G.R.

REPORT ON PRENTICE COMPUTER CENTRE GROWTH 1984-1990

1.0 INTRODUCTION

The aim of this report is to provide an analysis of the possible growth of the Prentice Computer Centre to the year 1990. To do this the role of the Centre in supplying not just computing support in the sense of central machines, but also providing the planning and infrastructure support services necessary for ecconomic long term departmental computing expansion, has been stressed. It is clearly necessary, in light of the major spread of computing to almost all disciplines of teaching and research, to indentify approaches which provide the facilities required in the most ecconomic terms of capital and recurring expenditure.

Whilst projecting requirements into the late 1980's it is essential to assess the current state of the University's computing setup to enable the Centre to move in the appropriate directions from a useful workable base. Appendix A provides some interesting illustrations of the growth of the Prentice Computer Centre and the services it provides.

The Centre has a large installed base offering a wide variety of facilities. These facilities are well founded with dual KL10 processors, a VAX 11/780, a Computer-Vision CAD/CAM system, and since early 1984, an IBM 3083 system utilising the virtual machine concept.

High quality graphics input and output devices are available for use with any system and high capacity printing facilities are available on all systems. A phototypesetter is provided for quality production of documents or publications.

An existing well planned network provides file transfer and virtual terminal facilities between most systems. Also connected to the network are a large proportion of the sixty departmental minicomputers at the University of Queensland and Griffith University. Development of the network has produced the experience and understanding necessary to undertake the major expansion of network services required to 1990 and beyond.

Terminal growth has increased rapidly in the last six years with over 800 terminals connected to the central systems in 1984. There is no reason to suspect that the rate of growth (approximately 30% p.a.) will change greatly in the next two trienniums although this is not to say that the nature of these devices and their method and speed of connection will not change. A great proportion of connected devices will not be "dumb" terminals but rather intelligent workstations or personal computers. Appendix B plots trends in terminal connections (Fig 1) and disk growth on the central systems (Fig. 1).

It is essential to realise that growth rate projections of 30% p.a. will raise the number of connected devices from 800 in 1984 to over 4000 by 1990. Given that the Prentice Computer Centre currently serves a total of some 4900 staff and 21000 students (at U. of Q. and Griffith University), these projections may be conservative. Clearly early rational and logical planning of network and other services is essential to provide effective and ecconomical growth strategies for University computing as a whole.

Currently, terminals are connected via a series of MICOM circuit switches both at the Centre and other locations such as Chemical Engineering and Griffith University. Such connections over copper wire circuits, utilising asynchronous transmission methods form what is referred to as the Asynchronous Transmission Mechanism (ATM). In 1984 over 100 terminals on departmental minicomputers have access to the central systems by means of the network (UQnet). For reasons given below it is desirable to reverse this situation and to have the majority of terminals and other devices connected to the network other than by the ATM. This methodology allows significant ecconomic savings in capital and maintenance expenses as well as providing far greater flexibility and accessibility to all available services.

Hence a thrust of this report is to stress the importance of the timely and expansive development of the network to provide a connectivity infrastructure upon which reliable departmental planning and costing may be based.

2.0 CENTRAL SYSTEM GROWTH

As can be seen from the projections of growth in computing demand (Appendix A, figure 3 and figure 4), any further possible growth in existing central systems should be utilised, provided of course, that it is cost effective in terms of the life of the equipment. The KL system installed in 1978 is estimated to have a life time of at least 8 years from 1984. That is we are less than half way through it useful life. Thus consideration should be given to minimum cost upgrades such as:

* CPU upgrade from model A to model B

* addition of 256 KWords of memory to symmetrise the two systems.

Additionally, the ANF/DNA interface requires considerable attention as this is currently a major throughput bottleneck. This problem is addressed further in the NETWORKS section.

The CPU upgrade costs are dependent on negotiations with the manufacturer with the cost of additional memory being dependent on the outcome of these negotiations. It is recommended that $80,000 be allocated for this purpose in the 85/87 triennium.

The Centre installed a VAX 11/780 in 1981. An upgraded version, the VAX 11/785 is soon to be available. This machine offers a 50% increase in performance (and job slots) and is a field upgrade to the 11/780.

Significant performance improvements are also to be made by increasing the amount of MOS memory available on this machine. Doubling of memory capacity from 4Mb to 8Mb would cost $50000. It is recommended that a total of $110,000 be allocated in the next triennium towards upgrading the 11/780 to 11/785 (including ECO changes).

The IBM 3083 virtual machine concept will become increasingly important for research and development, particularly in the areas with high database content (expert systems, artificial intelligence and, of course, database research). The concept allows many user environments on the one machine by running Guest Operating Systems on virtual machines. In particular, the availability of UNIX on the IBM machine provides a widely used teaching environment and a growth path for departmental UNIX users. Consequently, the desirable 30% growth path will be distorted somewhat by rapid growth in the demand for disk storage. To some extent this is a result of the storage allocation procedures of the VM monitor but also because of the minimum economic increment of storage purchaseable.

It would appear that a 40% increase in disk storage would be necessary to be installed by the start of 1988. An amount of $150,000 is required for this upgrade in the 88/90 triennium.

Main memory upgrade from 16Mb to 24Mb is a feasible option to meet the projected growth in demand by 1988. An amount of $60000 is required for this purpose.

Processor speed enhancments of the order of 6-10% are now available for the IBM 3083E. The cost of this upgrade is $20000 and is recommended during the 1985/87 triennium.

The Computervision CAD/CAM system was installed in 1983 with three workstations. Two additional workstations have been installed in 1984, while the disk capacity will be doubled to 600 Mb also in 1984. The system is primarily a tool for the Engineering departments. This system is discussed in detail in the GRAPHICS WORKSTATION section. Apart from the disk upgrade mentioned above, further development planned on this system from PCC sources is limited to the addition of one workstation.

To achieve the goals listed further in this report, it is desirable to be able to make gains in staff productivity. To the extent that terminals are the physical tools of programmers, the provision of quality terminals with sophisticated functions, usable over the range of systems installed, for all programming and related staff is essential. Such terminals should not necessarily be limited to "dumb terminals" although, for reasons of cost/benifit discussed later, microcomputers should only be purchased for development purposes. Numerous terminals now in use are approaching obselesence and do not offer facilities for productive programming particularly on the IBM system. Also the number of terminals available is not adequate for the staff size. It is recommended that $15,000 be allocated each year of the 1985/1987 triennium to increase the number of terminals available and to replace obselete terminals within the Centre. Microcomputers for development are discussed in the DISTRIBUTED SYSTEMS section.

Reference to Appendix B figure 2 shows a projected rise in disk requirements commensurate with the overall growth rate. Apart from extra disk capacity to be added to the IBM 3083 system, no further disk drives are asked for explicitly for the other central systems. Rather, the most ecconomical approach is to provide a network file server, discussed later, to provide at least 1.2Gb of storage sharable between any systems connected to the network. Primarily this server is required to provide needed capacity for the central systems; another identical server is discussed later to provide for departmental systems. A file server based on a MICRO-VAX system with 1.2Gb backed up by 1.2Gb of non-removable disks will cost $110000 and should be implemented in the 1985/87 triennium.

Additional software packages primarily for the IBM 3083 system will be required. An allowance of $20000 per annum should be allocated for this purpose.

It is important to note the recurring costs involved in supporting the central systems. The costs of hardware maintenance may be calculated at 6% of capital cost per annum However recurring software support costs are increasing rapidly as shown in appendix C. These costs have risen to $60000 p.a. in 1984. Of this amount, $10000 may be allocated to software support of departmental systems. These figures illustrate the change in the general balance of harware and software costs. The higher proportions of software costs will doubtlessly rise further in the following years, particularly as software complexity and specialisation increases as in for example, expert systems or artificial intelligence. While considering central systems costs, it is informative to consider the cost of software for personal-computers. On the basis that new software in the order of $500 is purchased each year for each machine, (indeed most systems are purchased with $1000 of software), software costs for 100 machines would be equivalent to that spent on the central systems. There are already several hundred personal-computers on campus. When the duplication of software is taken into account, there is a clear argument for funding central software purchasing and support.

2.1 MINOR EQUIPMENT

From the table in Appendix C it can be seen that minor equipment expenditure, mainly for disk packs, magnetic tapes, and associated storage devices has increased significantly since 1978. There is also a requirement to replace a quantity of older magnetic tapes. It is estimated that requirements of minor equipment expenditure in the 1985/87 triennium will be $11,000 p.a. with a fireproof safe costing $7,000 required in 1985.

2.2 SECURITY

The maintenance of security has always been a high priority issue within the Prentice Computer Centre. Access to the Centre is by key entry only. While practical in the past when the Centre was housed physically on one level of one building, the system has gradually become more and more cumbersome as the Centre's accommodation has been divided and spread across several levels and several buildings. Obvious problems occur with differing keying arrangements and required access to shared facilities (tea-rooms etc.) by non-Centre staff.

To control access in a reasonable and flexible manner it has been recommended for some years that a magnetic key and lock arrangement be introduced. Such a system would be computer based using a dedicated microprocessor and may also be used for alarm monitoring. A computer based system will provide security validation flexibility with staff changes and lost keys. An amount of $15000 is recommended for 1985/87.

3.0 DISTRIBUTED SYSTEMS

This area of support commenced in 1977 with the initial purchase of several departmental PDP 11/34 minicomputers. The PCC saw a requirement to provide support in three prime areas.

* consulting, purchasing and contractual advice
* hardware support
* software support

Such support was not only necessary but was far more cost effective than the utilisation of outside support. The support provided by the Centre, in terms of expertise and the ability to function in accordance with the University's interests, far exceeds that available from "outside" suppliers. To 1984, the growth has been staggering with approximately 60 PDP 11 systems and four VAX systems on the University of Queensland and Griffith campuses. The demand for support now requires twelve full time staff.

Hardware support problems now arise with the introduction of custom logic chips resulting in a change in maintenance procedures, and a probable lessening of internal maintenance. However there is a growing requirement for the support of development in both software and hardware areas, for example, specialised devices for laboratory applications.

Additionally, more third party equipment is being purchased (because of a very strong economic incentive) compounding the problems of any move towards vendor maintenance. The evaluation testing and installation of third party equipment requires a core of highly trained personnel. Thorough evaluation of all aspects of state of the art equipment (functionality, maintainability, software integration etc), while bearing in mind the diversity of requirements o the University community, consumes considerable resources. Considerable ecconomic benifits are obtained by rational standardisation of equipment purchased so as to be able to provide viable maintenance support over the lifetime of the equipment. It is important to note that the life time of most of the earliest installed equipment is still another five years or more especially in view of various upgrades organised by PCC (i.e. 11/34 to 11/73 processor upgrades and disk upgrades). The cost of this support is not inconsequential. The University of Queensland alone has spend some $4 million on departmental computing equipment in the last six years. At the internal maintenance rates of approximately 8% (c.f. vendor rates of 10-15%) of capital cost this represents a recurring cost (calculated at 8% of capital) of approximately $0.3 million p.a. on hardware maintenance alone. One method of reducing both capital and recurring costs and aslo increasing resource flexibility, is by the introduction of shared resources. Basically this refers to the provision of "bulk" resources (disks, printers etc) with access to from all systems. Access should be by high bandwidth links provided by the network infrastructure. Shared resources are made available to any connection on the network by means of "network servers". An argument to support this approach is given wtih further detail in the section dealing with network expansion.

An approach to lessen both the capital and recurring costs of the expansion in demand for upgrades of departmental equipment is by the provision of centralised facilities such as bulk disk storage or quality printing services. Provision of network servers will dramatically alter the availability of additional disk capacity, backup facilities and high quality output devices to departmental systems. Savings are made in the ecconomies of scale involved in all aspects; the cost of equipment, cost of maintenance, administration (backup, allocation), air conditioning and so on. Appendix D demonstrates cost savings involved with the provision of a network disk server in comparison with the provision of individual disk drives on departmental systems. The disk server concept is costed at almost half that of providing disk storage to relatively few users. Since network servers may be accessed by any connected "node" on the network, the resources are available to a far wider range of users.

Software support reflects the evolving hardware pattern. Software support has been largely operating system generation and maintenance. The evolution of more sophisticated operating systems with increased emphasis on auto- configuration methods will lead to fewer resources spent on tailoring operating systems for each machine.

Additional support will however be required for UNIX as this operating system pervades deeper into all levels of computer systems. (Versions of UNIX are available for machines from microcomputer size to the largest VAX).

3.1 Costs Of Distributed Systems Support.

Given a background of 30% p.a. growth of overall computing capital expenditure on campus, it is reasonable to expect an allocation of 5% p.a. of available capital for growth of support services provided by this group.

Currently there is approximately $0.2 million invested in development and maintenance tools, and test equipment. Note that this is 5% of the installed base.

Approximately $20-30k p.a. are expended on capital spares and upgrades with a similar amount of $20k required for specialised test equipment. A growth rate of $2k p.a. has been common in this area but significant costs will be involved if maintenance of VAX systems or new machine types must be undertaken and spares kit purchased. Initial spares kits for a single machine type can cost between $10000 and $40000.

Large departmental purchases are now being made of 16 bit microcomputers. At this stage purchases are primarily limited to four models of machine. While there are very good arguments for standardisation in this area, the marketplace is rapidly evolving and machines obsolesced in only a few years (3-4 years c.f. 10 or more years for minicomputers). As a result, for maintenance purposes it is necessary to have at least one of each of the "standard" machines for spare parts, with an additional machine for training and development work. For initial spares, initial software, and test equipment to support departmental computing development, provision of $120000 is required in the 1985/87 triennium.

3.2 Philosophy Changes.

The concept of networking will make significant changes to the economics of purchasing departmental systems.

A major example would be the development of file servers to provide additional disk storage for both departmental mini and microcomputer installations and for the expansion of the central systems. Costs for providing such servers would be less than half that of adding disks to individual systems. Recurring costs are also halved. Sharing of expensive items such as the photo-typesetter or large plotters is also possible by means of the "server" concept. File servers are discussed in detail in the NETWORKS section. A comparison of costs of upgrading departmental systems and providing disk capacity by means of a file server are discussed in Appendix D.

Higher levels of integration of hardware is producing hardware which has higher reliability and also higher functionality. Hardware is increasingly performing tasks previously performed by operating systems software (e.g. highly intelligent disk drives and controllers). Much software that previously formed part of the operating system is now found forming part of (more standardised) advanced applications packages (e.g. graphics, networks, databases). The availability of advanced applications packages lessens the requirement for low-level software development and produces software which is very much less machine dependant. More applications programmers are working with high-level packages rather than writing code directly. In respect of both equipment and software, the ability to interface systems to one another, or to other specialised systems to achieve a total goal is increasingly becoming the tasks demanded of the support staff. Thus, while much of the current hardware and software support services will remain, overall there is a significant shift developing in the nature of the work and the abilities required of both hardware and software staff. This must be a consideration in recruiting, in training, and in planning career paths for both current and future staff.

4.0 NETWORKS:

The effective use of the Universities computing resources depends on the ability to

* access the resources (centralised or departmental) appropriate for the application

* interchange data, programs, electronic mail, etc, to other machines or users both within the University or elsewhere

From the networking aspect, necessary conditions to satisfy both criteria are the high CONNECTIVITY of the network (i.e. access to the network must be extensive, with all necessary resources available from the network), and high BANDWIDTH so as to provide efficient service regardless of loading.

The network in existance at the University of Queensland and Griffith University currently encompases three major areas, the ANF network based on the KL10, the DNA network based around the VAX 11/780 and departmental PDP 11s, and the Asynchronous Transport Mechanism (ATM) used for connecting terminal devices into all systems. The ATM is based on the MICOM circuit switches at UQ and Griffith. A gateway links the ANF and DNA networks, while other gateways link to CSIRONET, OTC MIDAS and AUSTPAC.

In analysing the network expansion options it must be borne in mind that the two key attributes of a network are CONNECTIVITY and BANDWIDTH.

The University's major network implementations, ANF and DECnet, are currently STAR based point to point topologies and as a result are bandwidth limited primarily by the PDP 11/40s throughput. Point to point connections are expensive for the performance obtained, and with the STAR topology, suffer from obvious availability problems of the centre node.

An obvious move is away from the STAR topologies towards a BUS topology. The BUS topology provides a lower cost, higher bandwidth, high availability foundation.

It is worth noting that the variety and magnitude of machines and facilities available on the University network suggests that we could represent the network as a distributed expert system. It is evident that this analogy only holds so long as the condition of high bandwidth is maintained. Thus there is a need for high powered network interfaces or gateways between different protocol networks or machines.

4.1 Choice Of BUS Network:

DECnet is currently well established on campus and shows promise for the future from both the development/maintenance point of view as well as the vendor support aspect.

The future of VAX systems also seems assured as in the relevant timeframe these machines are the backbone of DEC's existance. VAX costs are falling dramatically enabling (in 1984) high power gateway type machines to be purchased for less than $15000.

Software tools such as VAXELAN which allow devlopment on a host VAX/VMS machine will provide powerful and efficient means for tailoring network gateways or servers.

ETHERNET is a local area network system conforming to international standards of data communications. Specifically ETHERNET provides the lower two layers of the ISO model and as such is supported under DECnet (DNA). With a 10Mbit/second maximum data rate, ETHERNET provides the required CONNECTIVITY and BANDWIDTH for the Universities' needs. It should be noted also that ETHERNET cable will perform as a physical link for devices not using DECnet protocols (eg UNIX machines, micros) along with DECnet devices. ETHERNET is currently running as a pilot system linking two VAXs a PDP 11/34, and a PDP 11/23.

Thus the main thrust of the PCC towards 1990 should be that the campus be served by an ETHERNET-like bus structured system.

4.2 DEVELOPMENT GOALS:

4.2.1 ETHERNET CABLE: -

The initial consideration is to serve the campus with network access. The cost of providing ETHERNET links to all areas of need is in the order of $50000. A further $30000 dollars is required to provide ETHERNEt interfaces into the major systems.

4.2.2 NETWORK MANAGEMENT: -

Essential to a high performance network is high reliability. It is important then to have in place a set of network management tools, in effect to create a NETWORK MANAGEMENT CENTRE.

These should consist of:

* tools for MONITORING; an PDP 11/23 system or similar with a graphical display, available to the fault reporting centre.

* tools for DEVELOPMENT; a dedicated machine for network development. A machine such as a MICRO-VAX is the most desirable for this level of development.

* tools for MAINTENANCE; in conjunction with monitoring tools, technicians from the fault centre should be able to perform remote diagnosis. This becomes increasingly important with the grater variety of devices on the network. There is some benifit in BUS topology in that any node can be polled or tested by a single monitoring machine with the appropriate software.

Cost of a MICRO-VAX for development purposes is $15000 plus $11000 for software tools (VAXELAN). An additional $3k is required to upgrade the current network monitor system for graphical display of network conditions.

4.2.3 GATEWAYS: -

The essence of the ETHERNET approach is that alternative protocols wishing to connect with existing network structures, be interfaced via GATEWAYS. (Note that some systems/devices may simply wish to connect to ETHERNET bus to communicate with like, consenting systems/devices and may not require access to the current network facilities. An example might be intelligent laboratory equipment or simply foreign protocols.)

4.2.3.1 IBM GATEWAY: -

An immediate need is the entry of the IBM system onto the network. A low capacity link is currently in operation but it is clear from traffic estimates that this can only be regarded as an interim measure until a high capacity, full functionality gateway providing file transfer and virtual terminal connections can be installed.

A number of alternative implementations are being carefully considered by the communications group, with a definitive answer not yet available. However it is clear that whatever approach is taken will require a gateway machine to interface with a channel attachment device provided by IBM. An amount of $32000 is recommended for 1985 to fund this development, including spares.

4.2.3.2 ANF GATEWAY: -

As previously noted, the ANF/DNA gateway distributed physically over several PDP 11/40s, is the source of a major bottleneck of the current network. It is essential to maintain the ANF network facilities for not only file transfer into and out of that network, but also because the ANF network provides the current highest speed printing service.

It is suggested that the ANF/DNA gateway be implemented in a MICRO-VAX with a DTE interface and UNIBUS to Q-BUS converter. Such a system would cost $15000 and should be implemented as soon as possible.

4.2.3.3 X.25 GATEWAY: -

The X.25 protocol provides useful interfaces into packet switched networks such as AUSTPAC and hence to overseas networks. For example, the Department of Computer Science make extensive use of the limited facilities now available to communicate with collegues both in the U.K. and the U.S.A. Current UNIX networks also provide a measure of X.25 support. The development of a DECnet/X.25 gateway based on a micro-VAX would allow the interconnection of UNIX systems (X.25 to X.25) whilst futher development of file transfer software could enable UNIX to VMS/RSX transfers. X.25

offers a firm base for development into the 1990s for communications external to the University campuses.

The necessity to provide a UNIX gateway for the increasing quantity of UNIX based machines on campus stresses the need for urgent development of the X.25 gateway.

The cost of this proposal is $14000 when implemented with a MICRO-VAX.

4.2.4 PROPOSAL FOR AN AUSTRALIAN ACADEMIC NETWORK: -

It is considered that there is a need for a national network linking academic institions enabling a much greater sharing of resources as well as the transfer of mail and files, and virtual terminal access to other systems.

It is not ecconomic for every institution to provide every possible computing facility or every possible software package. If reasonably high bandwidth connections were available between institutions and the above mentioned facilities were provided, each institution would have ready access to a much wider range of facilities than those available on its own campus. We have gone someway towards this goal but more formal and suitable arrangements are necessary in the longer term. No capital costs are involved but one person-year would be required for development.

4.2.5 TELETEXT: -

TELETEX is a high level X.25 based system primarily for electronic "document" mail (c.f. TELEX). Consider the uses with a laser printer for "mail" interchange worldwide for researchers and academics. Primarily a one way communications system and hence limited. Further developments should be noted but no major initiatives are suggested for the first triennium.

4.2.6 VIDEOTEX: -

Essentially VIDEOTEX is a public database system built on the X.25 standards. Database access is through specified formats using asynchronous terminals with (optional) special graphics features. Videotex has the advantage of being menu-driven and is easy to use by non- technical individuals without training. It is a system which could be useful for

Computer Aided Learning or for access to public databases.

The University could pursue the path of implementing class and exam timetables, the University calendar, or the University library catalogue, on a special database machine. This special machine may in fact be a virtual machine on the IBM 3083. Devlopments in this area should be monitored but again no major initiatives are suggested in the first triennium.

4.2.7 SPECIAL PURPOSE SERVERS: -

An extremely important area of development which would provide considerable increases in computing efficiency and large ecconomic savings, is the introduction of SERVERS for varying purposes. The concept of a server is to provide large quantities of resources, maximising the ecconomies of scale, and share these resources between users. With a bus network with high bandwidth and high connectivity pervading the campus, it is realistic to consider to use of servers to provide mass file storage, access to print facilities, and of course, access to the network itself from a terminal or microcomputer. Respectively, these are FILE or DISK servers, PRINT servers, and TERMINAL servers. Print servers of course are not limited to one printer, but may support several types of printers, of varying speeds and qualities, plotters, laser printer, and the photo-typesetter. Access to the network and hence to any resource (server or machine) connected to it, is most ecconomically performed by using a TERMINAL server. Such a device would interface a number of terminals or microcomputers into the network by providing a standard interface (RS-232 or RS-423) to the device. In effect a terminal server is a combined circuit switch and multiplexor onto the network.

A second ecconomy comes into being if the terminal server is used to interface a terminal into one of the central systems. This is due to the fact that asynchronous interfaces are no longer used on the host machine but rather only a share of the host machine's network interface. Depending on the nature of the network interfaces and asynchronous interfaces, significant nett gains in computing power can also be made in the lessening of overheads.

Disk or file servers allow the sharing of disk resources by any system or user connected to the network. The allocation of resources is dynamic, and because the cost of controllers, backup mechanisms etc are shared, the cost per user is considerably lower. Appendix D illustrates the cost advantages associated with file servers replacing upgrades on departmental equipment.

It is recommended that file servers be developed as soon as possible to provide disk resources to departments as an alternative to individual upgrades. It is recommended that a 1.2Gb server be implemented in the 85/87 triennium to support departmental computer systems, for a total cost of $110000.

4.2.8 Microwave Links Off Campus -

Significant proportions of the University facilities are located elsewhere other than the St Lucia site. The costs of providing adequate communications facilities to these sites prohibits the same level of growth as on-campus sites. Costs of leased lines and connection equipment limit the viable transmission speeds to levels which preclude adequate networking performance. Thus the ecconomics of using central systems or shared equipment (disk servers etc.) are not possible.

It should be noted that the newer systems, by utilising screen formatting techniques, are requiring higher line speeds for updating. While 2400 baud is now common it is likely that 9600 baud will be essential in the near future.

In late 1983 a report was commissioned to establish the feasibility of a microwave link to Griffith University from the St Lucia campus. here capital costs (approximately $100,000) were almost equalled by the current recurring costs of Telecom line rental over four years with a growth factor allowed. The microwave link offers a minimum of 2 Mbps transmission, adequate for foreseen growth in the 1990s. Maintenance costs for this type of equipment are typically very low, perhaps $4,000. Such systems may indeed prove viable alternatives to leased land-lines for the Medical School/Clinical Sciences facilities at Herston with a relay link to the Dental School in the city. The viability requires a detailed feasibility study of proposed routes by MITEC.

If feasible, the use of microwave could radically alter the nature of equipment installed at remote-sites with less dependence on expensive stand-alone options. It is recommended that, if agreed to by the faculties/departments concerned, a feasibility study of a microwave link to Herston from St Lucia be conducted. The cost of such a study would be $5000.

5.0 GRAPHICS WORKSTATIONS

The requirements of a graphics workstation in a University environment can be represented as falling into one of two main areas.

1. Drafting functions such as two-dimensional drawing, electronic circuit schematics, flow charts, diagrams and the like.

2. Design functions such as three dimensional solids design, pipeline layout, printed circuit board design, VLSI circuit layout, modelling and simulation and animation.

The former area requires good graphics display capabilities and not excessive processing power. The design area has requirements not only for quality graphics display performance but also for high processing power and sophisticated database techniques.

Dependent on the nature of the application, image processing may fall into either area but usually high processing power is required for effective analysis of image data.

5.1 The Growth Of Graphics At University Of Queensland

To meet the demands for graphics tools within the University, the Prentice Computer Centre as early as 1974 purchased a GT42 graphics satellite processor. Purchases of Tektronix graphics storage tube terminals and digitisers were made by 1977. Numerous other graphics devices have been purchased by departments since that time, primarily for use with the central computing facilities.

Primarily to satisfy the requirements of teaching and research in the Engineering departments, a Computer-Vision Computer Aided Design/Computer Aided Manufacture (CAD/CAM) Series 4000 system was installed in 1983. The system currently has five workstations installed and disk capacity will be doubled by mid-1984.

The Computer-Vision system provided a specialised graphics facility widely needed throughout the University. However the cost of workstations is very high and except for large and specialised users this severely limits the application of the CAD/CAM system to much of the campus.

Thus there is a need for a public workstation in a central location for access by departments unable use the machine because of geographical limitations. A colour workstation would cost $50000.

Apart from the specialised services there is a growing need for a more generalised lower cost graphics service which can easily attach to the network and use particular network facilities and software available on all connected machines.

It is expected that the cost of such a graphics workstation would reduce considerably in the next two years to around $15000 for a colour workstation. Initially the requirements would be for one workstation for development, training and maintenance, and one for use as a public facility. A major expenditure will be required for the purchase of graphics application software packages. This is estimated at $30000 in the 85/87 triennium.

6.0 ADVANCED DEVELOPMENT

Major developments are taking place in several areas of computing which will have considerable impact on a large proportion of the University. Initially these developments may be significantly directed towards research with teaching and other developments following later. The major items of interest are:

- Artificial intelligence
- Expert Systems
- VLSI design
- Voice recognition and synthesis
- Parallel processing systems
- Image processing
- Process control/laboratory measurement techniques.

As the awareness of the possible applications of these developments increases, greater demands for the provision of both the tools and the necessary expertise are made of the Centre. There is a major requirement for provision of suitable equipment within the Centre for internal training, development and testing of software, and for education of University staff via training courses.

Many of the areas of advanced development have intrinsic economic value to the University. For example, the establishment of a VLSI design facility (expertise, workstation and software) would provide not only the necessary infrastructure for teaching and research but allows development of devices specific to the University.

To illustrate this point, consider the development of network services referred to earlier. The Centre could undertake design of low cost Very Local Area Networks (VLAN) network interfaces for microcomputers or the design of a terminal server, i.e. a circuit switch "trunked" directly onto network, both items which would be widely used on campus, have potential for providing large cost savings during network implementation. Appendix E gives example costings. Applications also abound in the biomedical, bioengineering, and laboratory instrumentation fields.

Support of advanced development requires an increase in specialist expertise available within the Centre. The demands on the Centre's staff resources will be for a far greater diversity of expertise, with increasing demand for specialist development and support of new applications and tecniques in teaching and research. The infrastructure of computing resources required to meet the demands of advanced development is well in place particularly with the IBM 3083 virtual machine approach and the availability of the VAX 11/780. Major effort in equipment purchases would be for workstations, whilst software may need to be purchased for particular applications or obtained in joint development agreements.

Similarly there is a persuasive argument for the development of the PRINTED CIRCUIT BOARD design facilities now available with the C.V. CAD/CAM system. Much effort has been expended by computer centre staff to gain a working knowledge of the design procedure. It is clear that the system has enormous ecconomic benifit in the design, documentation, and production of PCBs. It is desirable then to provide such a facility to interested departments. A great deal of interest has been aroused about the facility by many departments who see considerable savings in time and money. The ability to obtain fast and accurate layout can considerably alter the feasibility of undertaking many projects. It is estimated that the demand for PCB layout services alone could ecconomically justify the purchase of a dedicated C.V. workstation. Much interest has also been expressed by outside bodies, in obtaining the contract services of the centre for the purposes of PCB design. No other PCB service of this nature is commercially available within Australia and it is quite possible that commercial contracts could cover the cost of developing and providing the service to the University community.

To provide the service it is initially necessary only to provide staffing of a full time technical operator. Cost at Laboratory Assistant level would be approximately $18000 p.a.

Laboratory data acquisition is another area of Prentice Computer Centre involvement. A low cost multifunction data acquisition system, LABPAK, has been developed by Centre staff. Needs for such a device within the University are clear. With developments in networks as suggegted, it is desirable to upgrade the LABPAK system to link to the network for high speed transfers (a current restriction). Further refinements to upgrade the system to a PDP-11 based one and thence to MICRO-VAX based offer a sound path for development in this area. Special application-specific integrated circuit development would be feasible if VLSI development is proceeded with. Costs for ETHERNET interface development for LABPAK along with upgrading to a PDP-11 base would be $25000 (hardware and software). Development is suggested in 1985. Further development on a VAX base would cost $20000 with development not suggested until 1988.

7.0 COMPUTER AIDED LEARNING

Current CAE work generally is based on a particular terminal or micro-computer. That is, software is now transferable to other types of terminals or micro- computer. The ratio of machines to student users is in most cases quite inadequate, with machines often being booked solidly over 18 hours per day. Such systems are neither flexible or particularly powerful, being limited to programmed learning techniques only. This is a mere fraction of the possible involvement of CAL into the University environment.

At this time suitable machines for sophisticated CAL are not widely available, those that are being very expensive (eg. PERQ costs $40k). Much of the cost stems from the requirements for high quality graphics, reasonable processing power and local storage. The availability of such machines at lower cost opens areas such as modelling and simulation. Highly compute intensive applications such as these may best be served by networking CAL work stations to central systems. Techniques such as REMOTE PROCEDURE CALLS to specialised machines (or virtual machines) via the network offer great scope for use in these areas.

7.1 LOCAL CAL

With the falling costs of microcomputers and the increased pervasiveness of computing into all areas of University study wider thought should be given to the use of students' own microcomputers or to the leasing of such machines to students. Indeed, in the U.S.A., many Universities require all Computer Science students and many others to purchase their own machines.

The leasing approach offers advantages in that some standardisation (which may be reviewed from time to time) is possible resulting in low costs and a high degree of interchangability. A lease could possibly be arranged over say three years with a minimum residual. Typically a system in the range of $2k to $3k would be required, although bulk purchasing in these volumes would lower prices much further. Msot of a students work could be performed by use of a minimum configuration machine, as long as ready access can be gained to shared resources such as printers, plotters, typesetters and so on. This approach lies well with the philosophy of network development and implementation of resource servers outlined earlier.

Low cost maintenance facilities could be provided by the Prentice Computer Centre as is now done with departmental equipment.

The concept of leased micro-computers is applicable to the more general CAL approaches now used. The more sophisticated techniques would require considerably more expensive machines than could be envisaged for realistic leasing.

The uses of such leased machines should not be considered confined to assignment production. Considerable use can be made of the word processing capabilities of these machines for thesis or report generation, particularly with access to quality printers and typesetters via network servers.

External working from home has advantages to the student of greater accessability, flexibility of time allocation and perhaps better working environment. The advantages to the University are severalfold; greater productivity of students and staff, lower overheads of building space for terminal laboratories, less requirements for building and equipment security, and of course less capital equipment costs.

Additional costs to the University are incurred in the need for far greater accessibility of the network via the dial-up facilities. It would not be unreasonable to suggest a minimum of 30 and perhaps up to 100 dial in lines would be required for access of common databases and shared resources. Capital cost would be limited to approximately $100 per modem but recurring costs would involve the rental of the additional Telecom exchange lines. Some increase in "common equipment" such as file and print servers would also be required.

7.2 DISTANCE CAL

The types of distance CAL may be classed as passive (one-way) or active (two- way) interaction.

7.2.1 Passive CAL -

Passive CAE techniques have existed for decades in the form of printed notes or "University Radio". Recent developments in video recording techniques now would allow distribution of lecture materials in video-tape form at very-low cost. It is not difficult to imagine video-lecture libraries operating in similar fashion to libraries dealing in the printed media. Such concepts must represent the lowest cost approach to distance CAE but of course they may not represent the most effective means. They must be considered as supplementing any further developments.

A University TV channel (c.f. University Radio) may offer a desirable means of assisting community involvement (particularly in professional refresher courses) and with the introduction of satellite transmission, could be quite widely available.

7.2.2 Active Distance CAL -

With further expansion of the AUSTPAC network it is conceivable to implement regional database centres connected via X.25/AUSTPAC gateways into the University network. With regional centres, students would be able to attend a nearby centre to utilise equipment (terminals, microcomputers, graphics workstations) to access a local machine with both the lesson database and sufficient resources to locally provide analysis, simulation, modelling or other functions as required. Such regional centres would lend themselves to all tertiary bodies interested in CAL thus perhaps simplifying the administration and siting aspects.

Alternatively students armed initially only with simple microcomputers and direct connect modems could gain access to the closest regional database to download the latest lesson or to upload lesson results. Machines (with cheap printers) could be supplied on a lease basis. See the previous discussion of local CAL for a leasing cost proposal.

As an indication of the costs involved, a suitable machine for use as a regional centre node would be similar to a MICRO-VAX capable of supporting up to 20 users. The estimated cost would be $30000 with 100Mbyte of disk storage plus $25000 for terminals including some graphics terminals. An additional $5000 would provide printing/plotting facilities.

The use of VIDEOTEX as a database access mechanism may lessen the terminal requirements and so lower the price of access for each student.

8.0 OFFICE AUTOMATION

Office automation is basically concerned with the electronic production and filing of documents. Additionally some accounting functions are likely to be performed but the main emphasis will be on word processing functions. Currently such functions consist of limited wordprocessing using dedicated (and relatively expensive) machines or somewhat restricted general purpose microcomputers. Additionally, some text processing is carried out on departmental minicomputers and the central systems.

Important factors conductive to wide spread acceptance of office automation are:

* User friendliness - case of use
* Confidentiality
* Quality of resultant output
* Security of data - adequate archival facilities
* Interchange of data
* Cost (capital and recurring)

Dedicated wordprocessors offer the highest functionality but high cost prevents wide implementation. Resource sharing is difficult because of network interfacing problems.

General purpose microcomputers lack the software sophistication and archival features required for user-friendliness. Resource sharing is easier than for dedicated machines but not fully satisfactory. Limited to minor document preparation.

Departmental and central text processing facilities lack the operational ease of the alternative methods (due to response times and screen updating methods). Resource sharing and archival facilities are quite sophisticated. Software packages for typesetting are readily available. This provides an excellent tool for major publication preparation.

All current implementations lack the ability to easily generate graphics integrated with text.

8.1 Development Areas

It is likely that the area of dedicated wordprocessors will be overtaken by general purpose microprocessors. Software advances will provide the sophistication and flexibility necessary.

For economy it is necessary to share resources such as high quality printers and archival systems (disks). Interchange of data is an essential ability.

Links into the UQnet will probably be via the Asynchronous Transfer Mechanism (ATM) of the MICOM or equivalent. Possibly within departments we can develop Very Local Area Networks (VLAN) to link all users to a departmental file/print/network server.

It is important to be able to create shared Local Databases. Areas such as electronic diaries, electronic mail will be important. Access to the network is critical to provide adequate and ecconomical office automation facilities.

From an ecconomic standpoint it is essential to assess the lifetime of equipment now being purchased for office use. Appendix F provides comparisons of departmental implementations using a timesharing minicomputer or individual microcomputers. Several configurations are discussed with and without networking. Capital and recurring costs of the individual microcomputers are shown to be twice that of the departmental minicomputer approach. Much of this cost differential is due to the enormous duplication of software inherent with individual microcomputers. Expansion of resources to accommodate increased computing requirements further tips the balance in favour of a departmental minicomputer. Provision of all forms of network services and software support are greatly eased with a single departmental machine.

It is essential to understand that the useful lifetime of a microcomputer based system is intrinsically limited by its very nature and construction. At the University wide level, upgrade paths are either very expensive or non-exsistant.

Ecconomically, further development in the availability of sophisticated word-processing packages available on the VAX/PDP-11 range is desirable. Special emphasis is required on the integrated production of graphics and text, and on the automated conversion of output from these packages to typesetter format. Development of draft typeset output devices is essential. Preferably, the typesetter and draft typeset devices should be configured onto a print server to allow access from any system on the network.

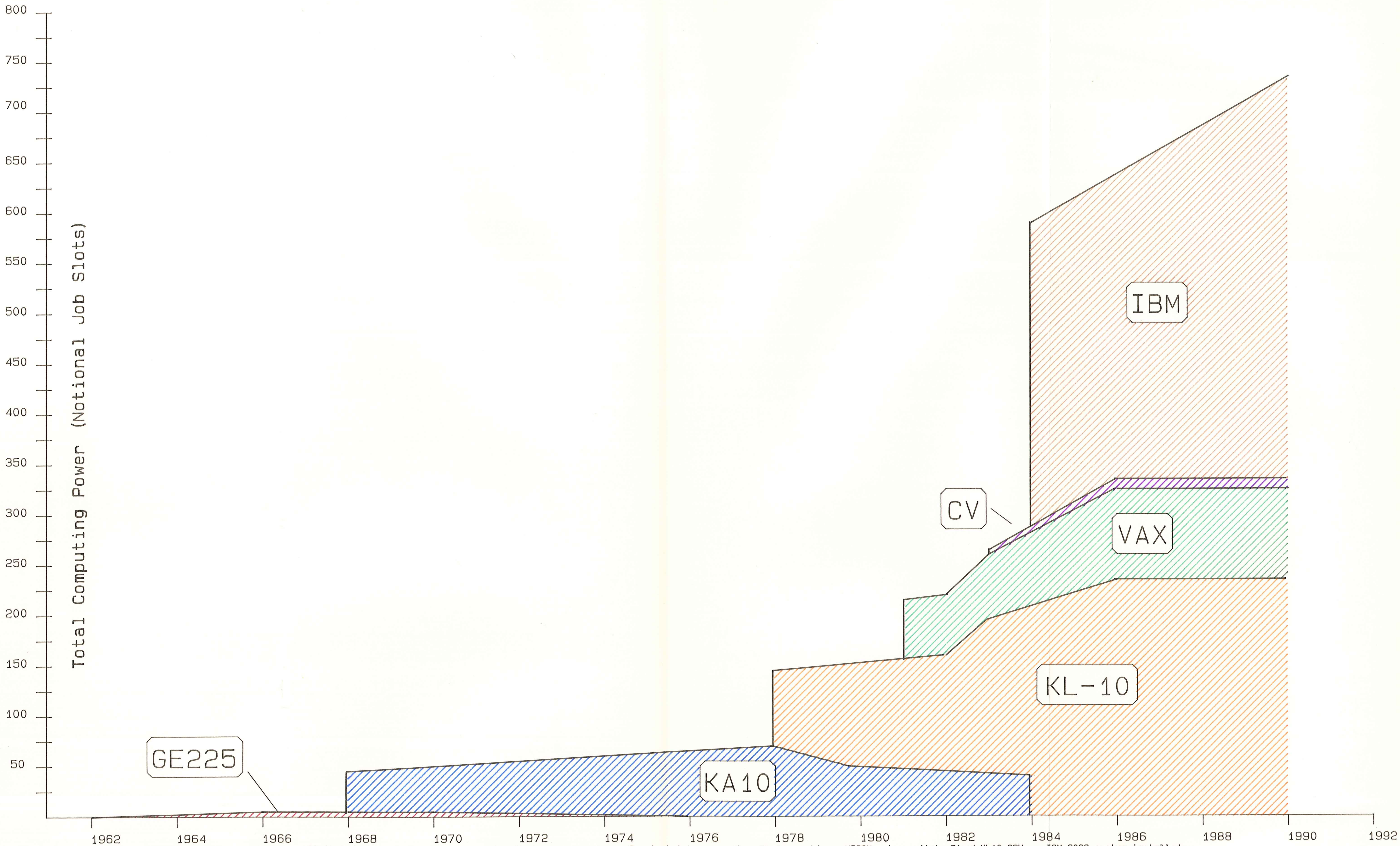
Cost of a draft typeset output device varies from $3k for a high quality printer with $10k of software packages, to $40k-$120k for a laser printer again plus software.

It is recommended that a PRINT SERVER based on a MICRO-VAX be developed. This machine should serve the photo-typesetter, draft typeset devices (to cater for different stationary, two units initially with expansion to six in 1986), and laser printer. Estimated cost is $15000 for the MICRO-VAX, $8000 for two of the high quality matrix printers, and $120000 for a high speed laser printer. An amount of $40000 is estimated as a notional figure to cover software costs associated with Office Automation, and the integration of graphics and text processing with advanced printing facilities.

APPENDIX A

GROWTH OF CENTRAL COMPUTING RESOURCES

Growth of Computing Power 1962 - 1990



1962 — First Digital Computer in the State installed at the U of Q.

The machine a - General Electric 225 - now resides in the Queensland Museum.

1964 — GE225 extended with additional memory, card - reader, line printer and magnetic tape units to meet increasing demand.

1966 — GE225 saturated so tender let for new comp.

1968 — Digital Equip. KA-10 comp. installed. First time-sharing system in the State. A lot of basic software dev. required.

1970 — 30 Terminals connected to KA-10 machine. extra disk capacity installed plotters installed giving first graphics capability.

1972 — Growth in work requires increased memory and disk and magnetic tape capacity. Most applications transferred from the GE225.

60 Terminals connected. applications programming services commenced.

1976 — Remote batch stations installed. First departmental machines connected. Memory and disk expanded to limit of CPU saturation.

1978 — New KL-10 machine installed and load shifted from KA-10. 120 terminals conn-ected KA and KL can service a total of 180 jobs simultaneously. Growth of mini-comps. in depts starts and PCC commences a distributed service.

1980 — MICOM circ.switch installed providing terminal access to all facilities. DECNET packet switch installed providing access to NETWORK. 1981 VAX11-780 installed primarily for research.

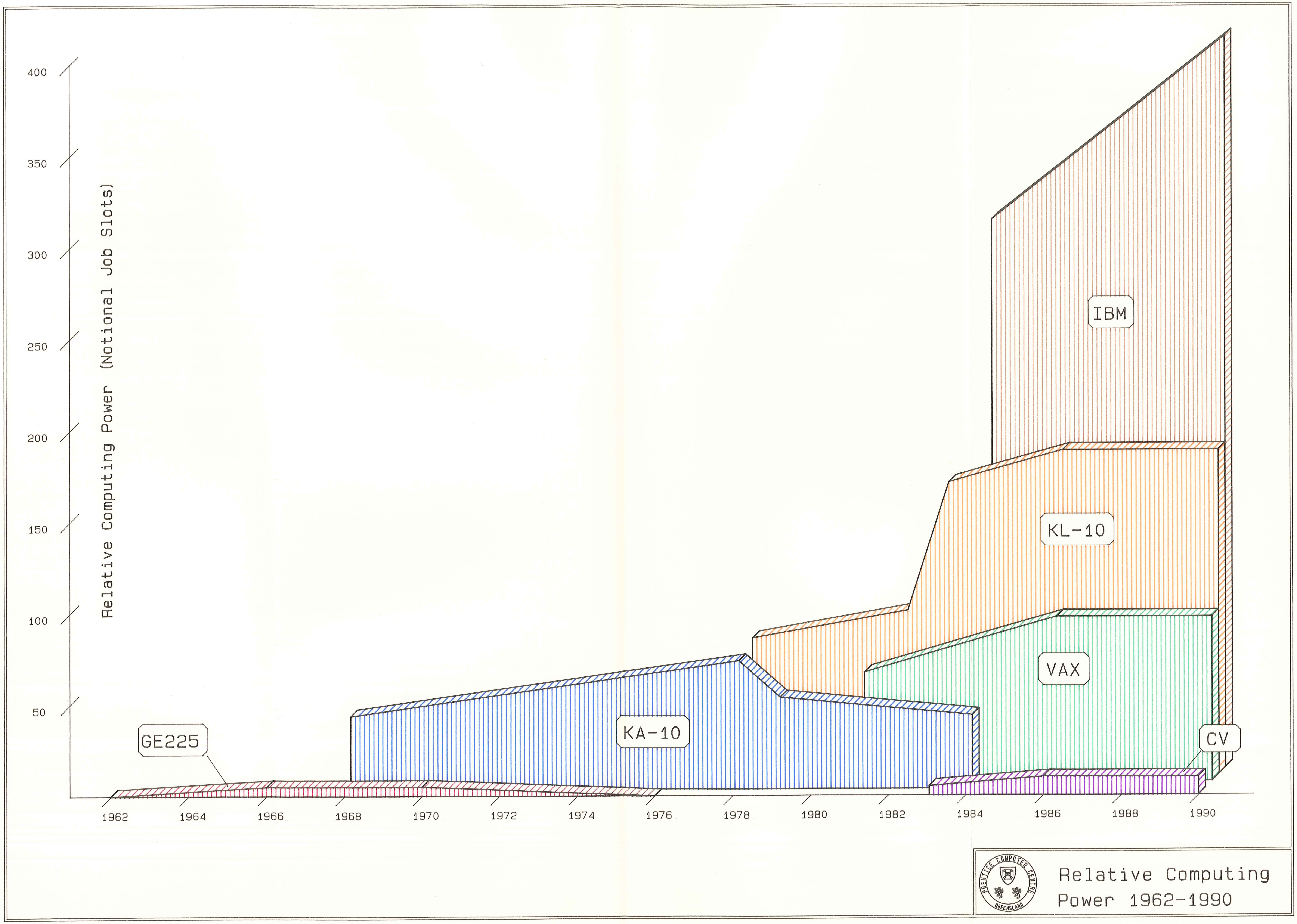
ETHERNET Local Area Network pilot links installed.

1982 — First KL10 CPU saturated, second KL10 CPU added in symetrical Multi-Processor arrangement. 1983- C.V. CAD/CAM system installed.

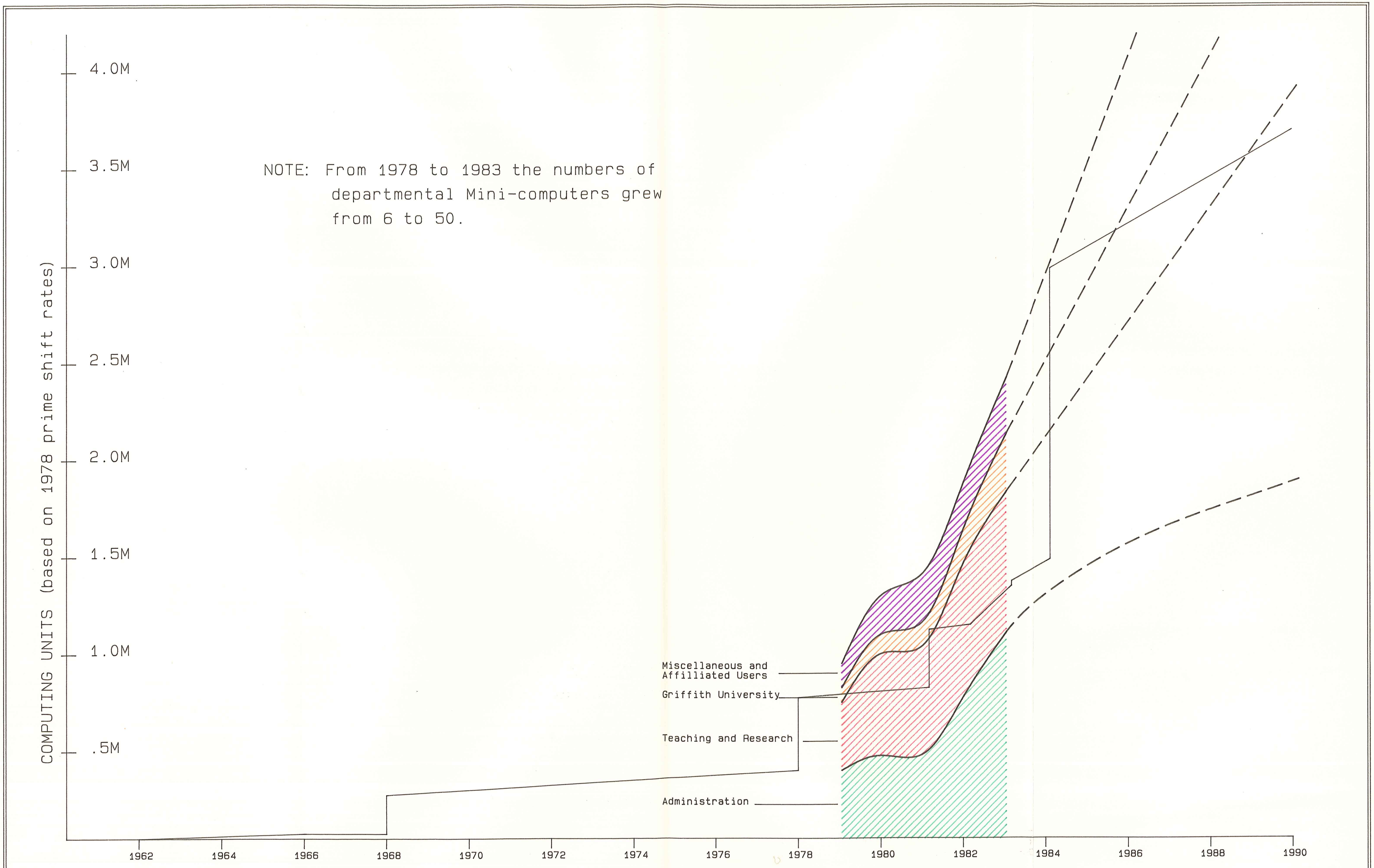
1984 — IBM 3083 system installed. Virtual Machine Operating system caters for widely variant research activities.

PRENTICE COMPUTER CENTRE QUEENSLAND

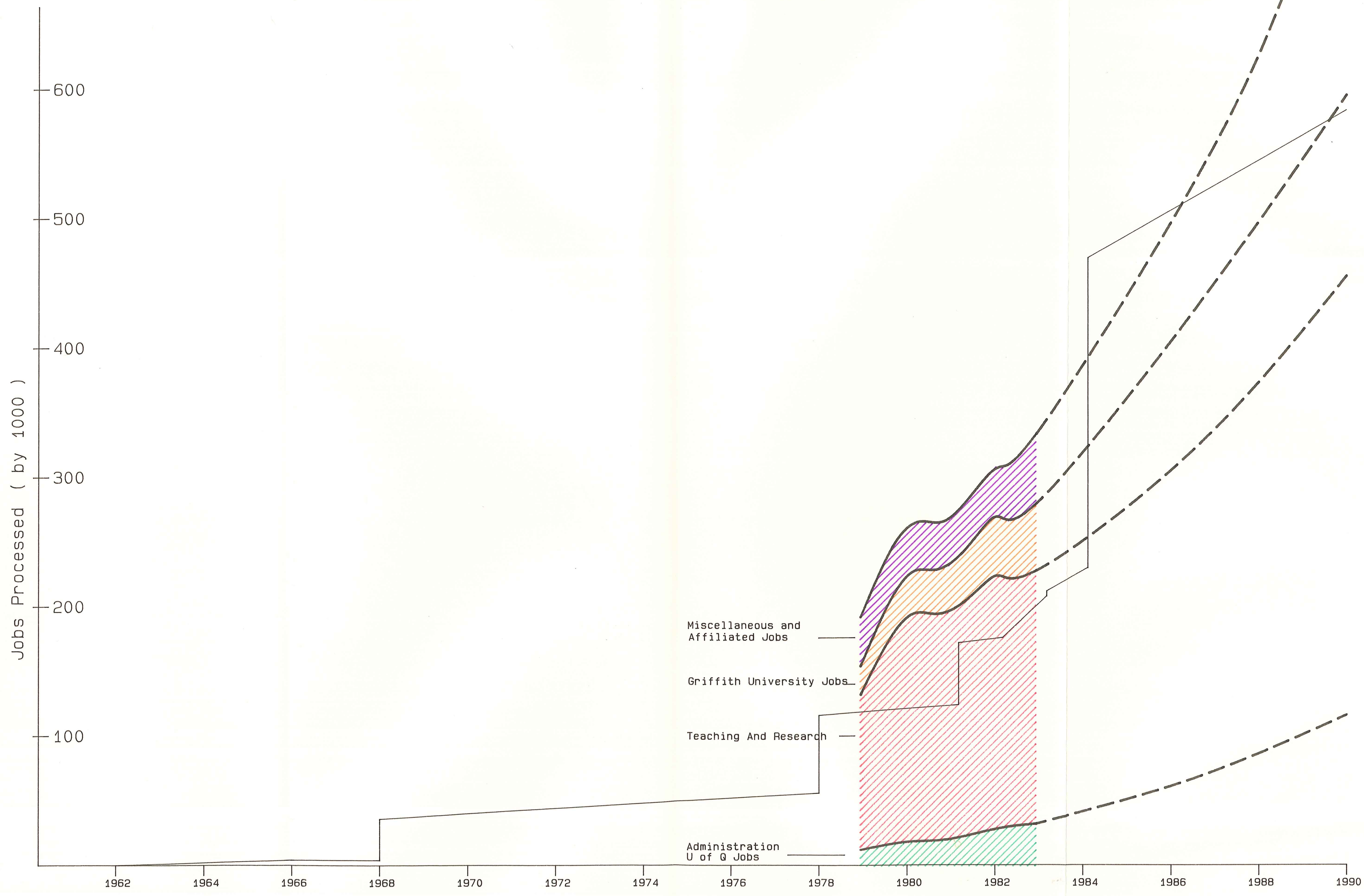
Growth of Computing Power 1962 - 1990



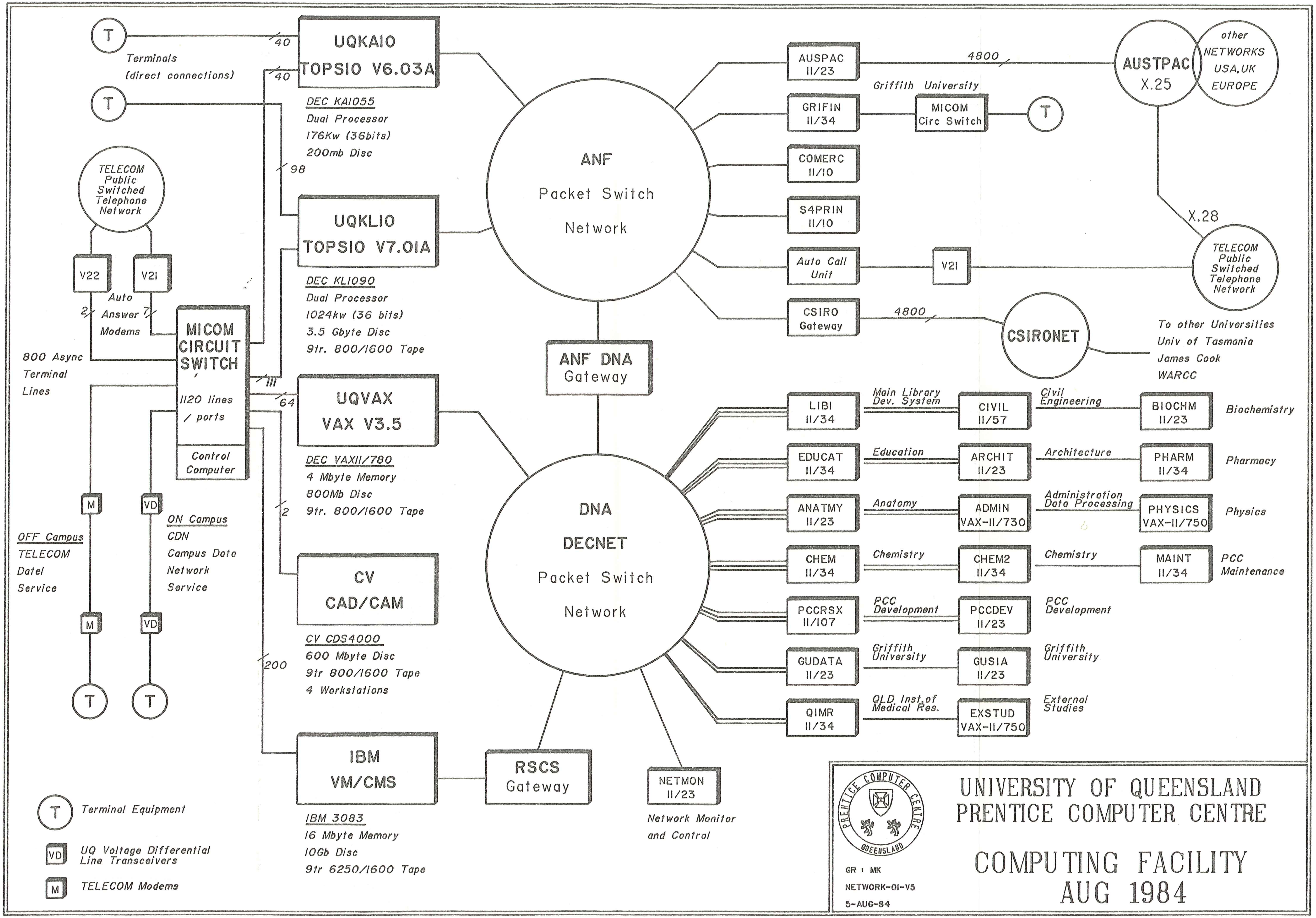
Relative Computing Power 1962-1990



Utilization of Central Computing Resources.
Part 1.

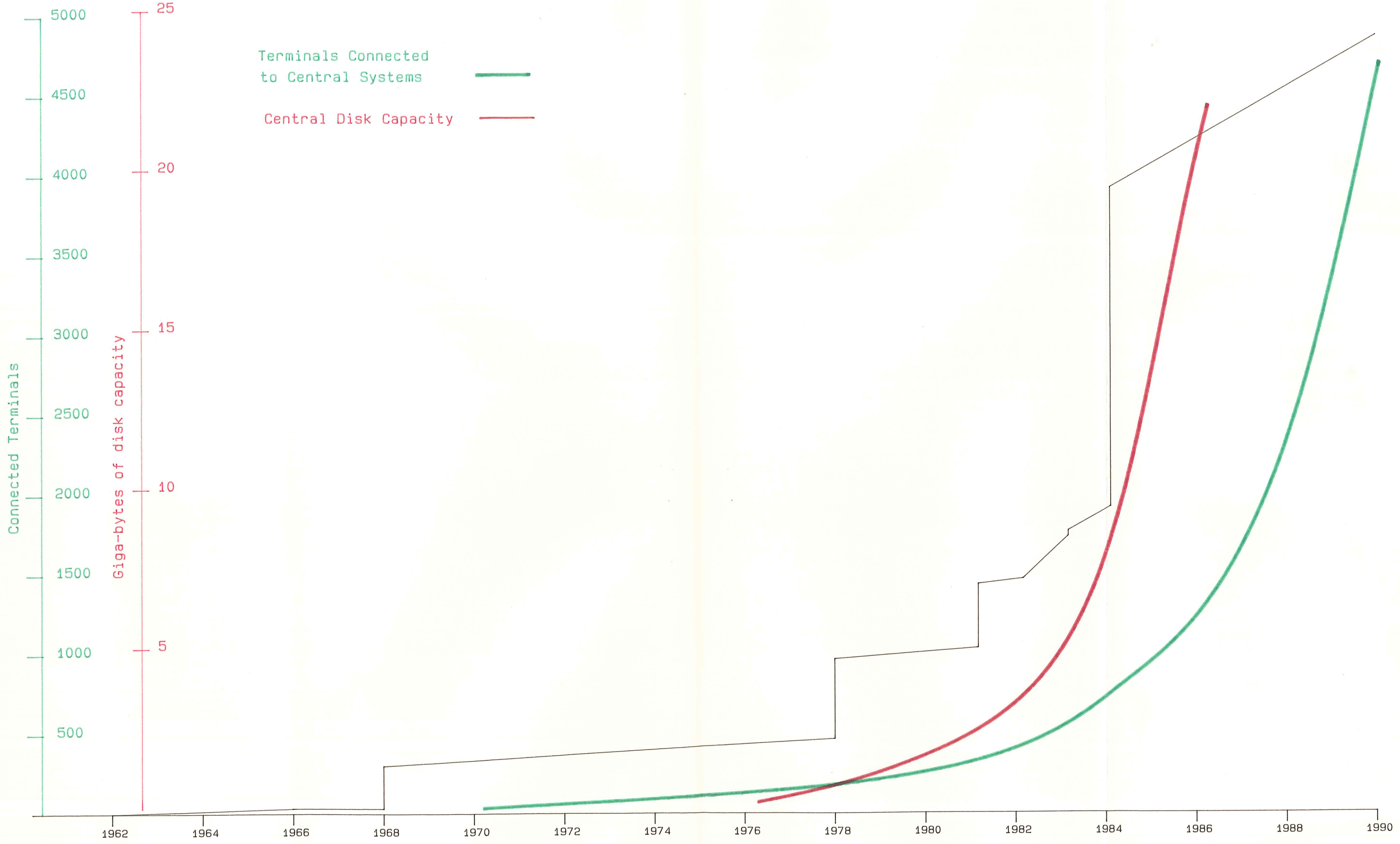


Utilization of Central
Computing Resources.
Part 2.


T
Terminals
(direct connections)
40
40
T
98
UQKA10
TOPS10 V6.03A
DEC KA1055
Dual Processor
176Kw (36bits)
200mb Disc
UQKL10
TOPS10 V7.01A
DEC KL1090
Dual Processor
1024kw (36 bits)
3.5 Gbyte Disc
9tr. 800/1600 Tape
TELECOM
Public
Switched
Telephone
Network
V22
V21
2
7
Auto
Answer
Modems
MICOM
CIRCUIT
SWITCH
1120 lines
/ ports
Control
Computer
111
64
800 Async
Terminal
Lines
UQVAX
VAX V3.5
DEC VAX11/780
4 Mbyte Memory
800Mb Disc
9tr. 800/1600 Tape
2
M
VD
OFF Campus
TELECOM
Datel
Service
ON Campus
CDN
Campus Data
Network
Service
M
VD
T
T
CV
CAD/CAM
CV CDS4000
600 Mbyte Disc
9tr 800/1600 Tape
4 Workstations
200
IBM
VM/CMS
IBM 3083
16 Mbyte Memory
10Gb Disc
9tr 6250/1600 Tape
RSCS
Gateway
NETMON
11/23
Network Monitor
and Control
ANF
Packet Switch
Network
ANF DNA
Gateway
DNA
DECNET
Packet Switch
Network
AUSPAC
11/23
4800
AUSTPAC
X.25
other
NETWORKS
USA,UK
EUROPE
GRIFIN
11/34
Griffith University
MICOM
Circ Switch
T
COMERC
11/10
S4PRIN
11/10
X.28
Auto Call
Unit
V21
TELECOM
Public
Switched
Telephone
Network
CSIRO
Gateway
4800
CSIRONET
To other Universities
Univ of Tasmania
James Cook
WARCC
LIBI
11/34
Main Library
Dev. System
CIVIL
11/57
Civil
Engineering
BIOCHM
11/23
Biochemistry
EDUCAT
11/34
Education
ARCHIT
11/23
Architecture
PHARM
11/34
Pharmacy
ANATMY
11/23
Anatomy
ADMIN
VAX-11/730
Administration
Data Processing
PHYSICS
VAX-11/750
Physics
CHEM
11/34
Chemistry
CHEM2
11/34
Chemistry
MAINT
11/34
PCC
Maintenance
PCCRSX
11/107
PCC
Development
PCCDEV
11/23
PCC
Development
GUDATA
11/23
Griffith
University
GUSIA
11/23
Griffith
University
QIMR
11/34
QLD Inst.of
Medical Res.
EXSTUD
VAX-11/750
External
Studies
T
Terminal Equipment
VD
UQ Voltage Differential
Line Transceivers
M
TELECOM Modems
PRENTICE COMPUTER CENTRE
QUEENSLAND
GR : MK
NETWORK-01-V5
5-AUG-84
UNIVERSITY OF QUEENSLAND
PRENTICE COMPUTER CENTRE
COMPUTING FACILITY
AUG 1984

APPENDIX B

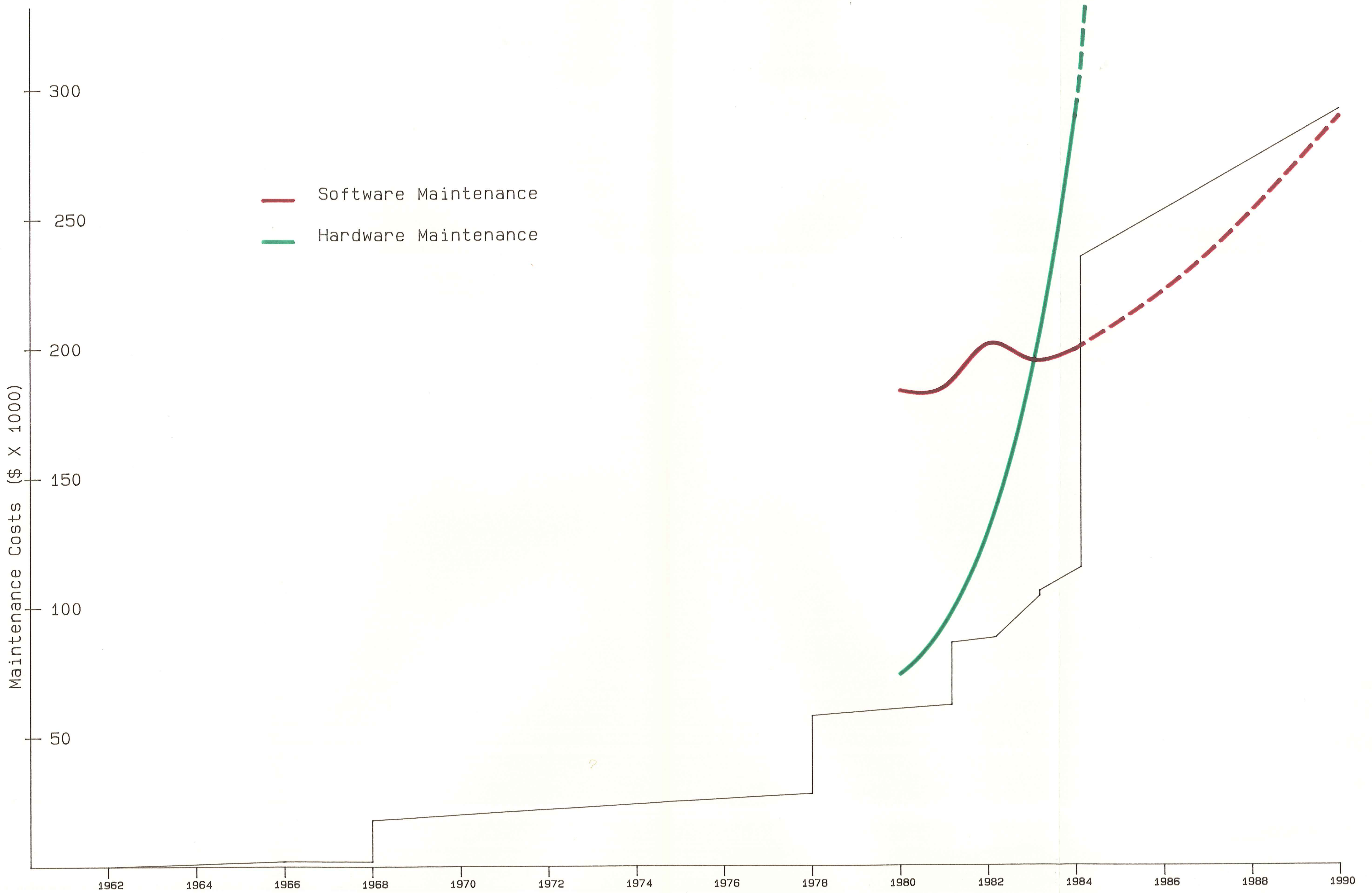
GROWTH OF COMPUTING DEMAND



Central Disk Capacity
and Terminal Growth.

APPENDIX C

RECURRING CENTRAL COSTS



PRENTICE COMPUTER CENTRE QUEENSLAND

Maintenance Costing on Central Systems.

APPENDIX D

FILE SERVERS VS DEPARTMENTAL DISKS

The installed disk capacity of departmental systems is approx. 2.7 giga-bytes. Of this amount the Library system has 1.6 giga-bytes. Considering only the remaining 1.1 giga-bytes it is informative to compare the cost of providing such a disk service by means of a network file server with the costs of distributed disk drives.

Most systems are or have been purchased with sufficient disk space for initial use (10-20Mb) and require an upgrade for efficient running. The current increment is purchase of 70Mb of Winchester disk drive, a controller and (for backup and archival purposed) a small streaming tape drive. This is the basis of the figures below.

Consider a figure of 1Gb (1000 Mbytes) for an upgrade requirement. (ie some 15 systems require upgrading to 70Mb).

(A)	70Mb disk drive	$4.7k	
	Streaming Tape Drive	$3.5k	
	Controller for both tape & disk	$4.8k	
	Total-:	$13k	

Cost for 15 systems is	$195k
Recurring cost @ 8% p.a.	$16k

(B)	Network server consisting of a		
	MICRO-VAX and ETHERNET i/f	$20k	
	Six 400Mb drives (3 for on-line backup)	$80k	(1.2Gb)
	Dual controllers	$10k	
	Total-:	$110k	

Recurring cost @ 8% p.a. $8k

APPENDIX E

EXAMPLES OF ADVANCED DEVELOPMENT

EXAMPLE 1: BIOMEDICAL

In 1978 the Computer Centre was approached by a member of the Medical Faculty to design a Heart Rate Monitor. This monitor was to be used to measure and record at minute intervals the heart rate of a wearer over a period of at least 24 hours. Obviously the monitor had to be physicaly small (cigarette packet size maximum) waterproof robust, reliable and accurate. To achieve accuracy fairly sophisticated signal processing procedures were necessary to remove unwanted muscular noise or stray electrical interference. The signal source was analog and the monitor was required to be "interrogated" by a computer at the end of the 24 hour measurement phase.

With "off the shelf" technology no such system with the sophistication and flexibility required was or is practical, basically due to constraints of size and power consumption.

With CMOS technology (low power consumption) and application-specific I.C.s using the combination of analog and digital circuitry possible on one chip, such a device is indeed practical at a reasonable cost. Such a monitor has a definite market potential which should not be overlooked.

EXAMPLE 2: COMMUNICATIONS

By the end of the decade it is envisaged that the University will be served by a major computer network interconnecting all areas of the campus. Alongside this there will be a staggering increase in the numbers of microcomputers/personal computers and intelligent laboratory equipment. It is preferable that these devices be able to connect to the network in order to distribute or collect data and to access "shared equipment" such as high quality printers, typesetters, and disk storage, not to mention the transfer of data to specialised machines for various forms of processing.

Hence, it is highly desirable to provide a cheap standard network interface with the necessary protocol conversions for connection of a wide variety of machines into the University network.

Such an interface would be required by the hundreds and would be as common as the "line driver" interface is today on the Campus Data Network. Cost savings over purchase of commercial devices would be considerable. Marketing to other Australian campuses is also a possibility.

APPENDIX F

DEPARTMENTAL COMPUTER IMPLEMENTATION COST COMPARISONS

In this appendice costings of several alternative implementations of small to medium departmental computing facilities are examined. In each case aspects of accessibility of all necessary resources (disk storage, printers etc.) are reviewed along with recurring costs of maintenance and provision for expansion. Software licensing and support is also examined.

The situation used as a median is that of a department wishing to provide computing facilities (of a mixed nature) sufficient to support sixteen simultaneous users.

System 1, the timesharing minicomputer has overall the least capital cost; half the capital cost of individual microcomputers.

Minicomputer software offers greater sophistication and quality than most software for microcomputers, although at a higher price. The overall cost, however, is far less when the costs of duplicating software over all microcomputers is considered. In the case of a simple microprocessor network with a single disk based system as a file server, it must be noted that no gains are made in respect of software since each microcomputer must have a licensed copy of software to run.

Resource sharing is only fully practicable in the case of the timesharing minicomputer systems. Here sophisticated disk allocation and protection features are available along with the ability to use any resource or system attached to the ETHERNET network. Hence, access to expensive devices such as plotters, typesetters (and larger machines) is readily available.

With respect to provision for expansion, microcomputer systems but their nature are not always easily upgradable. Usually hard disks may be added (approx. $3.5K for 10Mb) but not many options are available beyond this. The cost of upgrading minicomputer systems is considerably less (approx.

$5K for an additional 80Mb) but the ability to share network resources should greatly ease the demand for individual system upgrades.

Support services, both hardware and software, are easier to provide on minicomputer systems primarily due to the level of support available from vendors (i.e. updates of software, documentation, diagnostics and other maintenance aids) in assisting Computer Centre staff.

In summary, it is cost efficient to the University to promote the concepts of medium size computer systems within departments rather than a proliferation of microcomputers with an attendant duplication of resources particularly in software.

1. DEPARTMENTAL TIMESHARING SYSTEM

This example is based on a PDP 11/73 system with the following configuration.

PDP 11/73 CPU} 512Kb memory}	$7.5K
16 asynchronous terminal lines	$3.0K
1 ETHERNET network interface	$1.5K
1 printer port	$0.5K
80Mb Winchester disk	$5K
Half inch streaming tape drive	$3.5K
Disk and tape controller	$4.5K
16 quality visual display units @ $1.3K each	$21K
1 high quality matrix printer	$2.5K
TOTAL HARDWARE COST	$49K
SOFTWARE LICENSES	
Operating system and FORTRAN-77	$2K
Database package	$2K
PASCAL	no charge
RUNOFF	no charge
TOTAL SOFTWARE COST	$4K
TOTAL CAPITAL COST	$53K
Maintenance @ 8% of hardware capital	$4K
Miscellaneous costs (tapes, documentation)	$0.8K
TOTAL RECURRING COSTS	$4.8K

2. INDIVIDUAL MICROCOMPUTERS FOR 16 USERS

MICROCOMPUTER - 16 BIT

Averaging the prices of machines available to the University under bulk purchase arrangements, a typical machine with the following configuration would fit most applications.

16 bit personal computer
(IBM-PC, DEC RAINBOW, SIRIUS I, NEC-APC)
with .8Mb - 2.4Mb floppy disks
256Kb memory
printer port
asynchronous communications port

TOTAL HARDWARE COSTS	$5K
Software Licences	
Operating system plus FORTRAN-77	$.65K
Word processing package	$.5K
Database	$.7K
TOTAL SOFTWARE COSTS	$1.8K
TOTAL SYSTEM COST	$6.8K
FOR 15 USERS	$108.8K
RECURRING COSTS	
20 diskettes p.a. per system	$1.6K
maintenance @ 6%	$4.8K
TOTAL RECURRING COSTS	$6.4K

NOTE: NO PRINTERS HAVE BEEN COSTED INTO THIS EXAMPLE. ADD $.64K - $2.5K PER PRINTER.

3. NETWORK OF DISKLESS MICROCOMPUTERS WITH ONE FILE SERVER SYSTEM

Diskless system (16) 256K memory Local Area Network interface	$2.5K
File Server Hard disk system (1) 10Mb disk 1 x 320Kb floppy disk Printer port LAN interface	$10K
High quality printer	$2.5K
TOTAL HARDWARE COST	$52.5K

SOFTWARE COSTS

Operating system and FORTRAN-77		$.65K
Word processing		$.5K
Database		$.7K
	per system	1.85L

NOTE: Legally all CPUs must have an individual license for any software run on that system.

LAN software	$2K
TOTAL SOFTWARE COST	$31.6K
TOTAL SYSTEM COST	$81.6K

RECURRING COSTS

100 diskettes per year	$.5K
maintenance @ 6% p.a.	$3.2K
TOTAL RECURRING COSTS	$4.7K p.a.

APPENDIX G

PROPOSED CAPITAL EXPENDITURE

The costing of proposals cited in the body of the report have been sumerised in this appendix. The proposals fall under three main headings and have been grouped as such in the listing overpage. In summary the proportions are:

CENTRAL SYSTEMS ENHANCEMENTS	$370,000
COMMUNICATIONS AND HIGHER LEVEL SERVICES	$180,000
DEPARTMENTAL COMPUTING SUPPORT	$534,000
	$1084,000

As can be seen, support of departmental computing has been allocated high priority. Similarly, communications development will greatly affect departmental services. With this solid infrastructure in place, rational and cost effective development of departmental computing facilities is facilitated.

PROPOSED CAPITAL EXPENDITURE

ITEM	85/87 $	88/90 $
CENTRAL SYSTEMS		
KL10 CPU and memory upgrades	80,000	
VAX 11/750 upgrades	110,000	
IBM 3083 processor upgrade	20,000	
IBM 3083 memory upgrade		60,000
IBM 3083 disk upgrade		150,000
Staff terminals	45,000	
Minor expenditure	40,000	
Security	15,000	
COMMUNICATIONS AND HIGHER LEVEL SERVICES		
Ethernet cabling and interfaces	80,000	
Network development tools	29,000	
IBM gateway system	32,000	
ANF gateway system	15,000	
X.25 gateway system	14,000	
Additional dial-in facilities	10,000	
DEPARTMENTAL COMPUTING SUPPORT		
Maintenance spares, test equipment and development systems	120,000	
Disk servers (2 x 1.2Gb)	220,000	
Computervision public workstation	50,000	
Graphics workstations	30,000	
Advanced graphics software	30,000	
Advanced development of laboratory control equipment	25,000	20,000
Print server	15,000	
High quality output devices	24,000	
High speed laser printer		120,000
Software development	20,000	20,000