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SCIENCE AND ENGINEERING RESEARCH COUNCIL
RUTHERFORD APPLETON LABORATORY

COMPUTING DIVISION

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A P P E N D I X B

SOFTWARE ENGINEERING INFRASTRUCTURE POLICY

1. INTRODUCTION

This paper is a modified version of the current Alvey SE Infrastructure Policy as given in "Alvey Programme, Software Engineering Strategy, Nov 83".

2. PROPOSED SE INFRASTRUCTURE : SUMMARY

2.1 Software

SERC Common Software Base (see apppendix 2) to be used for:

(a) all academic projects (where sensible)

(b) all 1st generation IPSE consortia

(c) all other SE consortia where sensible.

2.2 Single User Systems

SERC Common Hardware Base (see appendix 2) to be used for:

all academic projects (where sensible).

Alvey consortia to conform to Infrastructure W P recommendations (where sensible).

2.3 Multi-User Minis

SE Infrastructure Policy (see appendix 1) to be used for:

(a) all academic projects (where sensible)

(b) all industial projects (where sensible).

2.4 Mainframe

New mainframe service to be set up based on IBM or Atlas 10 running UNIX and Common Software Base.

2.5 Communications

All Alvey SE participants to be networked together immediately by PSS or Janet to run

(a) coloured book electronic mail (local or via RLGB)

(b) COM

(c) coloured book file transfer.

Long term Alvey communications to evolve to use ISO standard protocols.

ALVEY SOFTWARE ENGINEERING

INFRASTRUCTURE POLICY

1. INTRODUCTION

The Alvey Software Engineering Programme is establishing an infrastructure, containing the SERC's Common Base Policy (CBP), which will form the framework within which to research and develop the first and second generation IPSEs (integrated project support environments) as outlined in the Alvey Software Engineering Strategy.

In outline the envisaged SE Infrastructure will see a typical project have a powerful, multi user mini (MUM) Unix system linked by high speed local area network to a set of high performance Single User UNIX Systems (SUS) running the Common Software Base and Communications protocols with access to the large data storage and cpu power of a mainframe also running UNIX and the Common Software Base.

2. SUMMARY

2.1 Software

a.	SE Research Tools (examples)	ML, HOPE, LCF.	
		Ada, Modula-2.	
		Affirm, Stanford Pascal Verifier.	
		Boyer-Moore, Iota.	
		LISP	(IKBS recommended version)
		Prolog	(IKBS recommended version)
		Pop-2	(IKBS recommended version)
b.	Languages	Pascal	(ISO Standard)
		Fortran 77	(ANSI Standard)
		Cobol	(which Standard?)
		Ada	(ANSI Standard)
c.	Graphics	GKS	(BSI and draft ISO Standard)
d.	Operating System	UNIX	(32 bit, virtual memory)

2.2 Computer Systems

a.	Single User Systems	32 bit SUS	(current CBP m/c is PERQ)
b.	Multi-user Mini	32 bit MUM	(VAX, GEC Series 63)
c.	Mainframe		(to be decided)
d.	Servers		(Not yet available)

2.3 Communications

a.	Local Area Network	Cambridge Ring Ethernet	(UK CR82 standard) (CSMA/CD for IEEE802)
b.	Wide Area Network	X25	(JANET & PSS)
c.	Protocols	JNT Coloured Books	(UK academic standards)

A more detailed exposition of the technical components and philosophy of the policy is given below.

3. SE RESEARCH TOOLS

The following list contains those tools which are known to be of interest to several groups of researchers and therefore would benefit from wider availability via the SE Infrastructure. The list should be regarded as 'provisional'.

3.1. Functional Languages

ML, HOPE, LISP.

An STI workshop at RAL led to the expression of considerable interest by the community in having LISP, ML and HOPE running identical versions on all SE Infrastructure supported systems.

ML is associated with LCF (see below).

3.2. Logic Languages

PROLOG

There was some interest expressed at the RAL workshop in PROLOG. The SE programme should be able to get PROLOG via the IKBS programme.

3.3. Procedural Languages

ADA, MODULA-2

Ada is available on VAX/UNIX from the SERC funded work at York. The same compiler is being moved to the PERQ.

The Cambridge VAX/UNIX Modula-2 compiler has been moved to the PERQ.

3.4. Verifiers, Theorem Provers

LCF, AFFIRM, SPV, B-M, IOTA

The UK does not have all of these systems. Only LCF and Boyer-Moore are available, currently on the Edinburgh DEC-10 which will be shutdown in October 1984. LCF is also available on VAX/UNIX.

There is considerable support for having LCF available on all SE Infrastructure supported systems.

The Stanford Pascal Verifier is being mounted on VAX/UNIX by Strathclyde via an SERC EMR.

The Alvey SE Director and Prof Jones, Manchester are working at obtaining AFFIRM and IOTA.

4. LANGUAGES

4.1 Cobol, Fortran 77, Pascal, Ada

Cobol, Ada, Pascal and Fortran 77 have been chosen as they are the most popular languages. They possess the properties of portability and official standard definitions. There is a large amount of software already written in them which allows people to make use of existing investment.

There is considerable SERC support for Fortran 77 and Pascal. This takes the form of software tools and techniques developed by the SERC Software Technology Initiative and the activities of the SERC Computing Service team and the SERC Common Base Programme.

The technical definition of Pascal is given in (ref 1).

The technical definition of Fortran 77 is given in (ref 2).

The technical definition of Cobol is given in (ref 16).

The technical definition of Ada is given in (ref 17).

4.2 Other languages

Other languages will be available with the set of software tools in the SE Infrastructure. For instance the Unix 'C' language is already available. LISP and Prolog are being implemented.

These other languages will not receive the same degree of support and tool development as Pascal and Fortran. They are not 'blessed'. This situation must be reviewed regularly.

Evolution of status from 'other' to 'blessed' is possible.

4.3. Mixed Language Working

It is a requirement of the SE Infrastructure that 'blessed' languages should be inter-workable at the procedure call level ie a Pascal program can call a Fortran subroutine which can call a Pascal procedure etc. This is a vital capability to ensure maximum use of standard components. It is ridiculous to have to, say, reimplement a Fortran graphics package in Pascal because Pascal cannot call Fortran.

Interworking has implications for compiler construction and operating system development. It has its limitations and difficulties, eg the difficulties in enforcing type checking across procedure interfaces, but its benefits outweigh its drawbacks. (Reference 15.)

5. GRAPHICS

In line with the policy of supporting international standards and portability aids the SE Infrastructure has 'blessed' GKS 7.2 (the ISO Standard Graphics Kernel System) as its basic graphics package. GKS will be available on all SE Infrastructure supported systems to help the transfer of graphics software and, via metafile standards, pictures themselves.

The technical definition of GKS is given in (ref 3).

The technical definition of metafile standards is under development by ISO.

6. OPERATING SYSTEM

6.1 CBP UNIX

Unix is already a de facto standard in many academic institutions in both USA and UK. It has enabled a great deal of software to be shared amongst research groups and has built up a large quantity of widely applicable software.

Unix is being used increasingly by industry again both in the USA and UK. The CBP philosophy is based on the following properties of Unix.

a. It is popular ie a de facto standard.

b. It is implemented on a wide variety of makes and sizes of computer (IBM 370 - M 68000).

c. It is cheap ($150 per PERQ).

d. It has a large body of user level software.

e. It is used by both industry and academia.

The CBP Unix has the following properties

a. It is full '32 bit'.

   Arithmetic is 32 bits by default to overcome the annoying limitations of microprocessors. 8,16,32,64 bit quantities are available.

b. It is virtual memory.

   Full 32 bit addressed linear address space (via paging) removes the size restriction which is often so frustrating.

The technical specification of Unix is given in (ref 4).

6.2 UNIX Evolution and Standards

There are several versions of UNIX either in existence or soon to be announced. These include Berkeley 4.1 and 4.2, Bell version 7, System III and System V version 1.0 and 2.0.

The SE philosophy is to run the same, stable version of UNIX on all the different types of hardware supported by SE ie only one version of UNIX will be supported by SE.

There must be a balance between the benefits of new developments and the benefits of stability and standardisation. Thus moving to a new version of UNIX will be a major evolutionary step for the SE Infrastructure, especially if and when more than one CPU type is involved.

For supported systems UNIX is mandatory. Ideally the standard should be the AT&T version. However, the support of languages and environments and the interactive style of program development make particular demands that in the past have been met only by the Berkeley version:

- virtual memory supporting incremental compilation, non-local patterns of access, etc,
- interprocess communication,
- superior job control and user environment.

AT&T System V2.0 is a significant move towards these requirements but is known not to provide IPC, and the initial version of virtual memory is not yet known to be satisfactory.

It is unavoidable therefore that a certain degree of deviation from standard AT&T UNIX will be required at least on the SUS and MUMs. This is likely to limit the number of different systems that can be brought into the list of supported equipment since resources will be required to enhance the basic systems.

The policy will be to converge on the AT&T version whenever that is possible.

7. SUPPORTED COMPUTER SYSTEMS

7.1 Single User Systems

The PERQ was the first machine which satisfied the requirement for a high performance single user system (see Appendix 2). Other machines are likely to follow (some are already here). The expected proliferation of machines will tend to fragment the software development activities because some things will always be machine specific. The Directorate therefore wishes to balance the benefits of standardisation (which acts against change) with the need to give state of the art facilities to researchers (which requires change). The SE Infrastructure is therefore expected to include more than just today's PERQ but such changes must be taken infrequently and given very careful consideration beforehand.

It should be borne in mind that the dominant criterion for choosing a single user system must be that it runs the Common Software Base rather than has some new hardware feature. The investment in software is already so large that computers must be purchased which run existing software rather than the Directorate's money be wasted on reimplementing existing software on some new hardware. Manufacturers will have to understand the changing balance of power between them and their customers. The cpu independence of Unix is a key factor in this equation.

The recommended CBP PERQ configuration is:

PERQ:
1 Mbyte main memory
16K writeable control store
24 Mbyte disk
tablet
puck (3 button 'mouse')
LAN interface
X25 front end (one per installation for connection with WAN)
1 Mbyte floppy disk
100 pixels per inch A4 display

For advice on peripherals such as printers suitable for use with PERQ contact CBP User Support at RAL.

The technical specification of the PERQ is given in (ref 5, ref 6).

7.2 Multi User Mini

The IPSE requires not only high performance SUS for highly interactive tools but also major computational power (verifiers), storage (database, backup) and peripherals (printer, communications, tape deck, archiving). It is expected that each research project engaged in a significant amount of SE research will have a MUM to complement the SUSs. The MUM must run the same Common Software Base as the SUS. The MUM is a necessary infrastructure component because

a. SE investigators need to run imported software

b. a MUM allows more users to be given access to simple services which do not require a SUS.

c. SUSs need a host machine to provide an interim 'server' capability for archiving, printing etc

d. many SE investigators now require computationally intensive tools such as theorem provers especially the VAX/UNIX implementation of LCF from Cambridge

e. it is important, as far as is possible, to provide technical compatibility with the IKBS and other Alvey communities as productive cross fertilisation is likely

f. an infrastructure machine could provide a pump priming facility to enable work to be done prior to and in preparation for an Alvey grant.

A typical SE Infrastructure MUM configuration is

MUM: Powerful, multi-user minicomputer eg GEC series 63, VAX
4-8 Mbytes main memory
500-1000 Mbytes disk storage
9 track 1600 bpi tape deck
Line printer, upper and lower case
Documentation quality printer (till Laser Printer LAN server)
Local area network connection
Wide Area network connection (till LAN server)
5 'conventional' VDUs (+5 SUSs)

The SE supported MUMs are the GEC Series 63 and the DEC VAX. This is a common policy with IKBS.

The SE Specialist System MUM is the High Level Hardware Orion which is approved vehicle for 'virtual machine' type projects which require good microprogramming facilities. IKBS and SE both approve the use of the Orion for such projects.

7.3 Linked SUS-MUM IPSE Distributed Computing System

The MUM/UNIX system is envisaged as being accessible to 5 users via conventional terminals and to 5 users via high performance SUS PERQ/UNIX systems, via a high speed local area network. Peripherals, including a laser printer and wide area communications, will be shared by all (SUS + MUM) systems through LAN servers eventually and via the MUM in the short term.

Such a distributed computing system will consist of 6 UNIX systems connected via file transfer and remote login facilities based on the JNT coloured book protocols. It is envisaged that a more unified, logically integrated (remember the IPSE target), physically distributed UNIX software environment will come into operation in the mid 80s as a result of non UK work, the SERC's DCS Programme and general UK progress towards the IPSE.

7.4 Mainframe

SE projects are likely to need

(a) large batch CPU power
(b) fast response + CPU power
(c) large data storage
(d) general service
(e) pump priming.

Large batch CPU power is likely to be required for work involving mechanical theorem proving. This type of work tends to be computationally intensive. For instance, ML/LCF is sometimes run overnight on a VAX 750 to reach a conclusion.

Similarly some theorem provers are interactive, using the man's skill to help speed up the proof process. Such systems still require large CPU power, greater than a minicomputer can provide.

Large data storage is likely to be required for archiving MUM and SUS data, for holding Alvey-wide data such as software libraries, conferences (in the electronic mail sense), online news bulletins, lists of projects and other management information.

Large data storage combined with CPU power is likely for tools which require both such as analysers (control + dataflow) and quality certification.

There is a requirement for a general service to researchers whose departmental facilities are inadequate. Often it does not make sense to buy a small VAX for a small project if a mainframe service exists. Pump priming is an extremely useful facility (cf ICF DEC-10) but cannot reasonably be done on anything but a mainframe.

A mainframe service is also a good coordination vehicle because software and data can be shared between many people. In particular the DEC-10 at Edinburgh has shown this to be true; additionally the DEC-10 has had the advantage of facilitating the development of single versions of software tools, whereas multiple MUMs and SUSs act against this uniformity. The mainframe version is a natural reference standard.

Much SE work is highly interactive in nature. A mainframe service for the most demanding users will therefore only be of benefit if the networking service is of a high bandwidth (greater than 4.8 Kbit/second) and the system response time over the network is low (less than 0.2 seconds). Providing such a service may therefore entail investment in high performance network links. Ideally the development of this service will include provision of the 5620 type of bit map displays, but current network protocols are particularly weak in the area of supporting highly interactive work.

A mainframe service only makes sense if it runs the same basic software as the SUSs and MUMs. Thus the SE Directorate would like to have a large mainframe, such as an ICL Atlas 10 or an IBM 3083, running the Common Software Base. This is feasible today through Amdahl's UNIX system UTS which runs on both the Atlas 10 and the IBM range. (Rumours abound about when IBM and ICL will announce UNIX as a supported product).

8. LOCAL AREA NETWORK

8.1 Cambridge Ring

The SE Infrastructure requires a fast local area network to link its machines together. The Cambridge Ring has been chosen because it is

a. a UK BSI standard (CR82, ref 7).

b. SERC CBP and SERC DCS Programme's common equipment

c. has protocols already implemented for Unix which are a UK standard.

d. it is an easily purchased and maintained commodity from a variety of UK suppliers.

The technical specification of the Cambridge Ring is given in (ref 7) and the protocols in (ref 14).

8.2 LAN Evolution

The Cambridge Ring is not the only LAN currently available, but has been chosen as the CBP LAN for the above reasons.

There are several different types of Ethernet and Token Ring LANs available or soon to be announced. The IEEE 802 standard initiative is having a beneficial influence but has yet to be adopted as an ISO standard.

The SE Infrastructure will support CSMA/CD to IEEE 802.

8.3 Campus X25 Switches

Where a campus has installed an X25 system to act as a LAN then the SUS can access this via the hardware and software given under section 8, ie X25 campus LANs are 'blessed' by the CBP and the SE Infrastructure.

9. SERVERS

The long term objective of the SE Infrastructure is to exploit the advantages of distributed computing and LANs which can be realised as Servers. The following Server requirements can be identified as desirable but not yet deliverable as 'service' equipment. There is an urgent need to develop such servers into commercial products.

9.1 Publication Quality Printing

There is a requirement for sophisticated, high quality (at least 300 pixels per inch) text and graphics printing capability to complement the Single User System's display.

Examples are hardcopy of scientific papers (camera ready including diagrams), graphical software tool output, 'mathematical' text (proofs) and so on.

It is envisaged that this need will be met by small, relatively cheap (<£5K) laser printers, one per department, configured as a LAN server. Until this technology is readily available (1984?) such items as Diablo daisy wheel printers and Versatek graphics devices are suggested (Contact RAL CBP team for advice).

9.2 LAN/X25 Gateway

It is seen that an LAN to X25 (JANET and PSS) gateway will be the most cost effective way of connecting a number of machines to the WAN. No products are currently supported.

9.3 LAN/LAN Gateway

Multiple campus LANs, whether the same type or not, are likely to arise with the consequential need to connect one LAN to another.

No products are currently supported.

9.4 File Server

Single user systems cannot hold all of the data to which a single user requires access. Nor can a SUS handle file backup and archiving requirements.

In the short term the SE Infrastructure recommends that SUS are not used stand-alone but are connected to multi-user machines with suitable peripherals to allow file access and archiving.

The more desirable solution is to have file and/or archive servers. No products are currently supported.

10. WIDE AREA NETWORK

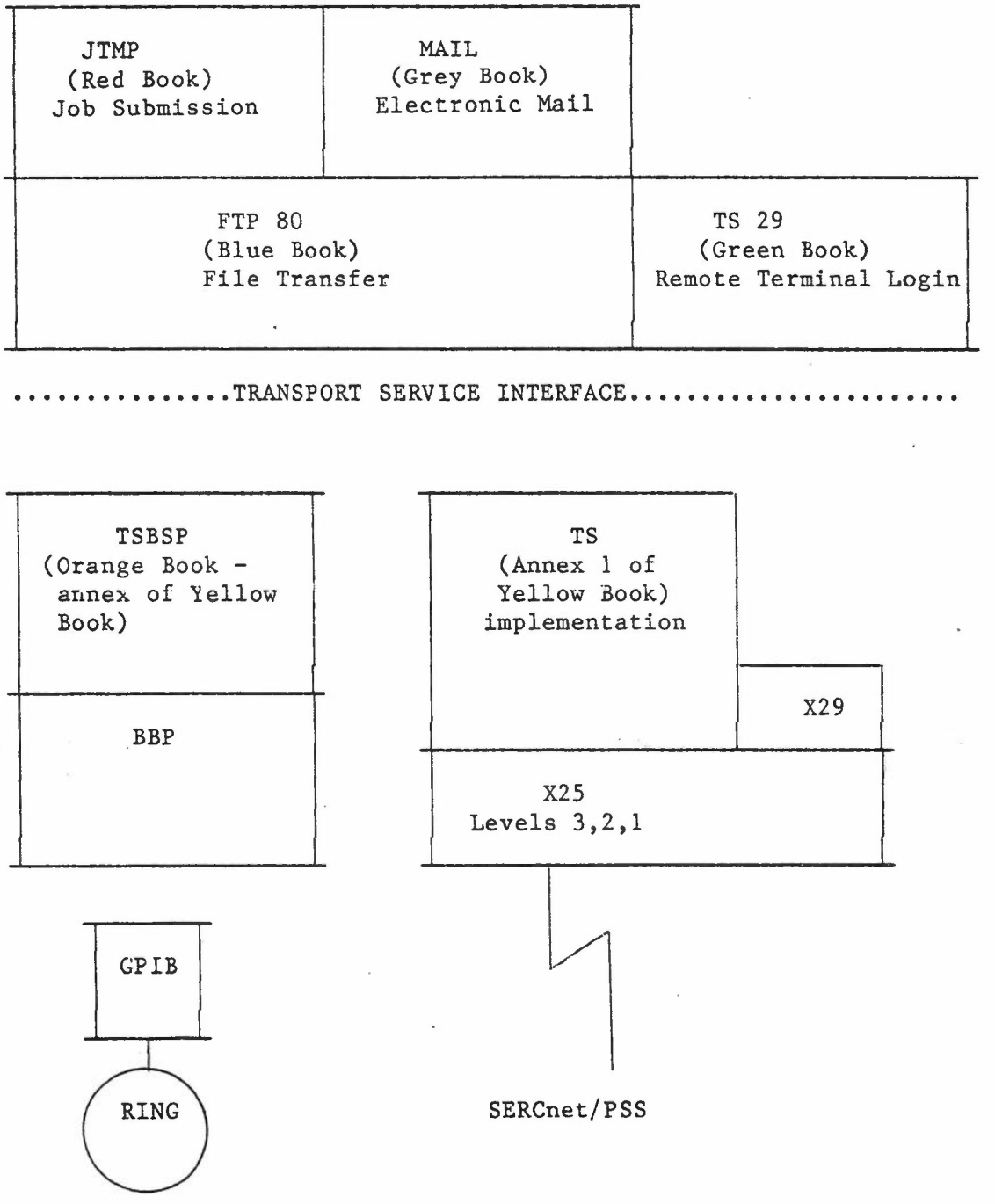
The SE Infrastructure requires a national wide area network to link both people and machines. The network will follow Alvey Communications Policy. The current SE Infrastructure uses JANET and PSS which are technically compatible X25 networks linked by a gateway.

The SE Infrastructure also requires access to Europe (including Scandinavia) and the USA. Such links are not all easily available.

The PERQ-X25 and VAX-X25 connections, in the short term, will be via the York LSI-11 transport service front end originally designed for the PDP-11.

The technical specification of JANET X25 network is given in (ref 8).

11. PROTOCOL STRATEGY



11.1 CBP Protocols

The protocol strategy is based on the de facto UK academic standards approved by the SERC/CB JNT in their 'coloured books'. The adoption of the Wide Area Network protocols of transport service and above for the local area network use gives a useful unification of LAN/WAN facilities. The average user sees only one and the same mechanism to move files, mail etc between machines independent of distance (ie local or wide area net). The adoption of transport service also gives a degree of hardware independence for local area networks.

The use of wide area protocols for local area networks is 'conservative' in that it does not allow various advantages of LANs to be exploited eg speed, reliability. More LAN specific (light weight) protocols could be employed for high speed intermachine interaction (eg remote process execution). Such protocols should only be 'blessed' if they attain a measure of widespread acceptability. Specific research projects are likely to require lightweight protocols. They should not be discouraged in appropriate circumstances.

Transport Service around the Ring is implemented by TSBSP (Transport Service Byte Stream Protocol) running above BBP (Basic Block Protocol). These are the de facto UK academic Ring standard protocols based on Cambridge University's work.

The protocols specifications are given in (refs 9-15).

11.2 Conferencing, Bulletins

Electronic Mail as implemented over the Grey Book is an extremely useful facility. However, experimental work at various sites in the world has shown the potential advantages of more sophisticated facilities above simple mail. Such facilities include message based conferences and public electronic bulletin boards.

No ISO approved or de facto standards exist in these developing areas. The SE Infrastructure could possibly evolve to include such facilities. Esprit is using COM.

11.3 Protocol Evolution

The JNT coloured books and the CR82 Ring protocols are not ISO standards nor are they likely to be. It will be necessary eventually to change the protocols on both WAN and LANs in the light of current development work on protocols to whatever emerge as international standards. This will be a major change for the entire network community and will not come quickly.

12. PORTABILITY

Fortran 77 and Pascal will, for example, allow PERQ CBP software to be moved to and from other non PERQ computers. However it is recognised that even when programs are written in Fortran 77 and Pascal much work often has to be done to move them because of the inbuilt operating system dependencies. By using 32 bit, virtual memory Unix as a de facto standard execution environment it should be much easier to move programs in Pascal and Fortran 77 from one CBP Unix system to another.

Portability is also one of the reasons for backing national and international standards generally, hence the use of the GKS graphics package. GKS will be available on all SERC supported machines.

Portability of software is also one of the aims of the networking side of the SE Infrastructure. Good communications are needed if software is to be easily shared by geographically dispersed research groups.

13. APPLICATIONS SPECIFIC SUPPORT

The SE Infrastructure is expected to be expanded to include some items related to specific applications. These might possibly be the NAG library, RAL graphics library etc as well as software development tools from the SERC CBP, Alvey SE, IKBS etc. In addition much applications specific software will be generated 'on top of' the SE Infrastructure and which will be generally available but which will not actually be part of the SE Infrastructure. The SE Infrastructure is supposed to form the 'base' not the totality of available software.

14. GENERAL POINTS

a. Great stress should be laid on the fact that the SE Infrastructure does not see single user systems as standalone systems. Networking is the key to file backup, mail, software update and interchange.

b. SE Infrastructure links people just as much as computers.

c. SE Infrastructure aims to back international standards if possible.

d. Software sharing and portability only really come when both the programming language and execution environment (ie operating system) are defined. The corollary is "it's OK to change the machine - just don't change the (user/program and program/operating system) interfaces".

15. REFERENCES

1. ISO Standard Pascal (BS 6192)

2. Ansi Standard Fortran 77

3. GKS draft ISO standard

4. UNIX Manual

5. PERQ glossy

6. PERQ hardware manual

7. CR82 UK Ring hardware specification
   CR82 Interface Specifications
   Orange Book

8. SERCnet X25 specification

9. TS29: Green Book

10. FTP80: Blue Book

11. JTMP: Red Book

12. MAIL: Grey Book

13. Transport Service: Yellow Book

14. TSBSP, BBP
    CR82 Protocol Specifications: Orange Book

15. Mixed Language Working
    A Williams
    RAL

16. Cobol Standard

17. Ada Reference Manual

APPENDIX 1

SERC COMMON BASE POLICY

1. INTRODUCTION

1.1 Overview of Distributed Interactive Computing

The appearance in the market place of cheap high powered single user computer systems with good interactive capabilities via high precision displays, linked together by high speed local area networks, heralds a completely new way for most SERC Investigators to achieve the major part of their computing requirements.

Within the next few years, many such systems will be available from different manufacturers. Consequently there is a likelihood of many different systems being purchased in the SERC environment leading to a great deal of duplication of basic software development.

SERC sees a need for a coordinated development plan to ensure that the UK makes the best use of its finances and of its limited manpower. The SERC has therefore decided on a strategy of creating a common hardware and software base for software development which will encompass all scientific subject areas. Briefly the common software base will be Pascal and Fortran running under the Unix operating system implemented on the common hardware base of PERQ single user computers linked locally by Cambridge Rings and nationally by the X25 wide area network systems (SERCnet and PSS).

SERC Subject Committees will participate in the implementation of this policy by enabling central purchasing of PERQs for grant holders to be done via Central Computing Committee and by ensuring that investigators use the PERQ in all appropriate circumstances as well as encouraging them to follow the common base software development policy. The Common Base Policy is not the same as standardisation, however, and it will evolve as the state of the art improves.

1.2 Common Base Policy

The whole academic community, not just Computer Science, is a major user and developer of software and so the degree of ease with which software can be developed affects the scientific productivity of many researchers.

The SERC has approved a plan to increase the productivity of scientific research requiring computing by:

(1) facilitating scientific cooperation by:

  (a) person to person links
  (b) computer to computer links
  (c) common software and hardware base policy.

(2) Set in motion a coherent plan to exploit software tool production by making such tools/techniques widely known and available in forms which can be readily used by the whole user community.

Currently the academic software technology base is very non-uniform in that the knowledge, experience, tools, techniques and equipment vary considerably between projects. The motivation to create a common Hardware and Software Base is to bring together all of the best existing tools, packages and techniques into a uniform framework so that the 'whole' is more effective than the 'sum of diverse parts'. This will be achieved via EMR contracts to move existing software into the common base, specific purchases, the direct results of SERC research projects using the common base equipment and the 'snowball' effort that will be generated as a natural consequence of providing a state of the art hardware base. A good example of the common base 'snowball' effect is the widespread use of the Unix operating system which has enabled a large number of software tools to be made available throughout the UK academic community.

The Common Base Policy briefly is:

(a) common software base,

(b) common hardware base,

(c) common communications.

The SERC wish the common software base to be the Unix operating system and the common hardware base to be the PERQ. The PERQs should be networked together via Cambridge Rings, SERCnet and PSS to allow widespread cooperation between users and developers. This combination of software and hardware is widely accepted as being the best combination for developing software in the coming years. A common base does not imply rigid standardisation however.

Computer technology develops at a rapid pace and it is expected that the next few years will see the cost of single user systems decline and their quality and capability increase. Therefore today's PERQ is seen as only the first machine forming the common hardware base. The common base will develop over the coming years.

1.3 Outline

In outline the Common Base Policy comprises

a.	Pascal	(ISO Standard)
b.	Fortran 77	(Ansi Standard)
c.	GKS	(BSI and ISO Standard)
d.	UNIX	(32 bit virtual memory)
e.	PERQ	(High performance single user system)
f.	Cambridge Ring	(Local Area Network)
g.	X25	(Wide Area Network)

A P P E N D I X 2

THE PERQ

The Perq is a high powered, single user computer system with a high precision display system which provides a significant improvement in the quality and speed of interaction. Its main features are:

(1) High Speed Processor

Approximately 1 million 'high level' machine instructions per second giving around two-thirds the CPU power of a VAX 11/780. The CPU is micro-programmable for further speed gains.

(2) High Quality Display

A4 size, 1024 x 768 pixel, high resolution black and white display featuring 60Hz non-interlaced refresh rate which enables pictures to be moved cleanly and rapidly as well as giving a significant improvement in the clarity of text and diagrams equal to a printed A4 page.

(3) User Friendly I/O Devices

A 2-D tablet and voice synthesiser, allied to the high quality screen, enable a much improved man-machine interface to be created.

(4) Large Virtual Memory

A 32 bit address virtual memory system.

(5) Local Filestore

A 24 Mbyte Winchester disk and 1 Mbyte floppy give a single user a large amount of local storage capacity.

(6) Fast Communications

Local communication at 10 Mbits/sec via Cambridge Ring and Ethernet. Standard RS232 serial and IEEE 488 parallel interfaces are also provided.

A high quality, superbly interactive computing system is created if each investigator has his own single user PERQ linked to his colleagues' PERQs and other departmental computing resources by a Cambridge Ring, with inter-university cooperation being fostered by the National X25 network connections.