PERSONAL WORKSTATIONS

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ABSTRACT

Personal workstations may be used to construct a distributed computing system in which the computing power of a processing unit (cpu) is dedicated to individual users and shared resources are accessed via a local area network. This talk will examine the requirements of some applications which exist in a large physics laboratory such as CERN and will compare such a computing system of personal workstations with a traditional computer installation.

The specifications of personal workstations will be discussed and special reference will be made to the Apollo Domain and the PER0.

1 INTRODUCTION

Physics laboratories, such as CERN, traditionally use large number crunching computers for data analysis, mini computers for graphical analysis of data and mini computers for accelerator control and experiments. In recent years the micro computer and bit slice technology have been used to simplify control equipment and to replace some of the functions of the mini computer.

As the cost of hardware has decreased, more attention has been given to simplifying the labour intensive job of programming. Programming has also become the most expensive, most time consuming and least reliable part of creating a computer system. CERN has a large IBM computing centre which is a great success because it provides extensive program preparation facilities.

Now, there is a new type of computing system appearing on the market which uses the micro computer and bit slice technology and has the sole aim of increasing a programmer's productivity. This new system is based on personal workstations and local area networks. The personal workstations contain their own central processing unit (cpu), local file storage and the ability to attach local devices. Shared resources such as printers, magnetic tape units and central file storage are accessed using the local area network.

This talk will endeavour to demonstrate in what respects the distributed personal workstation system can be used in the Physics environment. The PER0 and Apollo Domain systems will be taken as examples of state of the art personal workstations.

2 WHAT DO PERSONAL WORKSTATIONS OFFER

When the user of a PER0 or Apollo Domain sits at his personal workstation he has a moveable keyboard, a high quality bit mapped display that is capable of animation, a graphic input device, access to a Winchester disc with at least 25 Mbytes of storage and a floppy disc drive. He is also connected to a local area network which gives him access to other personal workstations, printers, tape drives, a common file base and any other expensive peripherals required by his user community.
Personal workstations have recently entered the commercial market and for many applications their price remains relatively high. Various models offer more or less the same facilities for the same sums of money. This ranges from ten thousand dollars for something slightly better than an intelligent terminal to sixty-five thousand dollars for the equivalent of a full mini computer configuration. The pricing structure includes reductions for educational or quantity orders.

The PERQ and Apollo Domain represent the top of the range of scientific personal workstations and will more than satisfy requirements for some applications. It is possible to buy a system consisting of five PERQs or Apollos and a network for the equivalent price of a Vax computer. In terms of processing power this is equivalent to two to three VAX computers. In order to increase the power of a personal workstation system, the user buys more personal workstations and adds them to the network. Increasing the power of a Vax computer system is more difficult.

2.1 Single user operating system

The PERQ and Apollo Domain personal workstations each offer the Unix operating system and one other. Apollo provide Aegis which is based on Software Tools (Ref. 1) and PERQ provide POS (Perq Operating System).

The personal workstation's software is constructed to enhance the productivity of the programmer. The software is specifically designed to give good source program maintenance. The latest in full screen editors, compilers, cross compilers and symbolic debuggers are available or being developed. New facilities include menu driven utilities and multi-tasking through a windowing mechanism. For example, a user can edit his source in one window, run his program in a second window and control the debugger through a third window. The programs take advantage of good interaction and the presence of a pointing device for selection from a menu. The presence of menus saves the user remembering how to access the facilities available in each program.

2.2 High Level Programming Language

The operating systems for the Apollo Domain and the PERQ are written in high level languages. Unix is written in C, Aegis in Fortran and POS in Pascal. On the PERQ the machine instructions are microcoded for good high level language performance. A machine code assembler for the PERQ is not available.

2.3 Local Area Network

A personal workstation is built around a local area network connection. The system is constructed to accept connections to other workstations, devices, computers or networks. The network connection is an integral part of the personal work station. It may be used for file transfer, remote job submittal and retrieval, electronic mail or to provide terminal access.

Apollo Domain connects to other Apollo personal workstations via a twelve megabit token ring and has external connections to Ethernet. A PERQ can be attached to a Cambridge Ring or an Ethernet.

The reliability of the system as a whole is improved by the amount of redundancy that has been introduced. If a personal workstation is not working the rest of the system will continue as before. If the local area network is not functioning each personal workstation can work alone. Maintainability is reduced due to the
geographical distribution of the system. This may be compared to the
maintenance of terminals with additional devices such as central
processors, Winchester discs and graphical input/output devices.

Personal workstations may be configured on a local area network
or as a stand-alone system so that a user can develop his programs in
a rich environment and then run on a single stand-alone personal
workstation.

2.4 Raster Scan Bit Map Display

The PERQ and Apollo Domain are equipped with advanced bit mapped
displays. The setting of bits in a part of memory is directly mapped
to the display. Special machine instructions which operate on the
memory are used for very fast graphics including the possibility of
animation. For good graphical working it is essential to have
excellent interaction. This can only be provided by a dedicated
processor.

The bit mapped display of the PERQ and Apollo Domain is the size
of an A4 sheet of paper and is capable of displaying many character
sets. This type of display may be compared to printing dots on the
page of a newspaper giving one the power to display graphics and
illustrations. Updating the display screen is done by the dedicated
processor operating on the bit map in memory. The PERQ uses microcoded
rasterop instructions to copy rectangular sections of memory and the
Apollo uses a microcoded bit mover instruction in a programmed loop in
order to do the same thing.

Minicomputers can only support a small number of people doing
interactive graphics and the resulting response times are
unpredictable.

2.5 Central Processing Unit

The Apollo Domain contains two Motorola 68000 chips. This is
available with a four kilobyte cache memory and a separate floating
point processor. The PERQ uses the AMD2901 bit slice with four
kilobytes of writeable control store. The AMD2901 is microcoded for
efficient high level language implementation.

2.6 Memory

Half to one megabyte of physical memory is now considered
standard. Access to this memory is via virtual addressing. The Apollo
Domain can page its memory over the network so that a local disc is
not necessary.

2.7 File Storage

Personal workstations normally include at least twenty-five
megabytes of Winchester disc. The Apollo Domain allows easy access to
all files on the local area network.

2.8 Interfaces

The PERQ and Apollo personal workstations are equipped with
RS232C connections. The Apollo Domain has a multibus option and the
PERQ provides a GBIP interface. A user may connect special devices to
his system without interfering with others or he may make special
devices become generally available to the user community on the local
area network.
3 APPLICATIONS

This is an attempt at giving requirements for computer systems that are used by physicists. There will be an attempt during the talk to solicit requirements from the audience. Whatever type of system one tries to construct there are some requirements which are general. The main ones of these are cost effectiveness, maintainability or reliability, how easily the system can be tailored to the user's needs etc.

In the text which follows the attention will be on specific needs associated with types of applications. Each section could be extended into a complete paper.

It will be seen that personal workstations can satisfy some of these requirements better than the traditional computer systems.

3.1 Control Systems

Control systems for accelerators are very special. They are constructed out of special fast local area networks and commercially available microprocessors.

3.1.1 Program Development for Micro Processors

In order to develop programs for a microprocessor the user needs to prepare program source, compile or assemble that source, link, load the resulting object module into a microprocessor and debug.

The problem of source maintenance may be solved by the provision of a reliable filing system, an editor, version management and access to a central library of routines. Compilation or assembly, for efficiency reasons, must take place on a computer containing a reasonably fast processor and fast access to file storage.

The microprocessor used in the development stage should be configured so that it is as near the finally required system as possible. Therefore both the source maintenance and compilation or assembly are best done on a machine other than the target microprocessor. It should be easy for a user to connect the microprocessor to such a system in a way which does not interfere with this aim. His connection at the host computer end should be simple and should not effect other users of the system.

A good debugger should debug using the symbolism developed in the user's program source. This is important for compilers and assemblers that produce relocatable code. The interactive symbolic debugger needs access to the symbol table produced by the linkage editor, compiler or assembler. The interactive symbolic debugger is best run on the same computer that linked, compiled or assembled the program. It is necessary to have a means of communication between the debugger on the host system and the target microprocessor.

A dedicated processor is needed if one is to keep track of selected locations, or take performance statistics.

The personal workstation can provide the processing power and the interfaces.

3.1.2 In Situ Micro Processor Fault Diagnosis

Debugging microprocessors is difficult due to the real time nature of their programs and their geographical distribution. In order to keep costs low it is not possible to have extensive debugging facilities in each microprocessor. So, as for the development stage,
it is desirable to have the same minimum software and hardware communication to another computer. The other computer must be able to connect easily to any of the microprocessors in the system. This implies portability and the ability to connect via a simple mechanism to the microprocessor.

A stand-alone personal workstation can be taken to the microprocessor or a local area network connection can be established.

3.1.3 Control System Display Console

The control system of an accelerator is difficult to control. There is maximum emphasis on the interface between the people who control and the control system. On the hardware side this includes special input devices, high quality colour displays, lots of computer graphics, a dedicated processor and a network connection. The display system must be fast when interacting with the operators. On the software side the handling of the graphics must be fast and easy. Special languages such as Nodal enable the operators to interact with the control system at a high level. In order to guarantee consistent response times it is necessary to dedicate a processor to each device.

This set of requirements describe a personal workstation.

3.2 Experimental Data Collection

The speed and the large amount of data which is generated during experiments require special techniques to read the data and to select that data which is to be kept for later processing. The processing of that data is complex so that large number crunching computers are required. The data storage must be accomplished by a computer with a means of accepting and storing large amounts of data. In order to check the validity of the data, some of that data must be selected as a sample to be sent immediately to a large number crunching computer where the parameters for the experiment are set up and checked. The results of sampling must be returned to the experimenter and displayed in a meaningful way.

The raw data sent back from the number cruncher may be further processed and displayed by the personal workstation.

3.3 Program Preparation for Number Cruncher

As for all program developments the main problem is one of source maintenance, compilation and debugging. While number crunching computers excel at fast real number calculation they are often lacking in other support functions. Front end computers are often required in order to control the stream of jobs entering the computer. It is therefore better thought of as a batch job device. This precludes any direct interaction which is normally necessary for editing source text and debugging. Such work should be carried out on a computer which is good at source maintenance and is connected to the main computer. The connected should enable the user to submit a job, examine its progress and obtain the results. The personal workstation should be capable of displaying the results in the most meaningful manner.

The problem of source maintenance may be solved by the provision of a reliable filing system, an editor and version management. The user would like as much checking of his program as possible before submitting his job to the number crunching computer. Local syntax analysis of the program source and computer generated job control language can be used to ensure that the program will at least get as far as linkage edition and probably execution.
The personal workstation is well equipped to provide a good user interface to an otherwise unfriendly system.

3.4 Analysis and Examination of Experimental Results

The analysis of experimental results needs a large number crunching computer as has already been described. However, once the results have been generated there are many techniques for examining them. Graphical representations of large data is necessary. This can be the simple generation of histograms to two dimensional representation of three dimensional data on partial tracks. The latter requires three dimensional rotation or true three dimensional techniques. Again this implies communication between a special purpose graphics processor and the number crunching computer.

A personal workstation with a special attached graphic's processor or detached array processor (e.g. PERS in future) would replace today's expensive partially interactive, three dimensional graphical devices.

3.5 Documentation and Papers

The aim of a text processing system is to give the user high quality layout of documents with the minimum attention to such details as text input and alteration. Hence, text will automatically be aligned. The user will need to work in terms of the completed document rather than some cryptic equivalent. Any changes must appear immediately in the final form. The system must be capable of displaying all parts of a document including mathematical formulae, graphs and illustrations. All of this should be done interactively so that the user may experiment with changes to the layout etc.

Personal workstations solve exactly this type of highly interactive computing intensive task. The provision of menus removes the problem of remembering the awkward commands that exist in present day systems.

4 CONCLUSION

The personal workstation has the following advantages -

- Improved reliability against system failure due to greater redundancy in hardware and software.
- Improved flexibility in tailoring the system to the users needs.
- Fast and consistent interaction with the system.
- High quality bit mapped displays for good graphics and text processing.
- Easy connection of special devices from microprocessors to graphical input devices.

The minicomputer has the following advantage -

- Large numbers of terminals may be attached.
- The maintenance of the computer is centralised.

When your way of working is not as good as using an Apple home computer there is definitely something wrong. Professional personal workstations can increase your productivity!
- 200 -

REFERENCE


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QUESTION

MR. M. TURNILL BNOC GLASGOW

• Q ---› To us in the oil industry, personal workstations look very attractive. However, we certainly need a much higher level of interfacing for the user than FORTRAN can provide. For each range of users, e.g. structural engineers, reservoir engineers, secretaries, a user-orientated station must be made available.

• A ---› (Mr. U.M. Wambach GSI/6100 Darmstadt) I see the workstations as a useful development tool in the development of physics instruments, if they satisfy these criteria:
  - Bring the software tools as close to the equipment as possible for debugging and system extension,
  - Provide a range of I/O capabilities to make interfacing easy,
  - Support a high-level system implementation language.