it is desirable that the components considered as part of the application software be widely available as third party products.

Responses to this request for proposals should address each of the following items, providing availability and pricing information where applicable.

2.4.1 System Software

1. The proposed operating system must fully support multi-tasking and virtual memory.
2. The proposed system must include ANSI standard compilers. The programming languages supported must include, as a minimum, Fortran 77, C, Pascal, and BASIC.
3. A vendor commitment to support the X-Windows user interface. The responses should document current and planned support, including dates of availability, and a statement regarding the vendor's level of commitment to this standard.
4. The system must support network communications using, as a minimum, the IP/TCP protocols. User-level services must include file transfer (FTP), virtual terminal (TELNET), and electronic mail. As stated stated previously, vendors must indicate a commitment to conform to ISO-OSI as it evolves.

2.4.2 Application Software

1. A full function spreadsheet (for example, Lotus 123 or 20/20) must be available for the proposed workstations.
2. A text processing package which includes support for mathematical equation formatting must be available.
3. A wide variety of engineering software packages must be available. Examples include mechanical CAD, electrical CAD, civil engineering CADD and COGO.

3 Continuing Costs

Continuing costs of the proposed computing environment are a critical issue. Two vendor dependent components of the continuing costs are software licensing and update policies, and hardware maintenance.

3.1 Software Licensing

Software licensing on a per-CPU basis is an issue of great concern to the University. Responses to this request for proposals should detail the policies and costs of software licensing for the vendor supplied software items listed in the preceding section. Continuing costs (software updates) should be specifically addressed. Costs for both the workstations and the server machines should be included.

3.2 Hardware Maintenance

The cost of maintaining the system hardware is another issue of importance. It is expected that the most cost effective maintenance plan for a system such as the one being proposed here will involve a high degree of self maintenance. Responses to this request for proposals should address this issue. Reasonably accurate projections of the continuing costs of maintaining the proposed hardware based on a self maintenance model should be provided.

4 Other Concerns

Additional issues which should be addressed in responses to this request for proposals are itemized in this section.

4.1 Student Ownership

Workstations which meet the functional requirements described in section 2 are currently too expensive to require student ownership. However, at the rate of change of the price/performance quotient, student ownership may be a viable option in the near future. Therefore it is important to plan for this possibility in the current phase of implementation. For student ownership to be feasible, a stand-alone version of the workstation costing less than $3,000 including software would be required. Responses to this request for proposals should comment on current or planned workstation configurations which are functionally compatible with the proposed workstations, and which fall into this pricing category.

4.2 MS-DOS Compatibility

Several departments in the School of Engineering have a significant investment, in terms of both time and software, in tools for engineering education based on the MS-DOS operating system. While it is felt that the computing environment proposed here will provide much greater capability than can be achieved with a computer running only MS-DOS, it is also recognized that there will be a transition period during which the capability to run MS-DOS programs on the workstation will be essential. Responses to this request for proposals should therefore describe any MS-DOS compatibility modes that are available for the proposed workstations. MS-DOS compatibility modes which allow the MS-DOS system to utilize the central file server will be considered particularly attractive. The mode of display emulation (*eg.,* CGA, Hercules, etc.) and the level of compatibility should be documented as well.

4.3 Floppy Disk Storage

Many students own personal computers and often have need to transfer data between those computers and the system proposed here. While it is recognized that there are many ways to provide this capability, some are more convenient and attractive than others. One approach

would be to have floppy drives directly connected to the server that could be accessed directly as a shared resource. Another (more costly) approach might be to have personal computers connected to the server via high speed links, with appropriate software to effect file transfers. Any solutions that the vendor offers to provide this type of functionality should be documented.