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A Proposed Computer Network for Researchers

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Abstract

In contrast to other countries, South Africa has sadly lacked a computer network for researchers. This paper starts with previous efforts to establish a national network for researchers and gives possible reasons for their failure. It then focuses on the present initiative of the Foundation for Research and Development. Various possible solutions for the proposed network are discussed and the recommended solution is given.
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1. Introduction

It is nearly twenty years since ARPANET (Advanced Research Projects Agency Network) was established as the first major research network in the United States [4]. This network has been operating ever since, and the initial four-node network has grown to a network consisting of more than 400 hosts. Numerous other networks have followed of which CSNET [1], BITNET and NSFNET are the most important [2,3]. In Europe, several research networks have been established as well, notably JANET, EARN and DFN. An excellent discussion of these networks and several others can be found in [5]. For the people using these networks daily it is hard to imagine what life would be like without them.

In contrast to other countries, South Africa has sadly lacked a computer network for researchers, although there were attempts to establish a network. As early as 1967 the CSIR attempted to set up a joint computer network between the universities and the CSIR. This culminated in the Marting Report which was rejected by the universities, the reasons being that at that time the universities had very few computer facilities and they were afraid that such a network would be detrimental to the development of local facilities. Communications technology was also not developed to such an extent that efficient solutions were possible.

During 1984 there was an effort by a group of Computer Science Departments to establish a network. The proposed network was to be called SAJANET (South African Joint Academic Network). The objectives were to share resources and to do experimental development work. The NCR Tower minicomputers which the universities received as a gift from NCR were to serve as nodes in the network. The nodes would have communicated using XXX-PAD's into SAPONET-P. This effort was unsuccessful mainly because of a shortage of funds within the Computer Science Departments.

Since then there were a number of independent, spontaneous efforts by universities and research institutions to establish connections. Several researchers at universities acquired terminal links to the network of the CSIR. A few universities also contemplated the connection of their mainframes. However, no coordinated effort has been forthcoming.

Early in 1986 a subcommittee of the Inter-university Committee on Computing (IUCC) of the Committee of University Principals (CUP) was formed to consider the different requirements and possibilities for creating an academic and research network and to make recommendations in this regard about requirements, implementation and costs. During August of the same year a meeting between representatives of the Computer Science Departments of the universities, Directors of Computer Centres of universities and research institutions (CSIR, MRC and HSRC), the Commission for Administration and the Foundation for Research and Development (FRD) was held in Pretoria. At this meeting it was unanimously agreed that the FRD should take the initiative and investigate the establishment of a computer network to assist South African researchers who were severely handicapped in their research because of the lack of access to large computers. A task group was subsequently formed with the objective of submitting proposals for a computer network for researchers to the FRD within six months.

The rest of the paper reports on the work done by this task group of the FRD (and because of the close cooperation they had with the sub-committee of the IUCC of the CUP, to a certain extent also on their work). Firstly, the objective of the proposed network is stated. This is followed by the results of a survey

conducted at the different research institutions. A summary of the lessons to be learned from existing networks is given. Possible solutions are considered and the paper ends with the final recommendations.

2. Objective

At its first meeting, the task group of the FRD decided on the following objective for the network.

To establish a computer network that will advance the quality and quantity of research at the South African universities, research institutions and industry by making it possible for researchers to collaborate on a national and international scale and by making resources that are available at the different institutions accessible to the researchers.

Collaboration will be made possible by the network through the efficient sharing of information by means of facilities like electronic mail and messaging, file transfer, computer conferences and electronic bulletin boards. The sharing of resources will ensure that researchers get access to available computer facilities - especially to computers with high processing speed.

It is important that the above should be provided by the network as easy and simply as possible. Strange and difficult customs should be avoided as far as possible. It would be ideal if the researcher could gain access to the network with the terminal or microcomputer with which he is familiar. Assistance in using a strange computer, getting an unfamiliar application program running or getting the address of a specific user should be readily available.

3. Investigation Methodology

3.1 Letter of Introduction

If the network was to stand any chance of succeeding the executives of the universities had to be kept up to date with what was planned. This was done by means of a letter signed by the head of the FRD. In the letter the problems of the researchers in terms of computer facilities were highlighted. The manner in which a computer network could address these problems and further advantages were brought to their attention. Their cooperation in assisting a member of the task group in obtaining the needed technical details was also asked.

3.2 Information Gathering

The directors of the computer centres of the different research institutions were visited. If was felt that they should be aware of the needs of the researchers at their respective institutions and therefore they and not the researchers were contacted. Information about all aspects related to the network was obtained from them.

Some of the interesting statistics that resulted from the fact- gathering mission were:

Computers from 15 different vendors were found at the universities alone.

- IBM (and IBM compatible) equipment was predominant
- Large amounts of capacity was available on several computers
- Several institutions already had X.25 access to SAPONET-P, the others can easily get access
- Several networks, ranging from PC networks to Campus networks and wider existed
- Several of the institutions were already connected or planned connections
- The most urgent services that the network must provide are: (i) access to supercomputers; (ii) national and international electronic mail; (iii) electronic transfer of programmes and data between computers; and (iv) access to international networks
- The preference for the type of network was evenly split between an IBM type network and a network based on X.25, independent of a specific computer vendor.

The most disturbing fact that came to light during the visits was the uncoordinated way in which networks and connections are being established. Not only do institutions mostly act independently, but in some instances several incompatible networks were found at one institution. Some institutions plan to connect their mainframes. Others prefer terminal connections to NIINET or GOVNET. Water Research independently makes it possible for universities to connect to them. Several institutions have already bought or ordered ISDN type of equipment. This uncoordinated, wasteful approach accentuates the need for an urgent concentrated effort for a national research network.

3.3 Existing Networks

A literature survey was done on the main research networks that exist abroad (i.e. ARPANET, CSNET, NSFNET, BITNET, JANET, EARN and DFN). The main lessons to be learned from these networks can be summarised as follows:

- Use existing networks as far as possible
- Provide network services of a high level
- Standardise on the protocols of the International Standards Organization (ISO)
- Provide professional service for information and support
- There must be a body that takes responsibility for the network and provides the necessary financial support to get the network off the ground.

The first point above led to an investigation as to what extent the existing networks in SA could be utilised. GOVNET is a network which links several mainframes and minicomputers in State Departments and which has been in operation for several years. It

consists of both an IBM network and a transparent protocol network. NIINET is a network which provides access to the computers of the CSIR and basically consists of an IBM network and an asynchronous network.

4. Possible Solutions

Using the information from the previous stage, three possible solutions of how to establish a computer network for researchers could be considered.

4.1 Full-scale Network

A full-scale network means a network providing the full range of available functions whereby any mainframe in the network can communicate with any other mainframe in the network. Such a network can be established in one of three possible ways.

Develop it from scratch

To achieve this, the necessary software must be developed for all seven levels of the ISO model for Open System Interconnection (OSI) in order that more than 33 computers at the research institutions can communicate with each other. This is no easy task. To give an idea of its complexity, it is worth mentioning that it took 8 man-years to develop one level for one operating system for JANET. Even though valuable experience can be gained this way, given the time and financial constraints and the shortage of skilled people, this seems highly unlikely as a possible solution.

Purchase the software

Some countries have already developed the software for a full-scale network (i.e. JANET). It seems reasonable to consider buying this software. If it is possible to do so, taking sanction into account, it must still be kept in mind that the software was most probably developed for an environment that is different from the one existing for the research institutions and that it would have to be adapted. This software must also be maintained and for any new additions to the technology, it must also be further developed. All this demands a high level of expertise.

Wait for OSI products

When enough products that adhere to OSI are available in the market, it is imperative that the proposed network be based on them. These products are presently not available and will not be until at least 1990. To sit back and wait for these products would mean that at least another three years will pass before a network is in place. Given the present urgent needs of the researchers and the fact that a network is already far overdue, a better alternative is to look for an easy and cheap solution in the interim that would provide most of the services.

4.2 Transparent Protocol Network

A transparent protocol network means a network whereby any terminal or microcomputer that is connected to the network can communicate with any mainframe (or minicomputer) in the network as if the terminal/microcomputer is directly linked to the mainframe. To achieve this all the existing terminals/microcomputers must be linked to certain black boxes to handle the necessary terminal emulations. Each institution will therefore in the long run phase out its existing terminal network in favour of a network consisting of the necessary black boxes. Because several universities already have this type of network installed this solution seems quite attractive on the surface.

However, for such a network to operate efficiently, it is estimated that a network control centre with at least 10 people is a necessity. One full-time person at each institution to look after the network is also required. The expenditure for this management function, together with all the equipment needed to give easy access to everybody at a particular institution, can be quite substantial. An additional drawback of this approach is that it is not compatible with the ISO standards. Mainframe-to-mainframe file transfer and electronic mail is also not possible at this stage.

A transparent protocol network will also be obtained if GOVNET is used as a carrier. The main advantage of this approach is that the management function will go over to GOVNET in return for a monthly rental charge. The computer resources of the Government will also become available to the researchers. However, the drawbacks as stated above will still remain and in addition the universities and research institutions can expect harsher sanctions against them for being associated with the network of the Government.

4.3 Phased Approach

Because of the difficulty to establish a full-scale network at this stage, a reasonable alternative is to start off with a network that can be established easily and cheaply in a short time frame and which would provide for most of the needs of a large majority of the users. This network should move closer to international networking standards in the interim and ultimately it should conform to a network based on the OSI model with all the advantages of a full-scale network. The following phases are suggested.

Phase 1 – Experimental Network

An experimental network can be established quite easily in the following fashion:

- Link the mainframes of interested institutions by means of leased or DIGINET lines. Each participating computer should be equipped for remote access via leased lines and should have at least two binary synchronous ports available in the computer's telecommunications front end for

connections to and from other computers in the network

- Purchase and install software for the RSCS (Remote Spool Communication System) protocol for IBM machines and RSCS emulators for non-IBM machines. RSCS emulators are available for VAX, PDP, CYBER, SPERRY, PRIME and DATA GENERAL computers
- Information originating at a given connected computer must be received by intermediate computers and forwarded to its destination

This network will provide the following services to its users: Real-time terminal messages and electronic mail; transfer of documents, programs and data; and batch processing.

The network as described above is a BITNET type of network. BITNET started in the Spring of 1981 as a connection between two computers in the USA. It has since grown to a network linking more than 900 computers [6]. Similar networks were established in Canada (NetNorth) and in Europe (EARN). Together they form a logical network of some 1600 computers and this number is increasing all the time. The network as proposed in phase one is therefore not only based on a very successful operational network, but it will also be easy to link this network to BITNET if the membership application is approved. This will open up access to all the computers in BITNET and through gateways, also to the computers of all the major research networks in the world.

The network as described above makes no provision for interactive access. If this is required, several possibilities exist:

- If there are links (separate from the RSCS link in the absence of SNA) between the IBM mainframes each with VM/Passthru installed, then any user connected to one of the mainframes can gain interactive access to any of the other mainframes. The IBM computers connected in this way will form a kernel network
- If a non-IBM site wants access to an IBM site, then terminals or microcomputers must be connected to the nearest node of the kernel network. This can be accomplished in various ways, for example 3270 type equipment via a 3274 cluster controller or an asynchronous terminal to a XXX-PAD through a protocol converter in front of the IBM mainframe
- If a user at an IBM site wants access to a non-IBM computer, a separate terminal link will have to be established
- If a non-IBM site wants access to a non-IBM site, standard asynchronous links can be used.

The development of local campus networks must receive high priority during this stage. Typically an individual researcher must have a terminal or microcomputer connected to a local (super)-minicomputer. These computers must be connected to a LAN that will provide local communications and resource sharing. This LAN itself can be connected to other LAN's, some of which will contain one or more mainframes. The interconnection of LAN's will form a campus network with ideally its own network control centre. The campus network in turn should have a gateway to the national research network, which in turn should have a gateway to international networks.

Even though the above network does not satisfy the needs of everybody, it is a start and should be supported as far as possible. Valuable experience of networking, of which there is a big shortage at this stage, will be gained. This can be put to good use in the following stages.

Phase 2 – Interim Network

The objective with this phase is to move the experimental network closer to international networking standards such as X.25. For the IBM sites, SNA is a prerequisite for X.25 and those installations not yet on SNA will have to acquire it. User-friendly software for accessibility to the network and interactive access, over and above those provided during phase one, can also be implemented during this phase. The required services and end-to-end protocols to provide these services should also be researched. Research should also be conducted on OSI.

Phase 3 – Final Network

This phase is the consolidation of the experiences, design decisions and deliberate research realised from the previous phases. During this stage the network should show maturity in terms of services and operation stability. Products developed according to the international OSI model should be implemented so that existing interfaces and facilities can be replaced (where necessary) with alternatives that provide more function and flexibility. The result should be a network based on the OSI model with all the advantages of a full-scale network.

5. Recommendations

Both committees recommended to go ahead immediately with an implementation of phase one of the phased approach. The task group of the FRD also recommended that a Network Information and Support Centre (NISC) be established with direct financial support from the FRD. The NISC should be staffed by four persons and is considered to be essential for the central co-ordination of the communication and computer needs of approved FRD researchers. The FRD must also make it possible for approved researchers to obtain immediate access to the computers of the CSIR and the University of Pretoria.

6. Conclusion

For different reasons a computer network for researchers has so far been unsuccessful in South Africa. However, most of the problems that stood in the way of a network have been solved and the time has now arrived for a new concentrated effort. After a thorough investigation of the present situation two committees, one of the FRD and one of the CUP, made much the same recommendations. A phased approach to the establishment of a computer network for researchers is recommended. The network should start off as an experimental network that can be established quite easily and cheaply and which will provide for the most urgent needs of the majority of researchers. The network can grow to a full-scale network based on the OSI model. It seems to be the best solution under the present circumstances. Let's hold thumbs that a national network for researchers is forthcoming.

References

[1] D Comer, [1983], The Computer Science Research Network CSNET: A History and Status Report., *Comm. ACM*, **26**, 747-753.

[2] D M Jennings, H L Landweber, I Fuchs, D J Farber and W R Adrion, [1986], Computer Networking For Scientists, *Science*, **231**, 943-950.

[3] H L Landweber, D M Jennings and I Fuchs, [1986], Research Computer Networks and Their Interconnection, *IEEE Comm. Mag*, **24**, 5-17.

[4] J M McQuillan and D C Walden, [1977], The ARPA Network Design Decisions, *Computer Networks*, **1**, 243-289.

[5] J S Quarterman and J C Hoskins, [1986], Notable Computer Networks, *Comm. ACM*, **29**, 932-971.

[6] D J Oberst and S B Smith, [1986], BITNET: Past, Present, and Future, EDUCOM Bulletin, 10-17.

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[1] E. Ashcroft and Z. Manna, [1972], The Translation of 'GOTO' Programs to 'WHILE' programs, *Proceedings of IFIP Congress 71*, North-Holland, Amsterdam, 250-255.

[2] C. Bohm and G. Jacopini, [1966], Flow Diagrams, Turing Machines and Languages with only Two Formation Rules, *Comm. ACM*, **9**, 366-371.

[3] S. Ginsburg, [1966], *Mathematical Theory of Context-free Languages*, McGraw Hill, New York.

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