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Report to the National Science Foundation
Grant ATM-8216250

ON THE PURCHASE OF A MINICOMPUTER SYSTEM FOR SCIENTIFIC RESEARCH

by

Harry T. Ochs
and
Stanley A. Changnon, Jr.

Illinois State Water Survey
Champaign, Illinois 61820

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Introduction

In July 1984 the Illinois State Water Survey (ISWS) took final delivery of a VAX 11-750 that was funded under National Science Foundation (NSF) grant NSF ATM 82-16250. This was the culmination of two years of effort on the part of many staff members, and the beginning of a new level of computational support for ongoing research in meteorology, hydrology, and water chemistry at the ISWS. The purpose of this brief report is to inform the relevant program managers at the Foundation of our progress in obtaining and utilizing this facility, and of recent developments that are leading to a significant upgrade in our computer analysis capability.

Purchasing the System

Figure 1 shows a block diagram of the system, as outlined in the ISWS proposal to the NSF for a computer facility. This facility was sought to allow our scientists to pursue research that was not possible with facilities on the University of Illinois campus, partly as a result of limited funding available to us to pursue this research. Table 1 presents a list of equipment and software that was proposed to fill our research needs.

Two broad categories of research requirements that were difficult if not impossible to adequately satisfy using campus facilities were 1) computations that required very large memory (and limited funds for massive data research studies), and 2) interactive color image processing.

As our proposal stated, we had intended to resurvey the computer market if our proposal was funded, and to choose the system and vendor that best met our needs at the time of purchase. As a result of a purchasing agreement

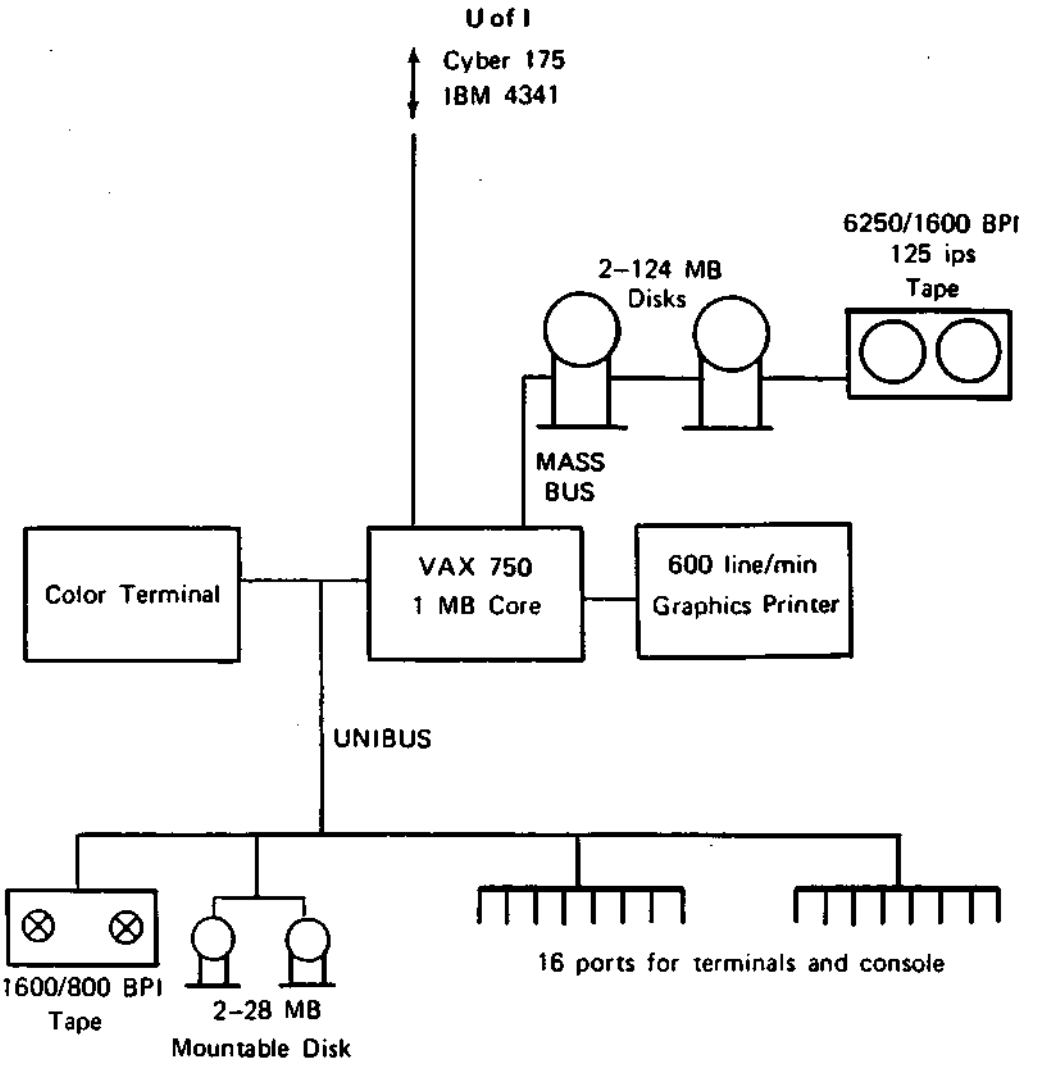

Figure 1. Original proposed DEC VAX 11-750 system.

between the NSF and Digital Equipment Corporation (DEC) (providing a 45% discount on systems purchased with NSF funds and the rush to make a purchase before the discount offer expired) the system in Table 1 was ordered at the end of June 1983. All equipment in Table 1 was converted to equivalent DEC equipment and the color graphics display was set aside as one ISWS contribution to the system since DEC did not make an adequate color terminal. Delivery of the system was first scheduled for late December 1983.

Table 1. Original Hardware and Software Specifications.

HARDWARE	SOFTWARE
32 bit Machine (DEC VAX 11-750)	Virtual Memory Operating System
One Megabyte of Memory	FORTRAN - 77 Extended
Two - 28 Megabyte Disk Dirves	Editor
Two - 124 Megabyte Disk Drives	2780/3780 RJE Emulation
Sixteen Communications Ports	Data Entry Package
Two Tape Drives	Data Management Package
Floating Point Hardware	NCAR Graphics
Console	
Printer/Plotter (600 LPM)	
9600 Band Bisync Line	

As a result of our later questions about a component of our system we learned that DEC would allow one change in our initial order. This realization became important because of the determination that DEC had never shipped the mountable disk drive that we had ordered and that engineering problems with this drive would delay delivery of our system. After learning from DEC that the order change could be as extensive as we wanted, the computer committee at the ISWS began a complete and in-depth review of our requirements. Suggestions from the NSF reviewers of our proposal were valuable in this reassessment. In

addition DEC had changed their policy of selling complete packaged systems and this provided greater flexibility in our choice of components.

From the NSF reviewer's comments and our own reassessment we concluded that our vision of what the system in Fig. 1 and Table 1 could accomplish in terms of the objectives of the research outlined in our NSF proposal was probably optimistic. Thus the goals of our reconfiguration effort were to increase computing capability and to position ourselves to best take advantage of new and cheaper technology as future expansion became necessary.

After budget constraints ended a brief attempt to substitute a more powerful DEC computer, we pursued options that would remove routine non-research tasks from the necessity for central processing unit (CPU) supervision. The following is a list of the changes made in the revised DEC order:

1) The connection to the campus computer utilizing both DEC hardware and software on the VAX was changed. Since the primary purpose for this connection was to allow local printing of jobs from the campus computer, we purchased a small used computer (using ISWS funds) of the type used at 13 other campus locations and an additional 600 line per minute printer from DEC.

2) Data entry was originally scheduled to be moved from key to floppy disk work stations to the VAX. Files were to be transferred to the campus computer using the communications software eliminated in 1 above. By retaining the key-to-disk equipment at ISWS expense, the VAX CPU could be further devoted to scientific calculation. A floppy disk reader was added to the VAX to read these data disks.

3) The new system of ordering from DEC allowed us to purchase only a license to copy the operating system from another campus station. This change

saved about $10,000. Other software costs were reduced by the decision to obtain RIM as our relational data base management system. This possibility was indicated in our response to reviewers comments and resulted in substantial savings since this package is in the public domain. In addition, RIM is written in Fortran and has been installed on several computers, whereas Datatreve from DEC is not a full data base management system and has the further disadvantage that our data bases would be locked into a single vender's hardware and software.

4) The small disk drives, the large mountable disk drive and the second tape drive were eliminated from the purchase. Mountable disks create significant management problems when included in a system with many users (e.g., several users files are always on a disk pack that is not mounted). The elimination of the mountable disks and the second tape drive required the inclusion of as many large capacity fixed disks as possible so that several large data sets could simultaneously be placed in the system from tape. Thus three 456 Megabyte disk drives were specified.

5) The main memory was increased from one to four megabytes. With more memory the operating system does not have to swap jobs to disk as often thus freeing up more CPU time for productive work.

6) The 16 ports for terminals on the original system required CPU intervention for each character typed. The 40 ports purchased each handle groups of characters at a time thus allowing more productive CPU work.

7) At that time it was also decided to purchase EUN1S (with ISWS funds) which provides a UNIX environment while still running under the DEC VMS operating system. Thus the public domain software available from the National

Center for Atmospheric Research (NCAR) and elsewhere that runs under VMS can still be used while providing a highly transportable environment for ISWS and visitor users. Many new computer systems are using UNIX and its use at ISWS will not constrain us to expand with DEC equipment in the future.

The final system which was ordered in early November 1983 is depicted in Fig. 2 and Table 2. We believe that this new configuration provides significantly greater capability and represents a more effective use of NSF funds.

Table 2. Purchased Syst em.

HARDWARE	SOFTWARE
32 bit Machine (DEC VAX 11-750)	Virtual Memory Operating System
Four Megabyte of Memory	FORTRAN - 77 Extended
Three 456 Megabyte Disk Drives	C Language
40 Communications Forts	Editor
6250/1600 bpi Tape Drive	Eunis (UNIX) Operating System
Floating Point Hardware	RIM Data Management Package
Console	NCAR Graphics
Printer/Plotter (600 LPM)	

Remote Job Entry System

DEC PDP 11/10
RJE Emulation
Printer (600 LPM)

The ISWS purchased and installed new air conditioning systems and specialized electrical wiring. In late December 1983 a minimal VAX system was received. After many negotiations with DEC, the remainder of our system was delivered during late June and July 1984. At ISWS expense, the Water Survey building was wired for terminal connections to the VAX. Total ISWS investment in equipment, software, labor, and facilities for the system was $26,000.

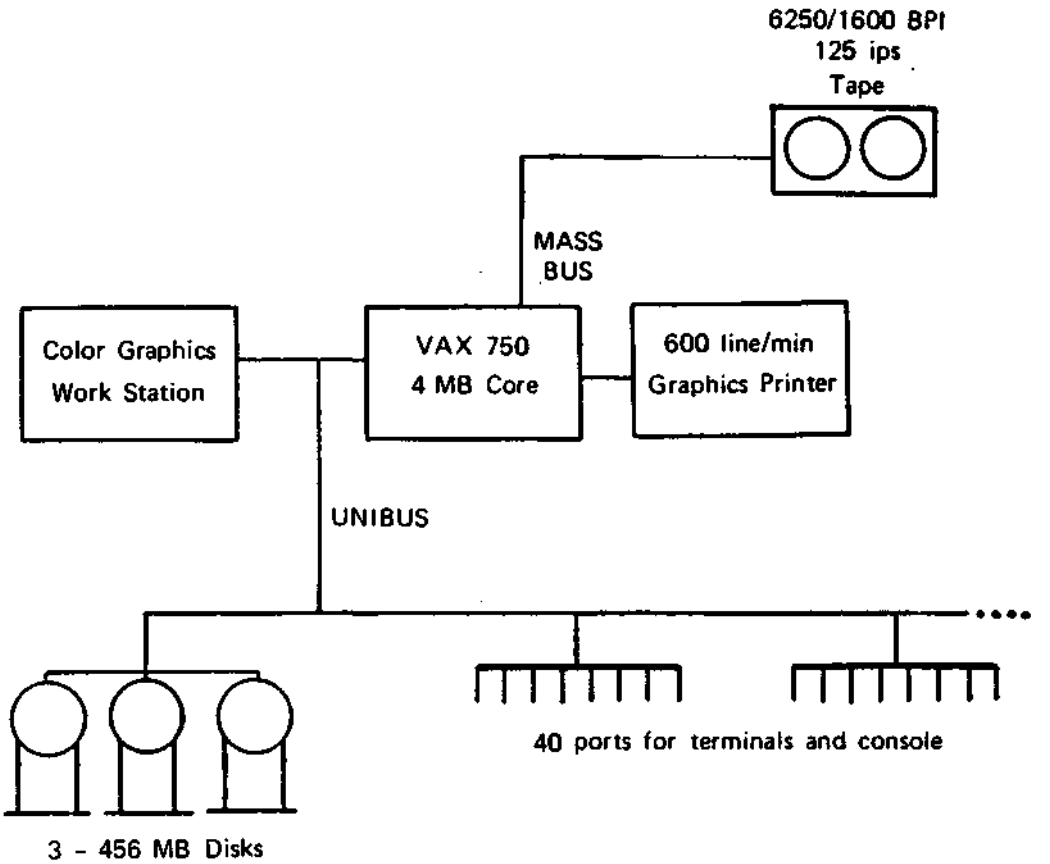

Figure 2. Existing DEC VAX 11-750 system.

Since installation the ISWS has funded maintenance charges on equipment as well as personnel costs of operating the system of about $45,000 including overhead.

Usage

Since July 1984 all system software has been installed including the VMS operating system, the EUNIS environment, RIM, and the NCAR graphics package. Numerous utility programs have been created such as one to read the specialized floppy disks from the data entry work stations and programs to facilitate the transport of various types of data from tape to disk and back to tape. An accounting package has been written that will allow us to track usage by both user and project. A system for backing up disk files has been created and is in routine operation. This entire effort has been at ISWS expense. Dr. Ochs has been the director of the system since the grant was received.

Several research programs and tasks have been moved to the VAX. The National Atmospheric Deposition Program data set which had grown too large to be maintained on the campus computer system because of the lack of sufficient disk space on that system has been moved to the VAX and is accessed for research using the RIM data base management system. Large historical water and climate data bases that were stored on a leased disk drive attached to the campus system have been moved to tape in a format compatible with the VAX and are being accessed on the VAX at considerable savings to our research effort. In the last 2 months three projects dealing with irrigation development, drought models, and weather change have used some of these data to do their computations on the VAX. Models have been moved to the VAX and programs have been written to allow interactive graphical analysis of results. Programs to

analyze satellite data are being developed on the VAX. Three new graphics terminals have been' recently purchased to take advantage of VAX capabilities.

Utilization of the system has steadily increased during the initial seven months of full operation. Our accounting system which runs automatically each week indicates a steady increase in usage with a maximum utilization in a recent week of 75% during the 8 am to 5 pm business day with significant usage during nonbusiness hours. Typical usage during the business day has been 60 to 70% of capacity with recent weeks exceeding 85%. This early usage level indicates that our effort to maximize hardware utility and minimize routine tasks on the VAX was justified. However, large blocks of unused time still exist during nonbusiness hours. As usage increases and more tasks move from the programming to the production stage, usage should increase. Production runs will be saved for over night execution.

Hew Developments

Two developments occurring in 1985 will significantly improve our ability to preform research with the aid of the computer. The first relates to our move to new quarters and the second involves the purchase of a graphics and image analysis work station.

Renovation is underway at a six building complex which will include a custom designed room to house the VAX. More importantly access to the VAX from laboratories and offices will be enhanced through the use of a new local network controlled by a Gandolf port switch. This switch will allow any terminal in the six building complex to gain easy access to the VAX, other small ISWS minicomputers, the main campus computer, or other campus computer sys-

tems. The switch will also allow the interconnection of any minicomputers or personal computers at the ISWS. Also, remote sensing devices such as laboratory instruments can be connected to computers with this network. Printers and plotters in locations remote from the VAX are facilitated with this equipment. Although the new computer communications system does not constitute a local area network in the usual sense of the term it will allow the transfer of files and data between any two sites at the ISWS.

The second development involves the purchase, with non-NSF funds, of a color interactive graphics and image analysis work station to be used in conjunction with the VAX. An Apollo DN550 computer and graphics display system costing $50,000 will be delivered in February 1985. Because of the anticipated work load on the VAX, the desirability of stand alone computing capability on the graphics work station was deemed extremely desirable. Intensive computations such as coordinate transformations of radar data or the generation of data for CAPPI displays from radar volume scans are best accomplished on an independent computer. Although these computations could be performed on the VAX in the time sharing mode, a scientist waiting at a color display for results would be significantly delayed by the requirement to share resources with other users. Since the work station will be equipped with one megabyte of computer memory and a floating point accelerator, it will have approximately the same computational speed as the VAX. Even with this dedicated computational power several anticipated computations can require many minutes. Competition with 10 to 20 other users on the VAX then becomes very undesirable. Since the Apollo has only a small disk drive a high speed connection to the VAX is still essential. Programs will be developed and stored on the VAX

and large data sets such as radar, landsat and weather satellite data will be accessed using the VAX tape drive.

Two other significant advantages to the choice of the Apollo work station involve the issue of compatible software and operating systems. First, the work station uses the UNIX operating system which is compatible with EDNIS on the VAX. Second, NCAR has recently obtained an Apollo work station and is in the process of converting the NCAR graphics package to the Apollo system thus providing a greater degree of compatibility with existing software and a graphics system that many of our scientists are already familiar with.

In conclusion, the VAX computer purchased with NSF funds has opened research areas to ISWS scientists that were previously not accessible. The additional facilities at our new location will continue this process and our new interactive graphics work station should significantly enhance our capabilities.