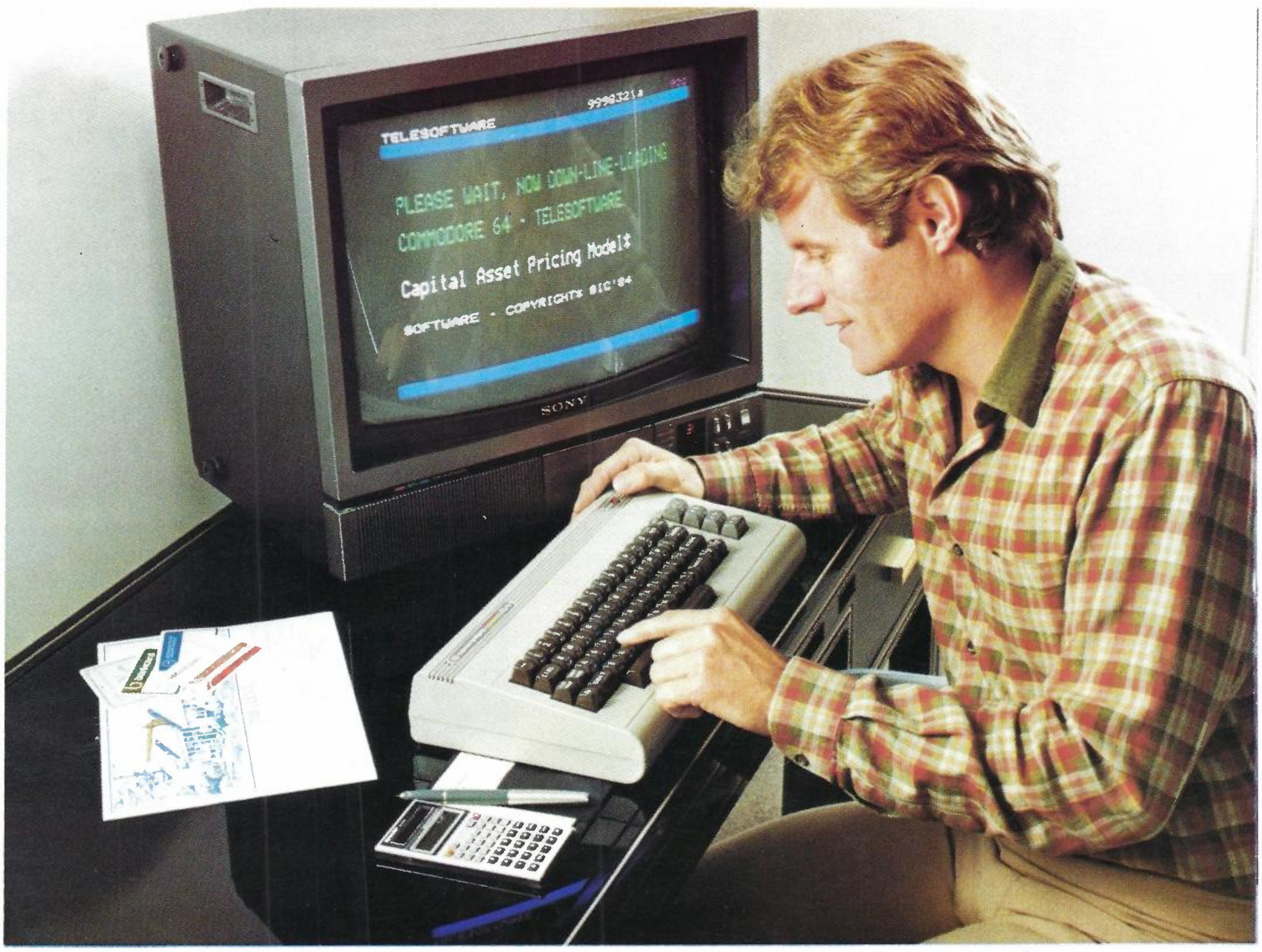
Volume 34 No. 3, 1984

the telecommunication journal of Australia



FEATURED IN THIS ISSUE

- VIATEL
- TACONET
- LAN/PSTN Interworking
- New Standard Telephone
- SULTAN
- TADMAR
- Melbourne-Sydney Route
- Outback Telecommunications

34/3

ELMI

SMART ECF 10

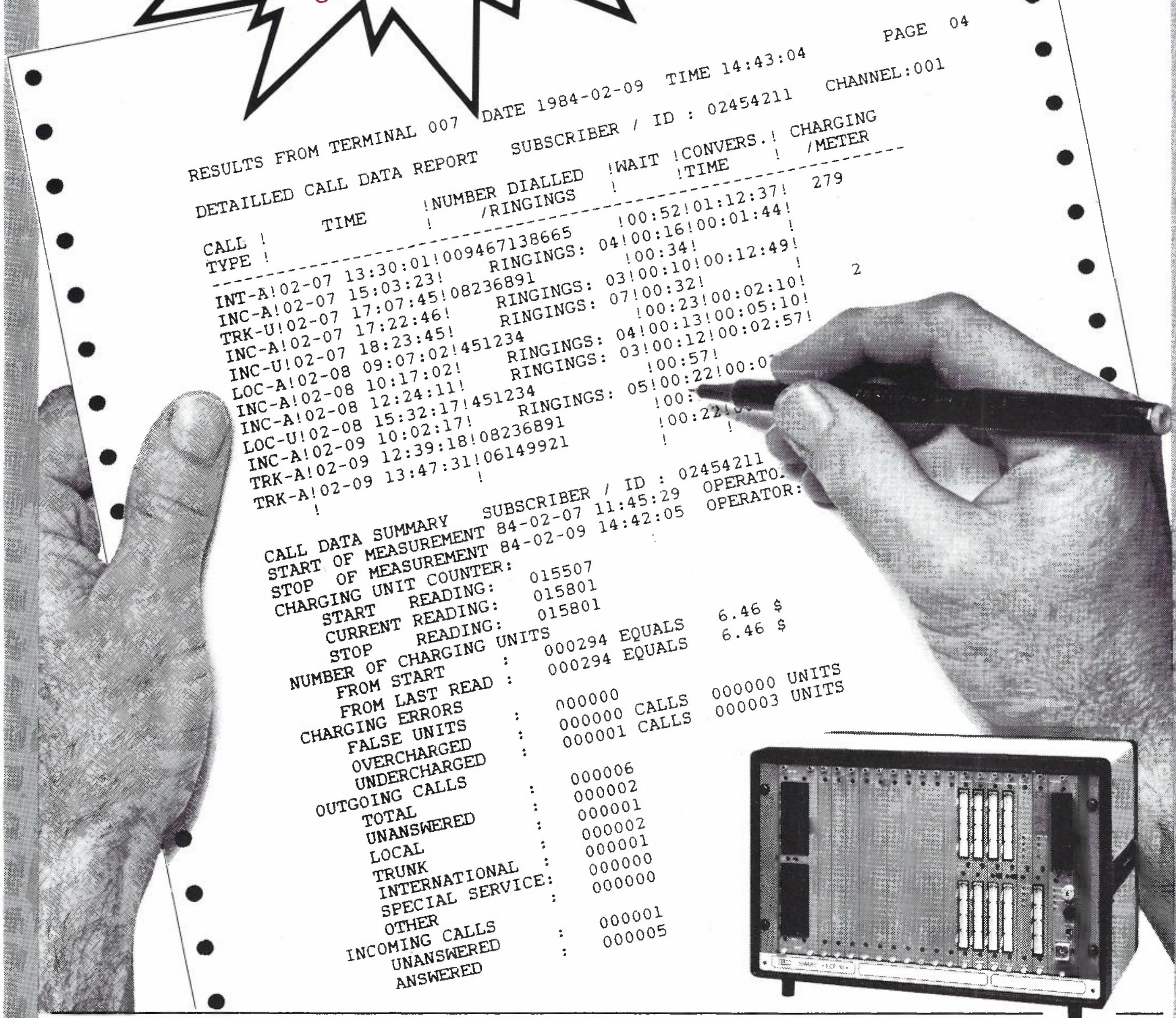
Subscriber Monitoring And Registration Terminal

FOR UP TO

540!

Subscribers

- Easily adaptable to different switching systems
- Detailed Billing for selected subscribers
- Electronic Billing (meter replacement)
- Large scale Billing Verification
- Collecting statistical information
- Can be used as independent working instrument with local call data storage and processing, or as part of a bigger call data system with central data processing



Telecom Test and Maintenance Equipment

ELMI develops and manufactures highly specialized Test and Maintenance Equipment for Telecommunication Systems.

The product range comprises – besides instruments for Telephone Charge Analyses and Billing – test equipment for:
- Pulse Code Modulation
- Multi Frequency Signalling

All products are designed with emphasis on great flexibility and reliability, and thus the possiblity of adaption to different telecommunication systems.

Today ELMI equipment is in world-wide use, distributed through agents in more than 50 countries.

ELMI

FROM ERICSSON

Industrial Products Division

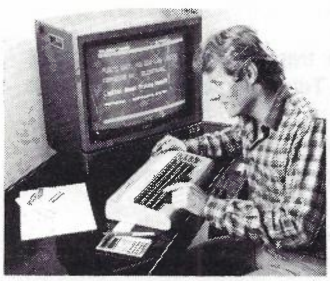
61 Riggall Street,
Broadmeadows 3047.
Victoria.

Phone:
(03) 309 2244
Telex: AA30555

THE TELECOMMUNICATION JOURNAL OF AUSTRALIA

ISN 0040 2486

Volume 34 No. 3, 1984



Cover shows a user using VIATEL, Australia's National Videotex Service.

CONTENTS

OTHER ITEMS

Editorial

F. M. SCOTT
Chief Network Engineer,
Telecom Australia, Queensland.
Queensland Editorial Representative for the Telecommunication Journal of Australia, and Life Member of the Telecommunication Society of Australia.

A meeting of interested PMG Department engineering, drafting and technical employees held on 15th August, 1949, resulted in the formation of the Telecommunication Society of Queensland (TSQ). The new society presented monthly evening lectures on current communications topics and issued notes based on the lectures delivered.

At that time the Telecommunication Journal of Australia (TJA) was published by the Postal Electrical Society of Victoria (PESV) which functioned in a similar manner to the TSQ. Other States also had similar Societies operating.

In 1959 the various Telecom Societies were merged into the Telecommunication Society of Australia with a central Council-of-Control, and Divisions in each of the Australian States. The TJA thus became a national publication and was supplied to each member in the new Society.

Queenslanders have always been strong supporters of the TJA. Apart from its informative articles on current telecommunications topics the Journal was almost compulsory reading for cadet engineers, cadet draftsmen, and Technicians-in-training as it was the main source of knowledge and information on new developments, methods and practices. Persons studying for the Senior Technicians examination also found the Journal indispensable, and the Answers to Examination Questions segment was vital to candidates for internal PMG Department examinations.

My involvement with the Society began in 1944 when I became a subscriber to the Journal and an avid reader. I was present at the inaugural meeting of the TSQ in 1949, became the first State Agent for the Journal in 1959 and in 1960 was the first Secretary of the newly formed Queensland Division of the Telecom Society of Australia. In 1959 the distribution of the Journal through the State agency was 12 copies per issue. This increased to 170 in the next year and now stands at approximately 900 copies per issue.

Some learned societies have experienced a fall off in membership, attendance at meetings, and readership of journals. The TSA has managed to retain interest in its meetings and publications and in fact is slowly expanding its membership. The Telecommunication Journal of Australia is an excellent product and still fulfills an essential role in documenting the latest telecommunications development in Australia. The Queensland Division co-operates closely with the Institution of Engineers Australia, and the Institution of Radio and Electronics Engineers in the preparation of the annual lecture program and currently three lectures per year are jointly sponsored by the three societies. The attendance at these meetings is extremely good.

I believe that the Society's objective ...

> "to promote the diffusion of knowledge of the telecommunications, information transfer, broadcasting and television services of Australia by means of lectures, discussions, publication of the Telecommunication Journal of Australia and by any other means"

... is being achieved and that the Society deserves the strong support of everyone involved — from government, semi-government and private industry — in the exciting evolution of technological developments in the telecommunications and associated fields.

VIATEL — Telecom's Public Videotex Service

L. N. CUNNINGHAM B.E.E., Dip.E.E., M.A.C.S.

Videotex is one of a number of new products that Telecom Australia is offering to its customers.

This paper discusses briefly the development of videotex, its features, and some typical applications for the service.

It also outlines the charges which will apply for the Telecom service, and discusses possible future developments of videotex.

INTRODUCTION

Videotex is a service which was designed to bring information and transactional services into the home. In practice however it has not been quick to penetrate the residential market and the majority of its early applications have been in the business sector. It is only now that its acceptance is beginning to grow around the world.

Telecom has followed developments in videotex for a number of years and first submitted a proposal to the Government in 1980. It was not until October 1983, after the change of Government, and following support from the Australian Videotex Industry Association and the Australian Science & Technology Council that Telecom was given approval to provide a videotex service. Telecom called tenders in late 1983 and in June 1984 announced that GEC had been selected to supply a videotex system which is based on the English Prestel* service. Prestel services are being operated by the Telecommunication Authorities in England, Holland, West Germany, Hong Kong, Italy and Malaysia.

Telecom has already set up a preparatory service to allow Service Providers to assemble data in preparation for transfer to the public service due to commence in February 1985. Prices for the service have also been finalized and these are discussed later in this paper.

DESCRIPTION OF VIDEOTEX

Videotex was originally conceived at the British Post Office Research Laboratories as a service which would use the TV set and telephone line in the home to access data base services. One of the aims was to increase the use of the telephone network in off peak periods. It was specifically designed to be used by the general public, and so is very easy to use and is attractive for specific business applications because of the low training, start up, and operating costs.

Videotex unables the user to retrieve information from data bases and to also carry out transactions on host computers. It utilises an adaptor connected to an existing TV set, a special videotex terminal, or a personal computer, to display selected information from a large store held on a computer, which is transmitted over the national telephone network, see Figure 1. The main features of videotex are:

It is Easy to Use.

The system has been designed to be operated directly by the general public and not computer professionals. To connect to the computer; the user just presses a button and an autodialler in the unit dials the telephone number of the computer centre. Information retrieval is possible using only a small keypad, and the user requires minimal training to use the service.

It is Low Cost.

The existing volume production of television sets and/or personal computers makes it possible for the terminal cost to be significantly less that conventional computer terminals. Connecting the terminals directly to the switched telephone network with an internal modem avoids costs associated with separate data communication modems or permanently connected circuits. In addition a low cost exists for the long distance telephone call component which results from the low data rate needed for videotex. At the data rate used for videotex (which is 1200 bits/second from the computer to the terminal) it takes about 7 seconds to completely fill a screen. Since most screens do not use the full capacity available; it only takes about 3-4 seconds on average to transmit a page. It is possible to multiplex up to 16 videotex calls onto the same normal voice band telephone channel and obtain a very low cost transmission facility over long distances.

It can provide a Wide Range of Information.

The easy access to the system makes it attractive to a wide range of information providers to supply information to the system. Information on stock-market prices, commodity prices, statistical information, bibliographical information, airline reservation information and timetables, etc, can all be accessed on the single sevice. Videotex has a defined presentation level, or standard, for display of information to the user, and this allows the one terminal type to access a wide range of information which has been formatted in the same way.

*Prestel is a trade mark of British Telecom P.L.C.

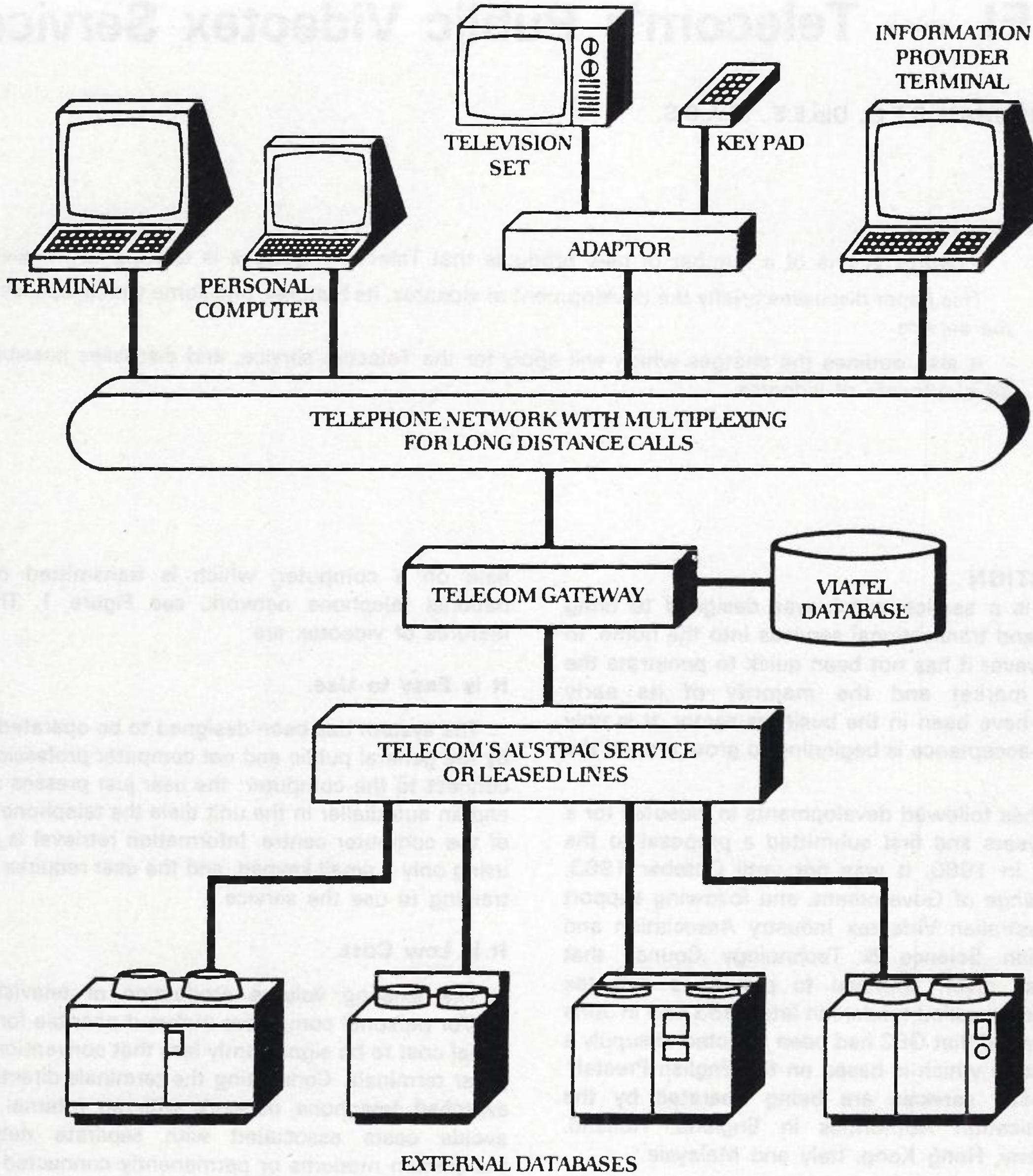
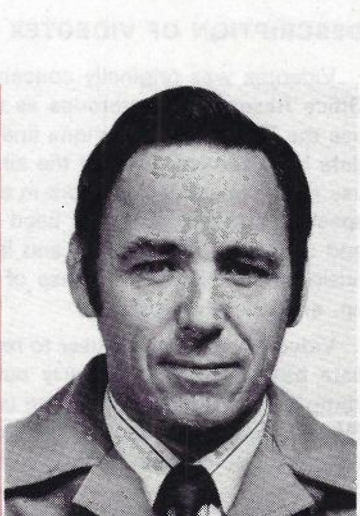


Fig. 1 System overview.

LINDSAY CUNNINGHAM is the Manager of the Videotex Branch in Telecom. He graduated from Melbourne University as an Electrical Engineer before joining Telecom Research Laboratories in the Line Transmission Section. After a number of years in the Engineering Planning Branch in the Victorian Administration, he moved to Telecom's ADP Department where he was responsible for the planning and provisioning of Telecom's data processing facilities.

He was the Engineering Manager in the Videotex Task Force set up in Telecom in 1980 and more recently was responsible for the marketing of Telecom's Trunk Network products prior to taking up his current position of Manager of the Videotex Branch.



It is a Two-Way Information System.

It allows the user to deal directly with the Service Provider (those responsible for putting information or providing other services on videotex) making many types of transaction possible on the system itself.

Videotex users are also able to access a much wider range of information services on external data bases through a gateway facility in the central videotex computer.

This gives users realtime transactional capability with a greater level of interaction. The external data base operator has greater flexibility of data base design and ease of updating frequently changing information on his own equipment, and videotex users get direct access to such services as computerised bank teller systems allowing banking transactions and funds transfer, airline reservation systems allowing airline bookings, mail-order houses to purchase goods, and a much wider range of more specialised information, eg. encyclopedic data bases.

The acceptance of videotex by the residential sector has been much slower than originally predicted, because of both and the limited domestic applications. The major growth to date has generally come from the business sector.

VIDEOTEX STANDARDS

The British Telecom Prestel system adopted by Telecom was specifically designed to be a low cost basic service and uses mosaic graphics, giving a resolution of only 80 x 72 elements on the screen, and the more sophisticated systems were developed to improve on the basic capabilities. The French Teletel system, with greater flexibility in use of the mosaic graphics, the Canadian Telidon System with the alpha geometric graphics system giving much high resolution, and the Japanese Captains System which was another high definition system operating at higher data speeds to meet the needs of the Japanese alphabet, were developed. North America has now adopted the NAPLPS North America Presentation Level Protocol Syntax as its standard and Canadian Telidon systems are converting to it progressively.

This proliferation in the number of standards inhibits universal communications in the same way as different languages do in the use of the telephone. Efforts are being made to develop a common European standard, which includes DRCS (Dynamically Redefinable Character Sets) to obtain higher definition graphics. It uses a common chip set that can be incorporated in terminals that can also access existing European systems, and this standard may, over a period of some years become widely implemented in Europe.

The countries where growth is proceeding fastest are those with a single national standard, with provision of low cost distance independent telephone access charges.

SERVICE GROWTH

There is a wide range of opinion in the world on the potential of videotex. Experience from the U.K. indicated that the rate of acceptance in the home will be relatively slow unless there is a large investment particularly in terminals. Telecom Australia is putting the emphasis on establishing a basic service as quickly as possible, and to expand the service in both size and facilities as experience is gained. The developments overseas are being closely watched to determine what factors control acceptability as a guide to the development in Australia. Telecom is initially installing a basic system that is to support the Prestel type terminals as that was the only standard operating in Australia when the decision was made.

The growth of the service obviously depends on a number of factors, the main ones being the way in which the service is marketed by Telecom, and the degree of participation and co-operation of the service providers, the terminal suppliers, and external system operators and Telecom. Telecom is working with the Industry to promote videotex and will be examining various alternatives to improve the acceptance of the service within the constraints of return on investment. Work is proceeding in the International standards setting bodies to establish interfaces between the various Telematic services such as Teletex, Mailbox services and Telex, and the provision of gateways to enable communications between the range of services is of continuing interest.

APPLICATIONS

The opportunities videotex offers for business vary with the type of business. There are a number of successful applications both overseas and in Australia—

These include spare parts location/availability systems and stock availability systems for a range of products, which have a need for an interactive communications facility at a relatively low data rate. The System allows the user to place an order and the data base can be updated frequently to take account of orders placed. The use of gateways to the computer actually running a stock control system in real time allows immediate updates of the controlling data base.

The type of application used the closed user group feature of videotex. The use of passwords keeps the transactions confidential. The terminal also is cheap and the cost of putting a terminal on a relatively large number of desks is a cost effective exercise. The task concerned is not one that is likely to justify a more expensive computer terminal or a desk top computer. If the particular task needs other terminal or computing functions there are now personal computers/multi-functional terminals which can provide access to a quickly and easily established application on a public or private videotex service.

Another typical application is dissemination of information by Government bodies, and an example of this in agricultural information. The rural community, because of the distance from cities and towns is attracted to low cost communications and videotex can deliver a wide range of up to date information to the farm, such as weather, stock and feed prices and their availability. It is also possible for the farmer to use videotex services to help calculate the way in which the business can best be run to maximise returns.

In the U.K., the Nottingham Building Society is using Prestel to widen its market base without having to open new branches throughout the country by using a gateway off Prestel into its own computers and allowing people to transfer money and pay accounts directly.

The above examples of specific applications justify terminals on desks and advantage can then be taken of access available to a range of business information. This information can be provided in association with an advertising message, or if it has value it can be charged for either per page for each page viewed, or on a subscription basis for high value information. Hence there are opportunities here for companies which have information of value which they wish to sell, or wish to use to attract business to their company.

Information on flight and train times, accommodation, restaurants, and entertainment, with associated booking facilities, then have an important place on a videotex service, as does financial information, such as current exchange rates and stock exchange prices.

One of the most popular items on these business oriented videotex services are the games, which on videotex are relatively basic.

TARIFFS FOR THE SERVICE

Charges for use of the service include a registration fee, a call fee, a connect fee and a page access fee. Business Users will pay an annual registration fee of \$12.50/month with a reduced rate of only \$2.50/month for residential customers with the fee discounted to only \$12.50 for the first year of operation of the service. A local call is charged to each telephone call to the service for anywhere in Australia and a usage charge of 8c/minute during business hours and 5c/minute off peak also applies.

The Service Provider can also charge for each page provided, however the majority of pages are expected to be free. The charges applying to any page must be indicated on the page leading to that page.

Service Provider charges are more involved, but the basic fee is \$225/month to become a full Service Provider, with up to 50 frames of information on the system. Additional frames come on a sliding scale of 40c/month per frame initially to 20c/month per frame for over 5000 frames. Other charges apply for sub-SPs and minor SPs and are available from the standard price lists and discounts apply for SP's who register users on the service.

The charges for connection of external computers to the service are somewhat greater than the SP charges and are dependent on the data capacity of the link between VIATEL and the external computer. They are independent of the location of the external computer in Australia.

FUTURE DEVELOPMENTS

Videotex currently is a low speed facility, but as communications are becoming cheaper, higher transmission speeds via what is called the Integrated Services Digital Network (ISDN), makes a "photographic" capability available on videotex. It is these new features that make it possible to carry out business activities more efficiently.

The growth of videotex in the non-business area is likely to be closely related to the progressive acceptance of the keyboard in the home. As children become familiar with computers at school the acceptance of terminals will progressively grow throughout society. The advent of voice activated terminals might also develop in this time frame, and is likely to be a further enhancement to videotex-like services in the future.

In the medium term then, the major application of videotex-type services is likely to be in provision to business of the opportunity to offer their products and services to people both in the home and the office and to finalize the sale and arrange delivery in the one transaction.

CONCLUSION

Telecom's Viatel service will provide an attractive, low cost information retrieval and transaction facility that is expected to meet a growing demand in the community. With the growth of personal computers, the reduction in cost of keyboards, and the increased acceptance of keyboards by more and more of the population it is expected that videotex will become significant both for home and business use.

VIATEL — A Value added Service

D. J. KING B.E. (ELEC), M.Eng.Sc.

VIATEL is Telecom Australia's first truly value added network service, where the service offered goes beyond that of networking to information management.

This paper describes VIATEL from both a service and networking point of view. It outlines the network that has been set up to give user access into VIATEL, as well as the network options available to Service Providers who may base their operation either entirely on VIATEL or partly on VIATEL and partly on their own external computer.

The paper also covers aspects such as user numbering, security and messaging.

INTRODUCTION

VIATEL is Telecom Australia's first truly value added network service. VIATEL's prime business is not to connect one subscriber to another; in fact the network component of the service is not even marketable in its own right. Instead, VIATEL provides a means whereby organisations can make available a range of services (request forms, product information) for the viewing and possible follow up by all those that are interested in the services provided.

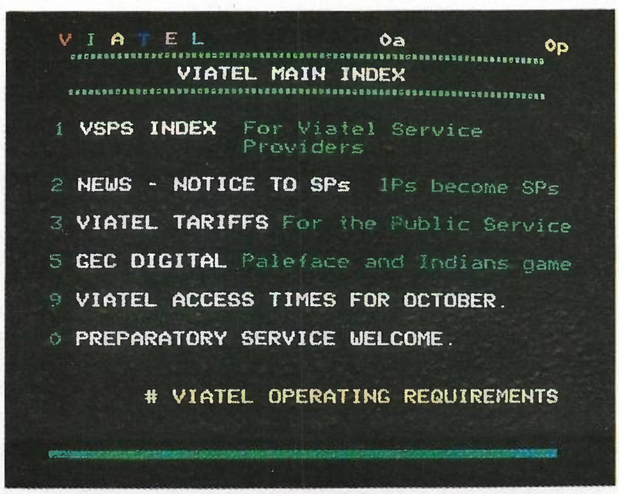
The range of services that could be put on VIATEL is as vast as the areas of possible user interest. Experience around the world has shown that this is so vast that Videotex services can only grow if the services put on are in step with the interest of the users subscribing. The reason for this is that the economic returns to a Service Provider are in proportion to the use of the service he puts on. His returns can only be high if either the number of VIATEL users is so vast that he is statistically assured of reasonable use of his particular service, or alternatively users have been recruited with known interests in the service area. Similarly, those consumers whose interests can be shown to be served, will be the first to subscribe. This matching of the services and user interests dictates that the approach taken must be one of identifying specific market segments and then promoting participation from both the Service Providers and the users that belong to those segments. More general promotion of videotex as a world of information and user interest can only succeed after a large base of users have already subscribed. Earlier promotion on this broad front could otherwise produce customer dissatisfaction and lead to a high turnover of both users and Service Providers.

In addition to providing a medium for delivering the service of Service Providers to the users, VIATEL provides two additional services. The first is a user to user messaging service. The second is the gateway service, whereby a user terminal is through connected to an external private database. This latter service greatly expands the extent of the services available to a user once connected to VIATEL.

The VIATEL service is based on the Prestel* standard. The need to support Prestel on VIATEL is based in part on the widespread adoption of the Prestel standard by several Australian firms. These firms have established operational systems, with a Prestel terminal population in excess of 1000. Furthermore, results from overseas systems indicated that the quality of the graphics is not a critical factor in determining customer acceptance and usage of the system. Recommendations from overseas marketing organisations to their users even go as far as to recommend not to overdo the use of graphics and to use text in preference. The great range of Prestel terminals and terminal adaptors readily available in Australia also meant good user choice. In fact, videotex terminal adaptors for Australian television sets were only available with Prestel videotex standard.

Considerable attention was given to the possibility of supporting multiple standards on the Viatel Service but, at this stage of development of Videotex in Australia, it is believed that the emphasis should be on developing Videotex applications, and that working with a single standard can best meet this objective.

At the time of preparing this paper, a preparatory VIATEL service is in operation and is being used by Service Providers who are actively building up their databases.



Viatel Main Index (Interim)

* Prestel is a trade mark of British Telecom P.L.C.

VIATEL APPLICATIONS

The applications to which VIATEL can be put are virtually unlimited. The applications that emerge first will be those that can either operate meaningfully or profitably with a small population of general terminal users, or those that encompass organised purchase of terminals by or for the target users of that application.

The prime applications are expected to come from the following market segments:

- Travel, Tourism and Transport
- Business, Finance and Banking
- Publishing and Media
- Rural and Agriculture
- Government and Semi-Government
- Education
- Micro-computer Services (Downline loaded software).

VIATEL however provides open ended scope for any interest group to come onto the Service. Any group that has a need to improve the dissemination of information within their group could find VIATEL attractive.

In the longer term, once the population of terminals is large and the diversity of information on the system sufficient, population growth could be rapid. But until this critical mass is reached there will be many potential providers of information who will not be able to commercially justify putting their information on the database.

DATABASE STRUCTURE

Information is held on the VIATEL database in the form in which it is displayed on the terminal. For each screen that can be displayed to a user there is a corresponding 'page' or 'frame' of information held on the database. Each page is addressed by its page number, such that the user has simply to key in the page number in the form * nnnn , where nnnn is the page number, to retrieve the page onto his terminal.

For the purposes of database administration the pages are logically organised in a hierarchical or inverted tree structure, and the page number is taken from its position in the tree.

VIATEL also provides routing facilities to allow the user to move through the database in a manner completely independent of the tree structure. The routing is set up by the Service Provider when he creates the pages. The text of the page then provides instruction to the user as to which digit 0 to 9, or to key in to select the information he desires.

USER REGISTRATION AND SECURITY

Any person throughout Australia that is registered as a user on the VIATEL System will be uniquely identified. This unique identity is used by the system for creating account structures, for customer billing and for overall system management. For the customer it provides a secure environment for accessing the system; the log on procedure checks the customer's identity, then requests a personal password before allowing access to the database.

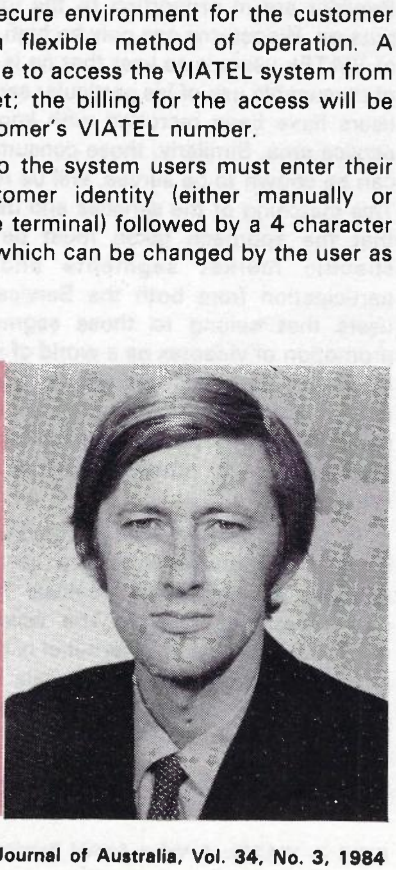
The unique identity of every VIATEL user in Australia is provided by:

- VIATEL Number
  Each customer registered on VIATEL will have a VIATEL number that is used to identify that customer within the system for billing, mailbox address, and for system management purposes in general.
- VIATEL Service Number
  The VIATEL Service Number is the VIATEL Number prefixed with the network identifier "V". This is used for unique customer identity in the Telecom accounting systems.
- VIATEL Customer Identity
  Each customer on VIATEL is also assigned a VIATEL customer identity. This identity is confidential to the customer and provides secure customer access to VIATEL.
- VIATEL Personal Password
  Each customer on VIATEL will require a personal password that will provide a further level of security for system access.

The combination of these four identity schemes provides a highly secure environment for the customer and will provide a flexible method of operation. A customer will be able to access the VIATEL system from any telephone outlet; the billing for the access will be debited to the customer's VIATEL number.

To gain access to the system users must enter their own 10 digit customer identity (either manually or automatically by the terminal) followed by a 4 character personal password which can be changed by the user as

DAVID KING is the Manager of the Systems Development and Operations Section of the Videotex Branch in Telecom. He graduated from Melbourne University as an Electrical Engineer before joining Telecom Research Laboratories in the Switching and Signalling Branch. He then worked for three years with I.T.T. in France before returning to Telecom, to join the Switching Design Branch, during which time he spent 18 months in Sweden on the AX-E/AOM project. He then moved to the AUSTPAC Project as Manager — Systems. After spending 9 months working with the French contractor for AUSTPAC he returned in time for the cut-over of the AUSTPAC system into service. He has been with the Videotex Branch since January, 1984.



required. After three unsuccessful attempts the user is disconnected and the event logged by the system.

The user's record indicates which Closed User Groups (CUGs) the user belongs to and this is checked before access is given to information pages which have access restrictions.

Information providers log-on to the system in the same way as general users; however, before they are given access to the data base editing facilities the system checks that they are registered as an IP and requests a further 4 character edit password. Unsuccessful attempts are again disconnected and logged.

IPs can only edit their own portion of the database and have the same access to other pages as normal users. IPs can use the CUG facilities to protect pages from access by users other than those they authorise.

NETWORK OPTIONS AVAILABLE TO SERVICE PROVIDERS

The Service Provider has a number of options available to him. Although all services and information must be expressed in terms or frames that can be displayed on a user's videotex terminal, the manner in which those frames can be stored varies from one option to another.

Standard VIATEL Operation

The standard and common approach is where a Service Provider's operation is based entirely on VIATEL. In this case the only equipment required by the Service Provider is videotex editing terminals. With these terminals the Service Provider is able to build up his database using the editing facilities provided by VIATEL. Using the VIATEL editor he has complete freedom to alter that part of the database allocated to him. He can enter a new frame, amend an existing frame, overwrite, copy or delete a frame.

Standard VIATEL Operation with Offline Editing

The option exists for Service Providers to create parts of their database off-line on their own computer. Having done this, the section of database so created is transferred in bulk to VIATEL using either the on-line bulk update facility or magnetic tape.

The on-line bulk update option is also useful for Service Providers whose information varies constantly. This allows the Service Provider's computer to automatically keep the data on VIATEL up to date.

Retention of Part of the Data on the Service Provider's Computer

The option exists to retain part of the information within any one frame on the Service Provider's computer. This option could be used for data pertaining to each individual user (such as the balance of his bank account) which, whether it varies frequently or not is only ever required when that one particular user calls for it.

To exercise this option the Service Provider must be capable of establishing a direct connection with VIATEL. Such a connection is referred to as a gateway connection. The protocol used between the computers is referred to as the Data Processing Gateway Protocol. This is discussed later.

Service Provider Storage of Videotex Frames

The final option is for the Service Provider to purchase a videotex system on which he stores the videotex frames. This could either be a videotex software package running on his existing mainframe, or a stand alone minicomputer. With this option the videotex frames are not only created by editing facilities on his own system, but in addition they are only passed to VIATEL when a user specifically requests the frame. VIATEL stores only the current frame being viewed by each user, and each frame must be re-sent in full every time a user requests it.

Exercising this option requires establishing a gateway connection to VIATEL and the protocol used between the computers is referred to as the Videotex Gateway Protocol, which will be discussed later.

VIDEOTEX TERMINAL ACCESS NETWORK

The principal requirements for videotex terminal access to VIATEL were defined as:

i. Australiawide access from any telephone service connected to the automatic network.
ii. Local call charge access regardless of location.
iii. Minimum response time.
iv. Reasonable error protection.
v. High availability.

In addition, the access network had to be cost effective both in the initial configuration and during its progressive growth.

There are several approaches that could be taken to satisfy these requirements, each one differing in the extent to which use is made of existing Telecom networks. The Telecom networks/services available are the Public Switched Telephone Network, the various DATEL services, the Digital Data Service and the packet switching service, AUSTPAC.

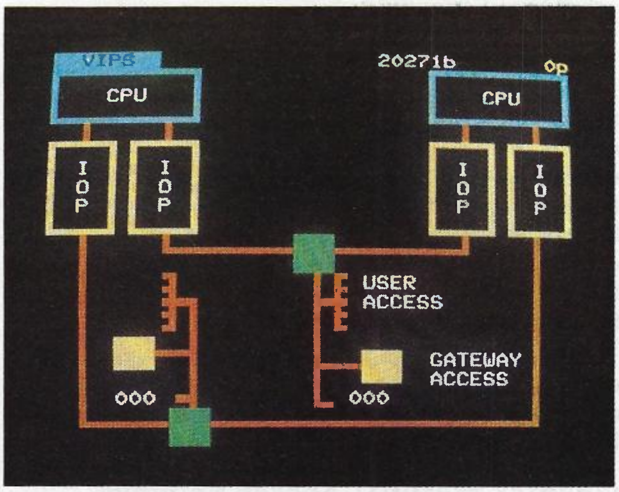
The solutions adopted vary markedly between the different countries that have installed public videotex systems. The principal difference stems from the extent to which use is made of their packet switching networks. And this difference arises from several factors such as the relative timing of the introduction of the packet switching and videotex services, the relativity of tariffs between the packet switching service and the leased line services, and the degree of centralisation of the videotex service.

In Australia, the most cost effective solution that also met the stated requirements was found to consist of a separate network of intelligent multiplexors with connection to AUSTPAC only on overflow. The network configuration is shown in **Fig. 1**.

Access to the network is obtained by dialling 01955 (normal access) or 01956 (bulk update access).

The network consists of a multiplexor in each State, interconnected by 9.6 Kbit/sec DATEL or DDN links. There are a minimum of two links from each State, one direct to the multiplexor at the computer site and the other to the multiplexor of another State. The multiplexor can either automatically share the traffic load between the links or use the links on an overflow basis. When a link fails the multiplexor will automatically re-route the traffic on the failed route to another available route.

The multiplexor provides port contention allowing the



Viatel Computer Centre (Illustrative Configuration)

number of inward ports to be greater than the number of outward ports. This allows increased computer port utilisation, effectively increasing the number of user ports presented. The multiplexer also gives comprehensive diagnostic and event reports to assist both in network monitoring and planning the expansion of the network.

The overflow capability to AUSTPAC provides extra flexibility in handling unexpected growth requirements. Once the number of circuits required on AUSTPAC or the utilisation of the AUSTPAC port becomes significant then it becomes more economical to install another DDN or DATEL link.

The use of both DDN and DATEL to each multiplexor is to provide additional diversity and hence protection against single failure.

BULK UPDATE

Bulk update is used by a Service Provider when the input data is supplied to VIATEL by another computer system, or by a microprocessor-based intelligent editing terminal.

Three different input media will be available to Service Providers wishing to Bulk Update:

— Magnetic tape batch update with exception reports output to a line printer.

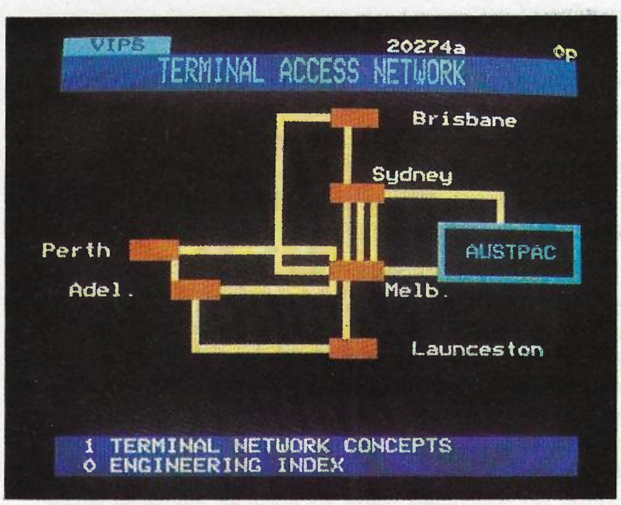


Fig. 1. Terminal Access Network

— Asynchronous on-line bulk update via the VIATEL customer access network on dialling 01956.

— On line bulk update via AUSTPAC.

The basic structure of the data records used is independent of the input media selected. The one 'VIATEL Bulk Update Technical Specification' will be used for all 3 cases.

Separate update records are defined for the separate functions of insertion of a new frame, replacement of a frame and deletion of a frame.

Retrieve frame records are defined to allow retrieval of frames from the database. In the case of magnetic tape the frame is output to the printer for inclusion in the output report. In the case of on-line bulk update the frame is sent to the computer over the VIATEL customer access network.

In the on-line cases, a message control record can be used to retrieve message/response frames (in part or whole). The options available are to retrieve a new message, retrieve a previously read and stored message, retrieve a new or stored response field, store the message just read and delete the message just read.

The magnetic tape format is NRZI mode, 9 track, 800 bpi. The asynchronous on-line bulk update protocol is character orientated with a transmission rate of 1200 bit/s. To minimise the effect of transmission errors the records are split into blocks of maximum size 255 bytes.

GATEWAY OPERATION

Gateway operation requires connection to VIATEL via Telecom's AUSTPAC, DDS, or DATEL services. Refer **Fig. 2.** The selection of service will depend on the expected data volumes. In all three cases the X.25 protocol is used. Since the X.25 protocol is mandatory it is expected that AUSTPAC will be used in the majority of cases. VIATEL tariffs will be set to ensure distant independent tariffs regardless of the method of connection used.

Use of AUSTPAC has the advantage that the VIATEL communication ports are shared between all external computers and can thus be dimensioned efficiently. DDS and DATEL connections require dedication of a VIATEL communication port to one external computer (EC).

Gateway access on AUSTPAC will use switched virtual circuits rather than permanent virtual circuits. This choice allows better utilisation of the virtual circuits into VIATEL, since the circuits can then be shared over all gateway computers.

User access through the gateway is obtained when the user calls up a gateway access frame. These frames appear like any other frame within the VIATEL internal database. The difference occurs only when the user responds to the frame by keying 'I' to request connection to the external computer. On receiving this response the VIATEL computer sets up a call to the external computer on the link (AUSTPAC or otherwise) assigned to the gateway access frame.

On receipt of a connection request from VIATEL the external computer acknowledges the call, checks the conversation request details, and selects a 'Welcome Page' to be displayed on the user's terminal. If the external computer doesn't wish to accept the call then a suitable 'Goodbye Page' is selected for display.

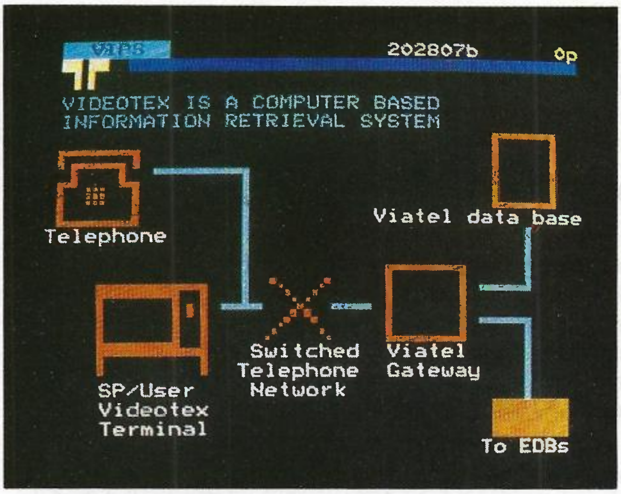


Fig. 2. Overall Viatel Network

Whilst connected to the external computer user operation is as it would be when accessing data on VIATEL's database.

There is a maximum number of times which VIATEL will allow a user to try unsuccessfully to establish a Gateway connection (currently 3) after which the user will be prohibited from making further connections for the duration of the call.

Two protocols are available for gateway use:

— Data Processing Gateway Protocol;
— Videotex Gateway Protocol,

and their application is discussed in the following sections.

DATA PROCESSING GATEWAY PROTOCOL

The Data Processing Gateway Protocol is designed for Service Providers who do not wish to format the data on the external computer in a VIATEL-like structure, or indeed in any videotex structure. The EC supplies information in simple block structure, and nominates a VIATEL frame into which this information is to be placed prior to presentation to the user. This presentation of a page on the user screen under the control of the EC is said to be "triggered" by the EC.

The frames triggered by the EC are like any other frame within the VIATEL internal database. The difference is that:

a) they can only be called up by the EC.
b) the frames typically contain several data fields which take on values supplied by the EC as part of the trigger information.

Any direct access to these pages by a user when not in the gateway mode will be blocked.

Because of the ability to fill in fields prior to the display of the frame to the user the frames are in effect a template to which the EC can add relevant information. An EC can have any number of these templates and so they can be tailored to each and every different possible application wished to be served.

The creation of these frames can be done using the VIATEL editor in the same way as other VIATEL frames are created. Alternatively they could be designed off line and then loaded by a bulk update.

The user will be debited and the service provider credited for the price of the frames triggered from ECs in a similar manner to normal frames; each frame carries price information which will be displayed to the user on the top line of the screen.

The great advantage of the Data Processing Gateway Protocol over the Videotex Gateway Protocol is that only that data which is user identification dependent or frequently varying need be sent over the gateway link each time a page retrieval is made by the user.

It is likely that any frequently changing data would be sent across the Gateway link at the time of information retrieval. However the on-line bulk update protocol provides an alternative method of keeping the templates up to date with frequently changing information. The choice between the two methods would depend on which is most cost effective, and this will depend on both the frequency of change and the frequency of information retrieval of that particular frame.

The normal frame select mechanisms are available to the user. The user can either key a direct page access command of the form * n n n or key a numbered choice (0-9) from among the choices offered on the current frame displayed. The information provided by the user is conveyed to the EC which then responds to VIATEL indicating the particular frame to be triggered from the database.

Facilities for requesting re display of the current or previous frame are also available. To service the request to redisplay the previous frame the EC is required to keep a history of frames previously triggered. The number of frames in the history file is required to be at least 3.

When collecting data from the user the EC need only nominate the template frame to be triggered. All details concerning the fields to be completed by the user, and the prompt messages to be sent to the user for each input field, are pre-specified at the time the template frame is created. This gives a considerable saving in the volume of data to be sent over the gateway link.

In summary, the advantages of the Data Processing Gateway Protocol over the Videotex Gateway Protocols are:

1. only the dynamically changing data is re-sent for each

Fig. 3 Mailbox front page

user request — resulting in lower volume charges when using AUSTPAC,

2. the definition of the input fields on data collection frames is only ever done once rather than with each user access,

3. improvements in the protocol allow faster user response time,

4. the protocol itself is considerably simpler having only half the number of block types requiring processing by the EC software.

VIDEOTEX GATEWAY PROTOCOL

The Videotex Gateway Protocol is a protocol that requires implementation of a videotex system in the external computer. The protocol has a similar block structure to the Data Processing Gateway Protocol, but whereas in the D.P. Gateway Protocol only selected data fields are supplied within the blocks, in the Videotex Gateway Protocol the complete page must be supplied.

Technically speaking it is not mandatory to implement a videotex system in the EC. However, in practical terms it would be difficult to format the videotex frames within the protocol blocks without having previously created them on the EC and checked them for correctness.

The data retrieved by a user once connected to an EC using this protocol resides entirely on the discs of the EC. No information can be taken from the VIATEL database until the user disconnects (via a GOODBYE frame) from the EC and returns to the VIATEL database. Furthermore if several users 'simultaneously' access the same frame then all details of this frame (approx 600 characters typically) must be sent separately over the gateway link to each user.

The protocol defines 12 block types, all of which are required to realise the full functionality available. This compares with 5 for the DP Gateway Protocol.

The basic function of information retrieval is fairly straightforward since it is only the page to be displayed that needs to be sent over the gateway link (plus control information). However, the data collection function is considerably more complex as the individual field definitions need to be sent as well as the prompt messages associated with each field.

The advantage of the Videotex Gateway Protocol over the DP Protocol is that:

1. readily available software packages exist for it,

2. for Service Providers that already run on existing Videotex System it is administratively simpler to only have their pages on one system,

3. a Service Provider may find it more cost effective to store infrequently accessed frames on his own database rather than the VIATEL database.

ELECTRONIC MAILBOX

VIATEL provides a simple user friendly method for sending messages between all subscribers on VIATEL. Readily available predefined Mailbox message frames reside on the system and the subscriber has simply to retrieve one of these frames onto his screen, type in the destination Mailbox address and his message in the fields provided and dispatch it with a single key stroke.

Since a VIATEL subscriber can access VIATEL from any telephone service throughout Australia messages can be sent or received from home, whilst on holidays or business Interstate, up skiing or down at a beach resort. The subscriber sending the message may not know, and does not need to know, in which State the destination subscriber is located, as the message is sent to a notional address, not a fixed geographic location.

The predefined Mailbox message frames gives complete flexibility to the VIATEL subscriber whilst at the same time reducing the amount of text he is required to key in. For instance VIATEL automatically enters the name and mailbox address of the subscriber sending the message. In addition a selection of commonly used message texts is available. The possibility of a completely free formatted message is also provided. There is no individual limit to the number of messages that can be sent or received. To send a message, the user first calls up the front page of the messaging service, **Fig. 3**.

As soon as a subscriber dispatches a message VIATEL time stamps it and stores it in a secure message pool logically independent from the rest of the normal information database. VIATEL then makes an entry in the destination subscriber's mailbox indicating that a message is waiting for him. Should VIATEL be unable to complete this process; for instance if the destination subscriber is no longer registered on VIATEL; then a negative acknowledgement is given to the sender. Only if the process is completed is a positive acknowledgement given to the sender.

The message once sent can only be accessed by the subscriber to whom the mailbox belongs. It remains there waiting for him until he cares to read the message. He will automatically be advised by VIATEL that he has new messages waiting for him whenever he logs-on or logs-off.

The journal to celebrate its Golden Jubilee in 1985

In August 1874, a group of officers of the Post and Telegraph Department, Melbourne, founded a society called "The Telegraph Electrical Society." The purpose of the society was stated to be . . . "The promotion of the knowledge of electricity, especially as connected with telegraphs." This was the first known Australian society formed specifically to cater for telecommunications interests. It is interesting to note that the Society existed for nearly two years before Alexander Graham Bell invented the telephone in 1876.

The original Telegraph Electrical Society flourished for some years but later declined. The Society was eventually superseded in 1908 by the Postal Electrical Society of Victoria which went through periods of reorganisation in 1923 and then in 1932. In its early days, proceedings of the Society were published in the Telegraph Electrical Society "Transactions." It was not until 1935 that the first Telecommunication Journal of Australia as we know it appeared. Since that date, the Journal has became a regular feature of the Society, but it was not until 1959 that the Society become the Telecommunication Society of Australia.

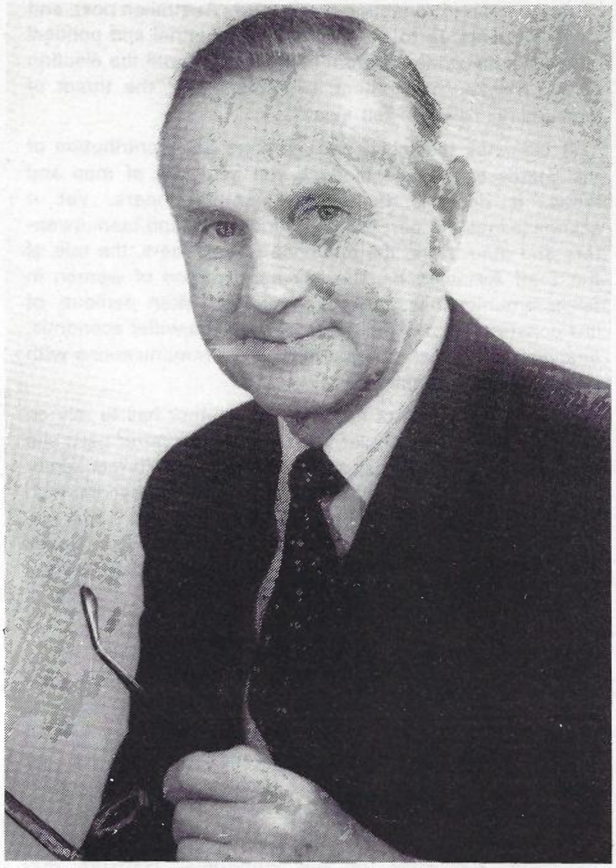
The objective of the Society was then, as now, to promote the diffusion of knowledge of the telecommunications and related fields by means of the Journal, lectures, etc.

The Telecommunication Journal of Australia reaches its Golden Jubilee of publication in 1985. To mark the occasion the Society has invited Sir George Jefferson, the Chairman of British Telecom to address the Society at two major celebrations. This was confirmed when the Society Chairman, Mr Keith Barnes discussed a number of details of a proposed Keynote Lecture with Sir George in London. Arrangements are being made to maximise the opportunity for all Society members to participate in the events. The first lecture is on the evening of the 22nd of May, 1985 at the Dallas Brookes Hall in Melbourne, with a repeat on the 23rd of May, 1985 at the Sydney Hilton. Both lectures will be televised to other state capital cities and centres. Details will be announced early in 1985.

Sir George will be speaking on the impact of telecommunications in society in the immediate future. The so-called Information Society is taking shape and bringing with it new social, commercial and technological relationships. Just what these relationships will be is not yet clear, and community awareness of them is low. The guest speaker is very well qualified to explain the likely impact on people in the telecommnunications and information industries of the future. As Chief Executive of British Telecom, he can provide insight and focus on the forces at work which are shaping the information society. These same forces could result in greatly altered prospects for people in the Australian telecommunications and information industries.

Sir George has also experienced the dramatic market place and ownership changes brought about by deregulation of the telecommunication industry and privatisation of British Telecom occurring in the U.K.

Further information will follow, including the cost of an optional buffet dinner preceding the lecture at Melbourne and Sydney. Admission will be by 'ticket only' and early reservations can be made by phoning the Secretary in Melbourne (Mr J. Hart — 606 5104) or Sydney (Mr A. Paschalis — 689 2165); or writing to Box 4050, GPO, Melbourne, Vic. 3001.



Sir George Jefferson, Chairman British Telecom.

Keith Barnes, Chairman Telecommunications Society of Australia.

Book Review

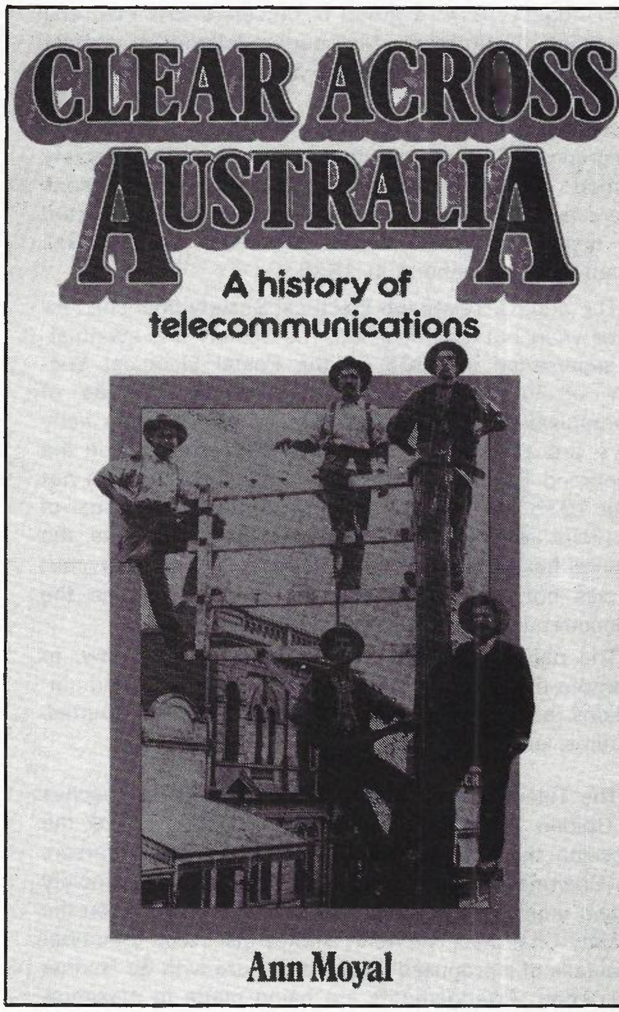
CLEAR ACROSS AUSTRALIA is an entertaining book, splendidly illustrated and clearly well researched which contains a vast array of information. The book covers the span of Australian telecommunications from the first telegraph line erected between Melbourne and Williamstown in 1854, with an introduction on the early Australian post, and surveys events up to the end of the industrial and political upheavals involving Telecom in the 1980s until the election of the Hawke Government in 1983 when "the threat of dismantling Telecom fell away".

It indicates the individual character and contribution of the States and, while marking the influence of men and ideas, it depicts the leaders and planners, yet it acknowledges the part played by individual and team inventors and innovators, the influence of engineers, the role of the Staff Associations, the key participation of women in telecommunications, the ongoing work, often perilous, of line construction and maintenance, and the wider economic, financial and social interaction of telecommunications with the developing community.

For the early part of her book, the author has to rely on archival material. However, for much of the latter part, she had the benefit of discussion with many of the former senior administrators of the PMG's Department and Telecom, with members of the Australian Telecommunications Commission, Telecom's Managing Director, State Managers, Heads of Divisions in Headquarters and the States, several Ministers of the portfolio, trade union leaders and a range of other staff.

The main events of telecommunications seem to be covered by the book — from mail services to the semaphore, telegraph, telephone, wireless telegraphy, picturegrams, radio, telex, co-axial cable, satellites, optic fibre cable and others. It traces the construction of the Overland Telegraph Line and the East-West Line; it discusses the contribution which the Research Laboratories made in peace and war; the roles played by the private suppliers over the years. It highlights the work of the Automatic Network and Switching Objectives Committee (ANSO) set up in 1957 leading eventually to a total integrated automatic (STD) dialling system in Australia.

As the dust cover says, the book is "a pioneering work covering a hitherto neglected aspect of Australia's development". It makes easy reading and is directed towards a wide audience.



Reviewed by
P. Carroll
Board of Editors, TJA.

Information Transfer News Item

Electronics Event Attracts Government Interest

South Australia has joined Western Australia and the United Kingdom in deciding to provide official support for a team of exhibitors at Australia's major electronics show in 1985.

With other States studying the possibility of participating on a similar basis. IREECON '85, the 20th International Convention and Exhibition held by The Institution of Radio and Electronics Engineers Australia (IREE) appears likely to be not only the biggest event of its kind in terms of private sector representation but also in Government involvement.

The strong interest of private industry is reflected in the fact that almost 80 per cent of the exhibition space available has been taken and the opening is a year away. IREECON '85 will take place in Melbourne's Royal Exhibition Building from September 30 to October 4, 1985.

From a small beginning in 1938, IREE's biennial event has expanded to become Australia's largest and most comprehensive exhibition of professional electronic equipment.

IREECON '83 saw the first team of Government-backed exhibitors when representatives of Western Australian industry participated with the support of the Western Australian Government. The State will be providing support for another team at IREECON '85.

Earlier this year it was announced that the British Government would be providing support for a contingent representing British industry to participate in IREECON '85.

South Australia's participation is being organised by the Department of State Development and Technology Park Adelaide Corporation, will also be involved.

Issued by:
The Institution of Radio and Electronics Engineers Australia — (02) 29 4051.

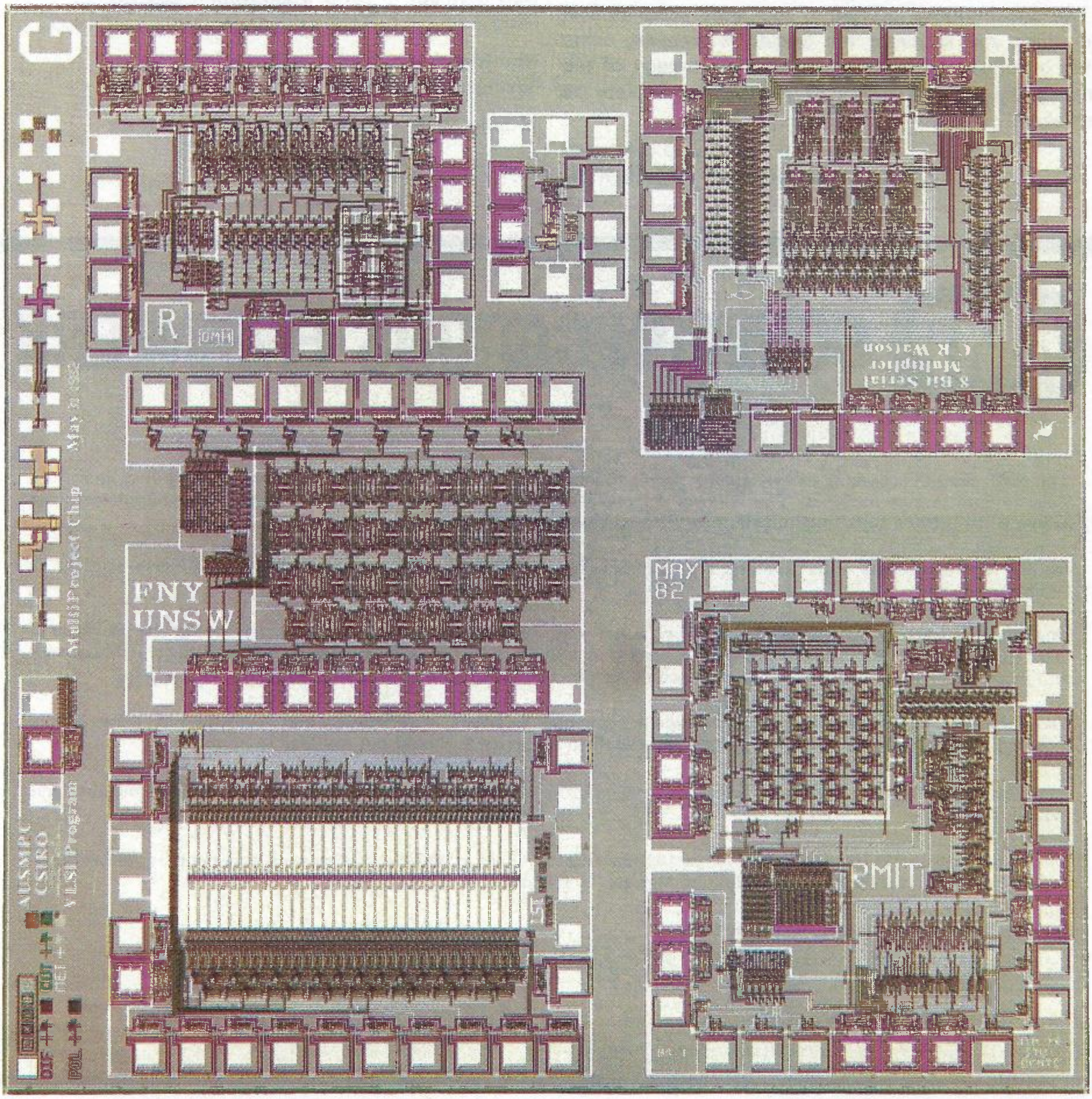
An Australian Multi Project Chip

D. M. HARSANT, B.E. (Hons)
Telecom Australia Research Laboratories

Over the last two years, a number of Multi Project Chips (MPCs) have been organised within Australia by both the CSIRO VLSI Program, and the Department of Computer Science at the University of New South Wales. The MPC technique, pioneered in the USA by Carver Mead of Caltech and Lyn Conway of Xerox PARC, uses simplified VLSI circuit design techniques to give circuit designers a means of prototyping small circuit designs in integrated circuit form at a relatively low cost. This is achieved by placing a number of circuit designs on a single IC die, which is repeated a number of times on a silicon wafer, possibly in conjunction with several other die types containing different circuit designs. Each designer eventually receives a number of packaged versions of his circuit. This technique enables the cost of fabricating the wafers to be amortised over the total number of designs implemented on any particular MPC run.

The photograph below is of die type G, implemented on the first Australian MPC, dubbed AUSMPC 5/82 and sponsored by the CSIRO VLSI Program. This die contains six individual circuits (contributed by various Australian designers), surrounded by their bonding pads, and a starting frame along the top of the die for alignment and testing purposes. During the packaging stage, this die would be cut from the wafer and placed in an integrated circuit package, with the bonding pads of one of the six circuits connected to the IC pins. The die dimensions are 6.35mm x 6.35mm, and a total of nine different die types were implemented on 3" and 4" silicon wafers. The technology is nMOS silicon gate with a minimum feature size of 5 microns, and six mask levels are required in the layout design.

A number of circuit designs produced at the Telecom Australia Research Laboratories have been implemented on various MPCs during the past two years. Included on the above die, in the top right hand corner, is a prototype design for an Error Rate Monitor which may be used to implement part of the front end of a signalling link controller for the CCITT No. 7 signalling system. This programmable circuit monitors the number of error bytes occurring on the signalling link, and uses a 'leaky bucket' error counting scheme to indicate a link failure if the number of bytes in error exceeds a preset threshold. The circuit uses about 1000 transistors, which is equivalent to around 400 logic gates, and has a maximum operating speed of about 4Mhz.



Rates for 1985

TO OUR MEMBERS AND SUBSCRIBERS:

Following examination of the tendered printing costs and the financial plan of the Society, the Council of Control has found it necessary to increase costs of the Telecommunications Journal of Australia and the Australian Telecommunications Research in accordance with the adjoining table.

The Council of Control is concerned about the increased costs of both the TJA and ATR and continues to be mindful of its objective of providing up-to-date information about advances in telecommunications technology to its members at prices they can afford. The Society has been assisted generously by Telecom Australia which in 1984 provided financial assistance in the form of subsidy amounting to $11,500. This subsidy, together with prudent management of costs and increased revenues from higher rates, has consolidated the financial position of the Society to a degree where increased confidence about the future of the Society is shared by all of the Executive.

The Society looks forward to your continuing support and urges you to assist the Society in keeping costs down by encouraging others to take advantage of the services the Society offers by joining the Society as members.

D. D. Mattiske
HONORARY TREASURER

TELECOMMUNICATIONS SOCIETY OF AUSTRALIA PUBLICATIONS RATES FOR 1985

Telecommunication Journal of Australia

Member (Aust. only)	1985 Subscription $9.00 Telecom Payroll Deduction 35c/pay Back copies or single current copies $6.00 each
Non-Member (Aust.)	1985 Subscription $15.00 Back copies or single current copies $8.00 each
Non-Member (Overseas)	1985 Subscription $22.00 Back copies or single current copies $12.00 each

Australian Telecommunication Research

Member (Aust.)	1985 Subscription $11.00 Telecom Payroll Deduction 43c/pay Back copies/single copies $8.50
Non-Member (Aust.)	1985 Subscription $22.00 Back copies/single copies $14.00
Non-Member (Overseas)	1985 Subscription $26.50 Back/single copies $16.50
Monographs	Aust. Member $5.00/Aust. Non-Member $7.50 Overseas $12.00

SULTAN — A Computerised Test Network for Telephone Lines — Facilities and Operation

KEITH L. HICKIN Dip. Elec. Eng.
ROBERT W. DITTON
JOHN R. McINTYRE Dip. Electronic Eng.

Telecom Australia has developed and is progressively implementing a major computer based system to replace the existing customer line testing facilities. This system, called SULTAN (Subscribers Line Test Access Network), incorporates central minicomputers, and outposted microprocessor driven test robots in terminal exchanges. This article introduces SULTAN and describes, in general terms, the system and its application.

THE SYSTEM CONCEPT

SULTAN (Subscribers Line Test Access Network) represents the most significant change in the method of customer line and terminal equipment testing since the introduction of automatic telephony and the analogue test desk.

The system, which was wholly conceived and designed within Telecom Australia, is being installed progressively in all States of Australia as an integrated system. The basic system philosophy is to use a network of computerised controllers connected by data links to microprocessor robot testers (MRTs) installed in terminal exchanges. When requested, the robot tester performs tests on the customer's line and transmits the test results back to the controller.

SULTAN replaces the existing test networks used by Service Assistance Centre (SAC) operators, and the existing test networks used by Fault Despatch Centre (FDC) testing officers.

SULTAN is designed to access and test customer services connected to the public switched telephone network (PSTN). Another computer based system, RATES (Remote Access Test Equipment for Special Services), caters for the testing of non-switched services within Australia.

In this article the general term "Fault Despatch Centre" (FDC) will be used in describing the telephone maintenance centres where technical testing is performed and fault repair staff despatched. In some Australian states these centres are known as Subscriber District Centres or Subscriber Equipment Groups. Also, in this article, the term "customer" will generally be used in place of the earlier term "subscriber".

SERVICE ASSISTANCE TESTING FUNCTIONS

All customer complaints on telephone services are reported to Service Assistance operators on service code 1100. SAC operators access and check customers' lines in the case of those reported by a "calling" customer as being 'always busy', or alternatively, 'doesn't answer'. The operator uses the test network to access the "called" line to determine the cause of the difficulty, while the reporting customer is waiting. The operator is then able to immediately advise the customer of the test result and if the service appears faulty, report the fault to the FDC as a trouble report (TR).

TECHNICAL TESTING AND DESPATCHING FUNCTIONS

FDC testing officers conduct line tests for trouble reports received from the SAC. FDCs have testing facilities which are more comprehensive than those available to the SAC operators.

The purpose of technical testing is to determine if a fault is present on the reported service, and if so, to localise that fault into a particular plant area (exchange equipment, lines, or terminal equipment).

Depending on the plant area concerned, the fault is allocated to an appropriate fault technician, for attention. In Australia, the repair work in each of the three plant areas is handled by a different staff group. The accuracy of the test and diagnosis is important, because it directly influences the accuracy of despatch. Incorrect despatches are costly and can significantly delay service restoration.

BENEFITS OF INTRODUCTION OF SULTAN

The SULTAN system when fully implemented will provide the following benefits:

- A reduction in incorrect fault diagnosis. With existing test networks, the effects of long test trunks or junctions often mask the actual measurement. SULTAN equipment will perform line tests at the local terminal exchange, allowing more sensitive measurements to be made. A reduction in the incidence of incorrectly despatched fault staff will result.
- Improved diagnosis of open-circuit faults. At present it is very difficult for testing staff to determine whether an open-circuit fault is in or out of the exchange. Many

open-circuit faults are incorrectly despatched to exchange staff or line staff, making a second despatch necessary. The calibration and accuracy of SULTAN's open-circuit test enables it to indicate to a testing officer whether an open-circuit fault is "in" or "out" of an exchange.

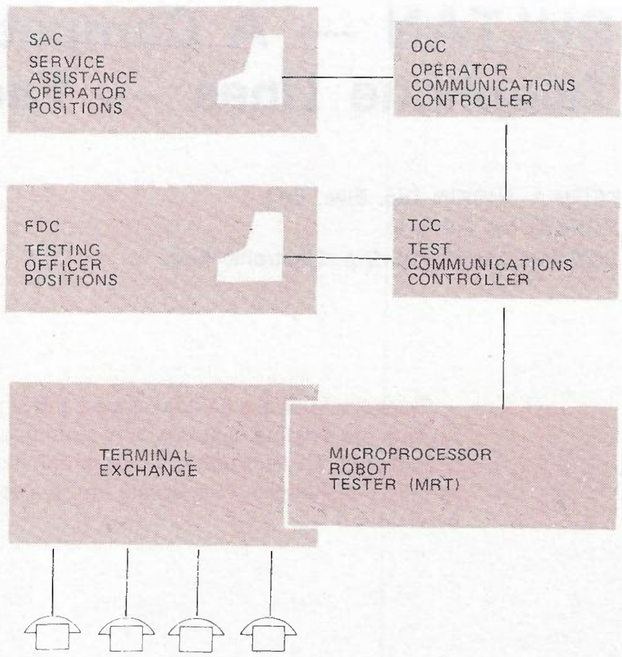
- Improved efficiency of Service Assistance Centre (SAC) operation. At present, operators require the assistance of other operators to test distant telephone services. With SULTAN, these tests can be performed by one operator and this will allow more efficient use of operator time.

GENERAL DESCRIPTION OF SULTAN

Basically the SULTAN system consists of Operator and Test Communications Controllers, and MRT robot testers arranged in a hierarchical overlay in which each element of the SULTAN system has a corresponding component in the existing Telecom telephone fault reporting and testing structure. This is illustrated in **Fig. 1**.

The Operator Communications Controller (OCC) provides the interface between the Service Assistance operator positions and the SULTAN test facilities contained in the lower two tiers. When an operator requests a line test the OCC passes on the request to the appropriate Test Communications Controller (TCC). For a customer within the Service Assistance operator's own area the TCC is contacted via a dedicated data link. For other areas the OCC will access the responsible remote OCC using, for example, a dial-up data link. This remote OCC will then organise the appropriate tests via the relevant TCC.

The TCC arranges access to the line via the exchange based testing device (MRT) and test access circuitry. The MRT performs tests under control of the TCC. Results are



SAC — Service Assistance Centre
FDC — Fault Despatch Centre

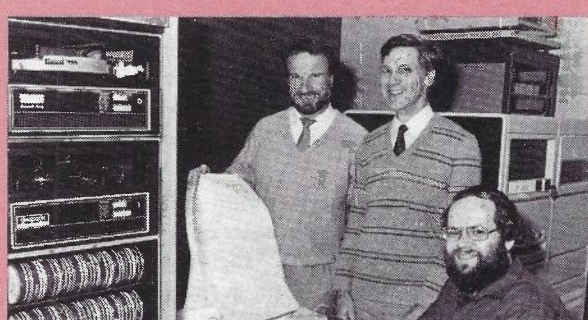
Fig. 1 — SULTAN System Hierarchy.

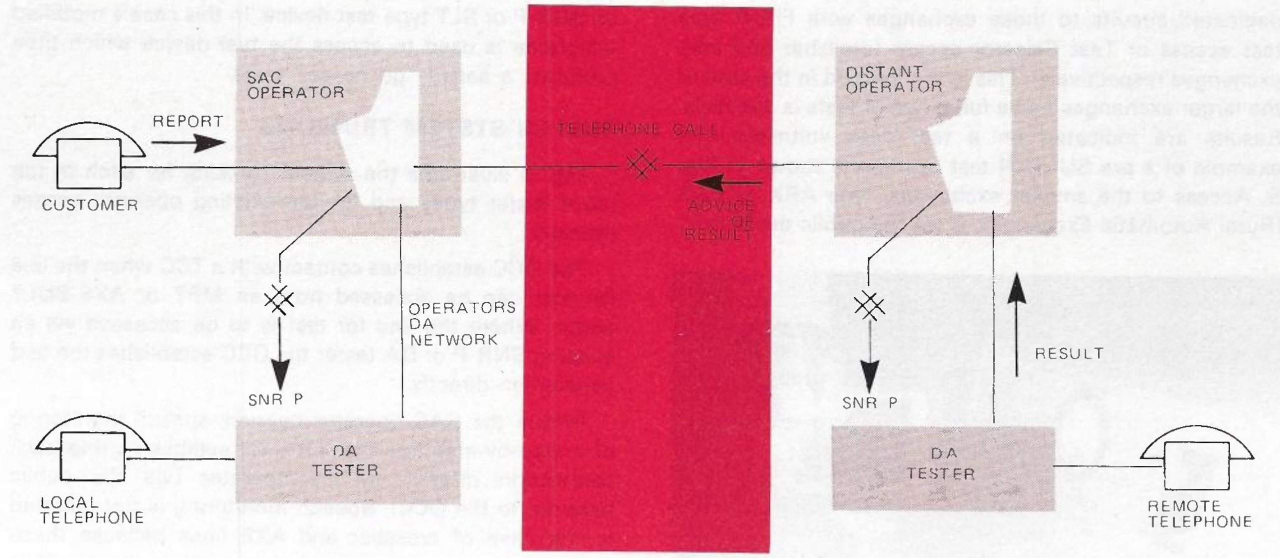
returned through the TCC and OCC to the operator's VDU. On command from the operator the fault report, along with detailed results of tests, is automatically transferred to the appropriate FDC. For FDC areas that are also equipped with the LEOPARD system the report will be passed to the LEOPARD processor, otherwise the report will be passed direct to the FDC, eg via the TELEX network. LEOPARD (Local Engineering Operations

KEITH HICKIN (centre) is a Senior Engineer in the Management and Operations Support Systems Branch of Telecom's Engineering Department, Headquarters. He joined the PMG's Department in 1953 and worked as a technician on exchange and customer equipment maintenance. He graduated with a Diploma of Electrical Engineering from Footscray Institute of Technology in 1959. As an Engineer with the PMG he worked in Metropolitan Service, Victoria and in Customer Equipment Operations in Headquarters. During the last few years he has been involved with specification and implementation aspects of SULTAN.

BOB DITTON (left) commenced with the PMG's Department in 1959 as a Technician-in-Training and worked on exchange and customer equipment maintenance in Victoria, before joining Telecom Headquarters in 1979. He is currently a Senior Technical Officer in Management and Operations Support Systems Branch, Engineering Department, Headquarters, and has been involved with the SULTAN project since 1981.

JOHN McINTYRE (right) is a Senior Engineer in Switching Design Branch, Telecom Headquarters. After graduating from the Ballarat Institute of Advanced Education in 1971 he joined the Telephone Switching Equipment Branch of the PMG's Department. Since 1976 he has been occupied with the design and development of the SULTAN system.





SAC — Service Assistance Centre.
DA NETWORK — Existing, dedicated, decadic network used for test access in the case of "doesn't answer" (DA) and "always busy" reports.
DA TESTER — Existing, "go no-go" type test device accessed via the DA network.
SNR-P — Existing, "go no-go" type test device used in the smaller exchanges.

Fig. 2 — SAC Testing — Pre SULTAN Arrangements.

Processing, Analysing and Recording of Data) is an on-line system for keeping customer service records and for handling customer reports. (Ref. 1).

The TCC provides the test control function for the exchange based test devices and also it interfaces with the FDC test positions and with the OCC. Each TCC has access to a group of exchanges and all tests in those exchange areas are controlled by that TCC.

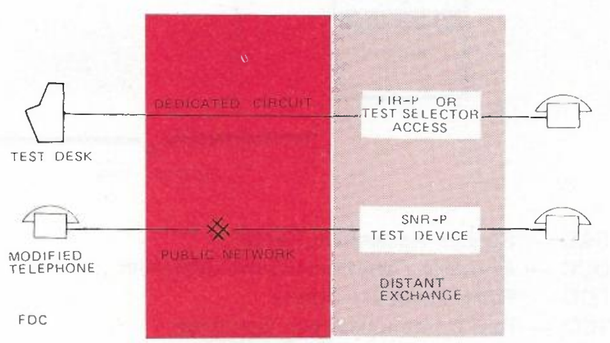
TRADITIONAL TESTING ARRANGEMENTS

Before we examine the SULTAN system in more detail it is useful to consider the traditional testing arrangements. Although the detail of these test networks varies between Australian states, the principles are the same.

Fig. 2 illustrates the pre SULTAN arrangements for SAC operator testing. Note that operators have direct access to lines in the local area only and require the assistance of other operators for out-of-area tests. A fixed series of "go no-go" tests is performed by the test equipment and the operator determines the state of the line by means of tones, or if a customer is speaking the operator hears the conversation for a limited period. Access for testing is via a dedicated, decadic type test network (known as the "Doesn't Answer" network) or via the public switched network in the case of the SNR-P type test device. (SNR-P is a dial-up relay set which can access a line, perform a set of tests and give a tone indication of the result). **Fig. 3** shows some typical pre SULTAN, pre LEOPARD SAC operator positions.

Fig. 3 — Typical pre SULTAN/LEOPARD Operator Positions.

Fig. 4 illustrates the pre SULTAN arrangements for FDC testing. Testing is performed from a test desk via



FDC — Fault Despatch Centre
FIR-P — The type of test access equipment used in ARF and ARE type crossbar exchanges.
TEST SELECTOR — The test access selector used in step by step exchanges.
SNR-P — Existing, "go no-go" type test device used in the smaller exchanges.

Fig. 4 — Technical Testing — Pre SULTAN Arrangements.

dedicated circuits to those exchanges with FIR-P type test access or Test Selector access (crossbar and step exchanges respectively). This is the method in the case of the larger exchanges and a full range of tests is available. Results are indicated on a test desk voltmeter. An example of a pre SULTAN test position is shown in **Fig. 5.** Access to the smaller exchanges, type ARK or RAX (Rural Automatic Exchange), is via the public network to an SNR-P or SLT type test device. In this case a modified telephone is used to access the test device which then performs a set of "go no-go" tests.

Fig. 5 — Pre SULTAN Test Desk Unit at Lonsdale Fault Despatch Centre, Melbourne, Victoria.

SULTAN SYSTEM TRUNKING

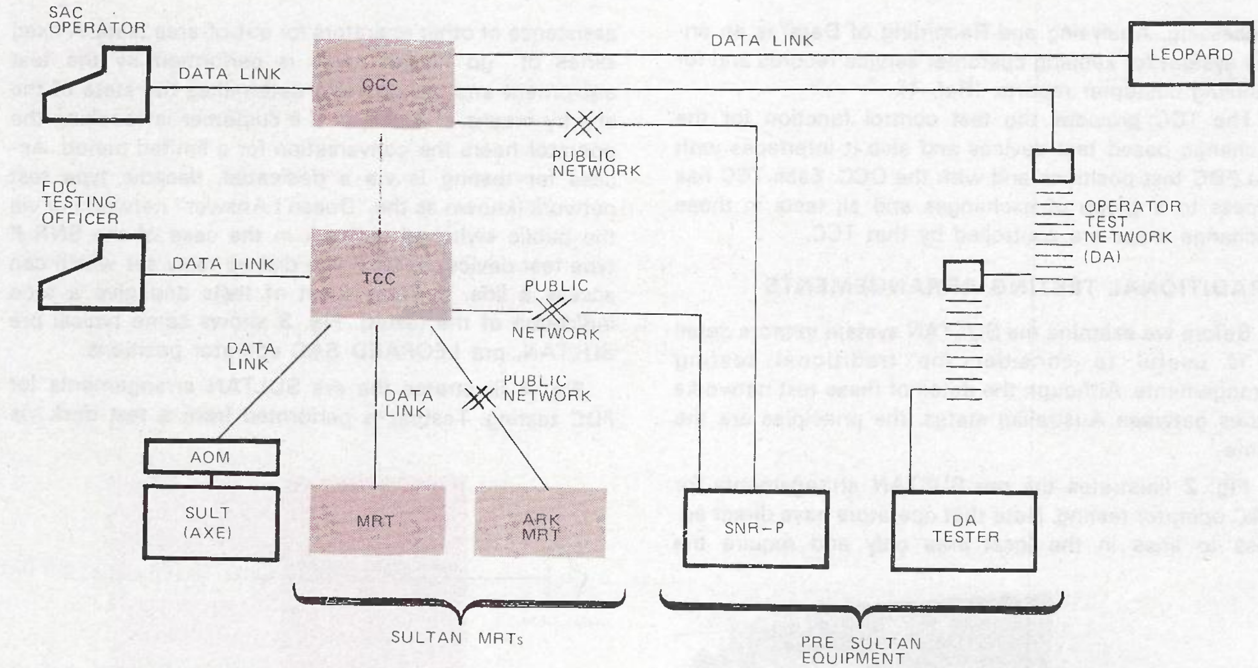
Fig. 6 illustrates the system trunking for each of the robot tester types and for the existing operator access network.

The OCC establishes contact with a TCC when the line for test can be accessed from an MRT or AXE-SULT tester. Where the line for test is to be accessed via an existing SNR-P or DA tester the OCC establishes the test connection directly.

Where the SAC operator requires speech monitoring of a step-by-step line the MRT will establish a ring-back connection directly to the operator (via the public network to the OCC). Speech monitoring is not required in the case of crossbar and AXE lines because these exchanges return a positive circuit condition that signifies that the customer is "busy speaking".

Each OCC has data links to the LEOPARD processor. The OCC directs LEOPARD transactions to this processor and returns responses to the operator's VDU.

Each OCC will have one, or for reliability two, direct data links to each local TCC. For access to distant areas a



SAC — Service Assistance Centre
OCC — Operator Communications Controller
FDC — Fault Despatch Centre
TCC — Test Communications Controller
MRT — Microprocessor Robot Tester
ARK — A type of small, crossbar exchange used in country areas.
AXE — A type of processor controlled exchange manufactured by L. M. Ericsson.
AOM — A message switching processor for operational access to AXE exchanges.
DA NETWORK — Existing, dedicated, decadic network used for test access in the case of "doesn't answer" (DA) and "always busy" reports.
DA TESTER — Existing, "go no-go" type test device accessed via the DA network.
LEOPARD — The processor for the LEOPARD system.

Fig. 6 — SULTAN System Trunking.

Fig. 7 — A SULTAN/LEOPARD Operator Position. Shown are the ACD Console and the SULTAN/LEOPARD VDU and keyboard.

link (eg a dial-up data link) will be established with the appropriate OCC for that area.

The FDC testing officer has access through the TCC to the MRTs, AXE-SULT and existing SNR-P type test devices. There are multi drop links from the TCC to MRTs in exchanges. A direct data link connects from the TCC to the AOM (an exchange message switching system associated with AXE exchanges). If speech access to the customer is required the MRT establishes a separate ring back connection to the testing officer at the FDC.

SERVICE ASSISTANCE OPERATOR FACILITIES

It is intended that ultimately any SAC operator will be able to conduct a line test on any customer's line covered by the SULTAN system anywhere in Australia.

The operator's position is shown in **Fig. 7** and will consist of:

- An AWA VTE-6 VDU. (LEOPARD as well as SULTAN facilities are accessed from this one VDU)
- A headset connected to both the SULTAN equipment and the local customer queueing system, eg. Automatic Call Distribution (ACD) System (Ref. 2)
- An ACD Operator's unit.

Each operation from the VDU requires the operation of a "command code" key followed by entry of relevant data and operation of the "SEND" key.

Initially the operator requests a "REPORT FORM" which is issued by the OCC and displayed on the VDU. This form is illustrated in **Fig. 8**. When a line test is required the "called" number field is filled and the "Test"

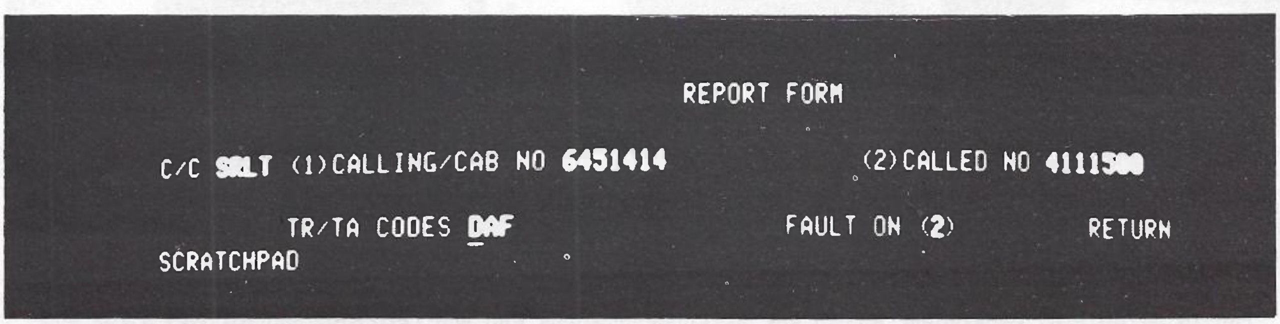


Fig. 8 — Report Form, showing Operator and SULTAN Entries.

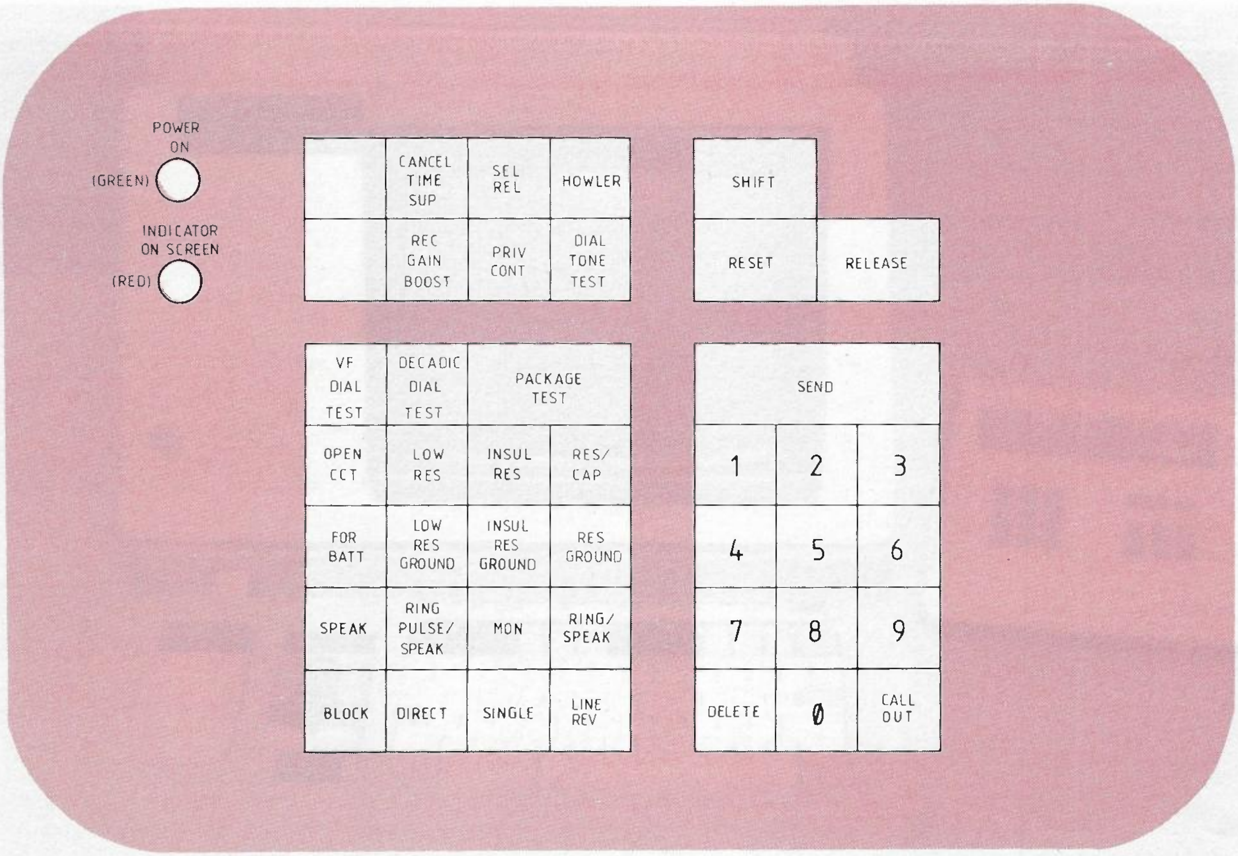


Fig. 9 — SULTAN VDU Keyboard Layout. The keys are engraved with the test function (or abbreviation).

command code SRLT (SULTAN Request Line Test) is entered. On recognising this command code the SULTAN system organises a package line test for:

- AC Voltage
- DC voltage
- Resistance to ground
- Pair resistance
- Open circuit (capacitance)

The result of this test is displayed as a three letter code, eg. DAF or FLT ("Doesn't Answer Faulty" or "Fault") in the TR/TA (Trouble Report/Technical Assistance) field. The detailed test results are not available to SAC operators but are stored within the system for later inclusion in the fault report to the FDC.

For tests on local services not yet covered by SULTAN MRTs, the OCC will access the operator test (DA) network directly, or call up an SNR-P via the PSTN. In

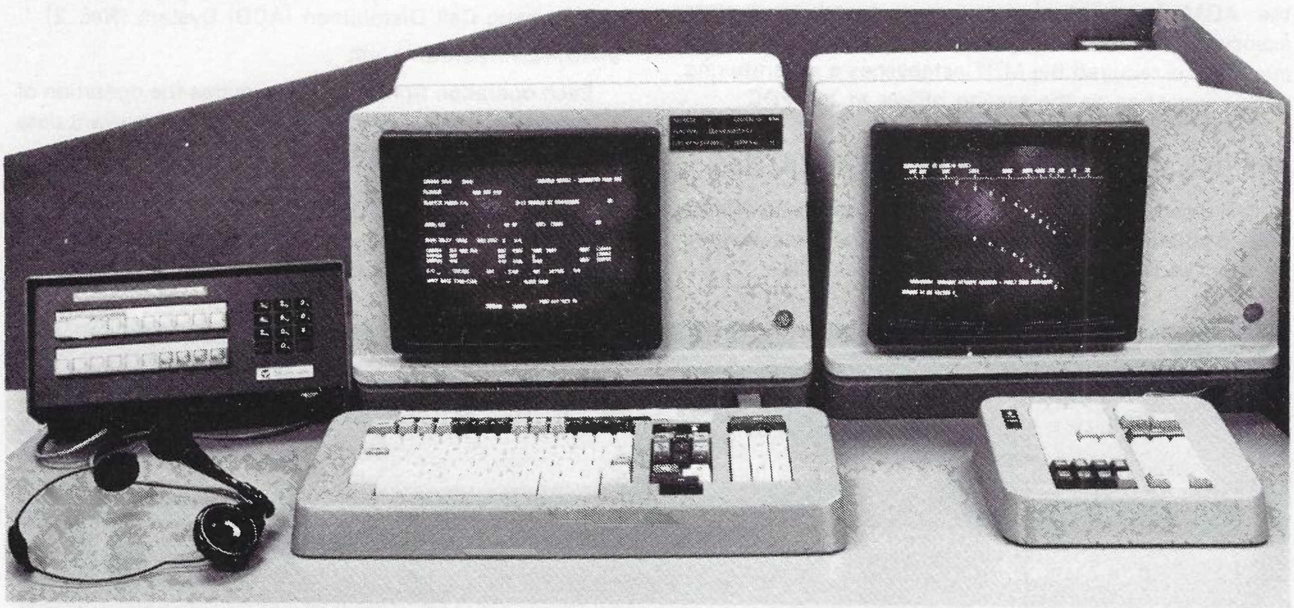


Fig. 10 — An FDC Workstation. Shown are the Communications Unit and LEOPARD and SULTAN VDUs and keyboards.

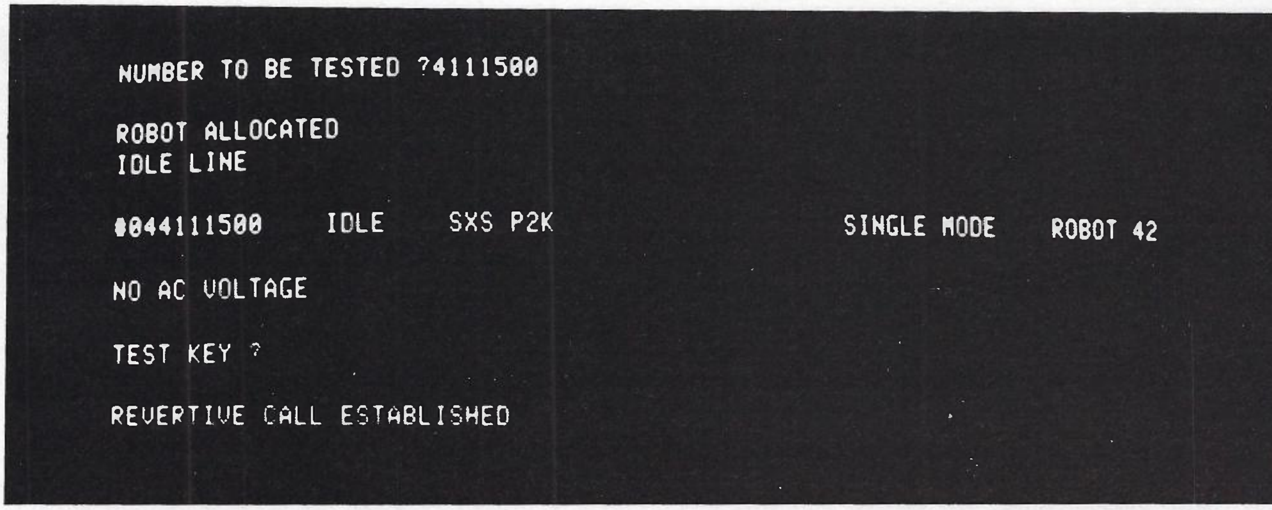


Fig. 11 — Test Access Display (MRT).

both these instances a "result of test" tone will be returned to the operator's headset.

The operator may then enter information into the scratch pad area of the report form and send the report to the FDC. Where LEOPARD is available the operator may also request a "service status enquiry" display. In LEOPARD areas the fault is passed via LEOPARD and in other areas it is passed via the TELEX or other network.

FDC TESTING OFFICER FACILITIES

FDC testing officers are able to conduct a line test on customer's lines within their own area of responsibility. The test facilities available are dependent upon the type of test device installed in the exchange to which the customer is connected.

The test desk position will consist of:

- The SULTAN Test Desk VDU
- A Communication Unit
- A LEOPARD VDU

The Test Desk VDU is of a similar type to the LEOPARD VDU (AWA VTE-6) but its keyboard is adapted to provide the specific test function requirements for SULTAN. The layout of the SULTAN VDU keyboard is shown in **Fig. 9.** Each VDU operates independently and the SULTAN and LEOPARD processors do not interwork at the TCC level. An FDC workstation is shown in **Fig. 10.**

To access a line for testing, the testing officer enters the customer's number to be tested into SULTAN via the VDU. The SULTAN system accesses the robot test device and then directs it to access the line to be tested. The testing officer is notified if a line test cannot proceed due to an invalid number, untestable number or system congestion.

Where an MRT is employed the testing officer is given preliminary information on the line status and AC foreign potential conditions. A full range of tests is then available. **Fig. 11** illustrates the display when an MRT is accessed.

With the MRT, various modes of test result display are available to the testing officer. They are:

- Direct Reading. Operation in this mode simulates a moving coil meter. There are 5 updates per second.
- Single Reading. For this mode a once-only reading is taken and the result displayed.
- Graphical Block of Readings. For this mode, 20 readings are displayed as a graph covering a time period of one second.

These three modes are illustrated in **Figs. 12, 13 and 14** respectively.

FAULT DIAGNOSIS USING SULTAN

SULTAN has many features which will assist a testing officer to diagnose and localise a fault.

SULTAN arranges for the digital voltmeter readings, taken during a SAC initiated MRT test, to be included in the report passed to the FDC. Thus, although some time

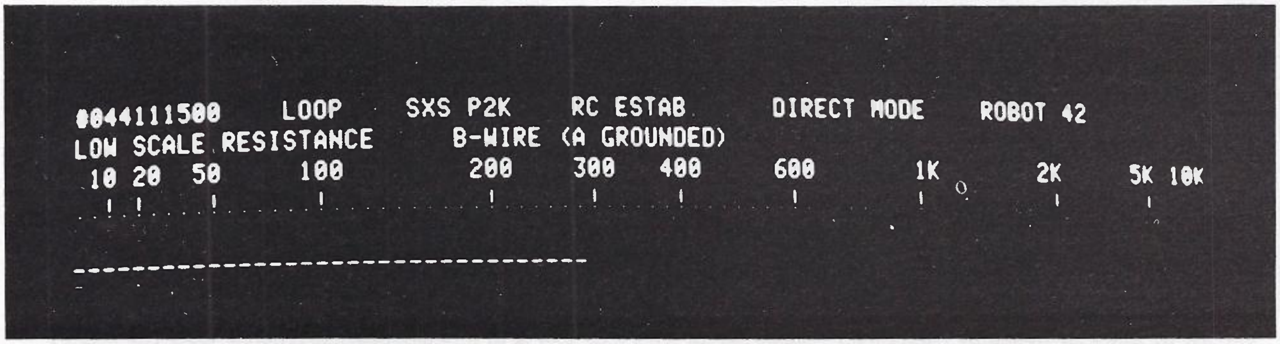


Fig. 12 — Direct Reading Display Mode. The example shown is a low scale resistance test on the "b" wire and the reading is 300 ohms.

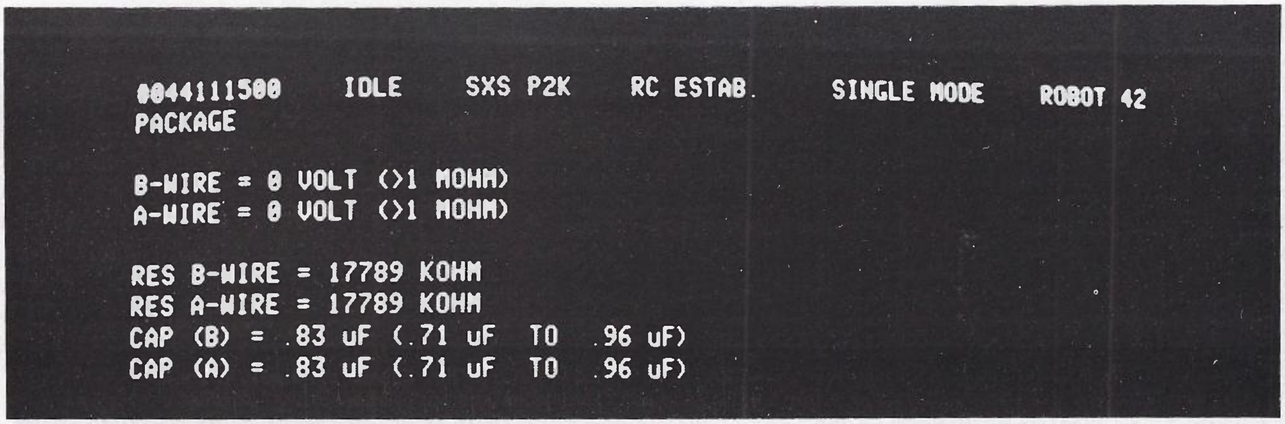


Fig. 13 — Single Reading Display Mode. In this example the results are from a Package test.

may have passed since the service difficulty was experienced, the testing officer is aware of the actual condition of the line at the time of the report.

An MRT package test (the same as that applied by the SAC operator) may be applied by the testing officer. This pre-programmed sequence of tests can be initiated by a single command. This provides the testing officer with a quick indication of the overall condition of the line, the results being displayed as in **Fig. 13.** If a fault is in evidence, appropriate individual tests, eg. foreign battery or resistance to ground, can then be applied.

For the individual tests, a readout mode may be selected which is appropriate to an indicated or suspected fault condition. To check for an intermittent condition or examine a variable condition the "direct reading" mode is used. A dotted line is displayed on the screen and the length of this line varies according to the reading. This mode effectively provides a continuous indication, as with a voltmeter. In the case of a definite or steady fault, an accurate, digital indication of a test measurement will be given following selection of the "single reading" mode. Where a picture of the electrical characteristics of a line or service is required, this will be given in the graphical display provided by the "block of readings" mode. With experience in the use of this mode a testing officer can quickly interpret the display and judge the equipment type and the presence of normal or abnormal conditions.

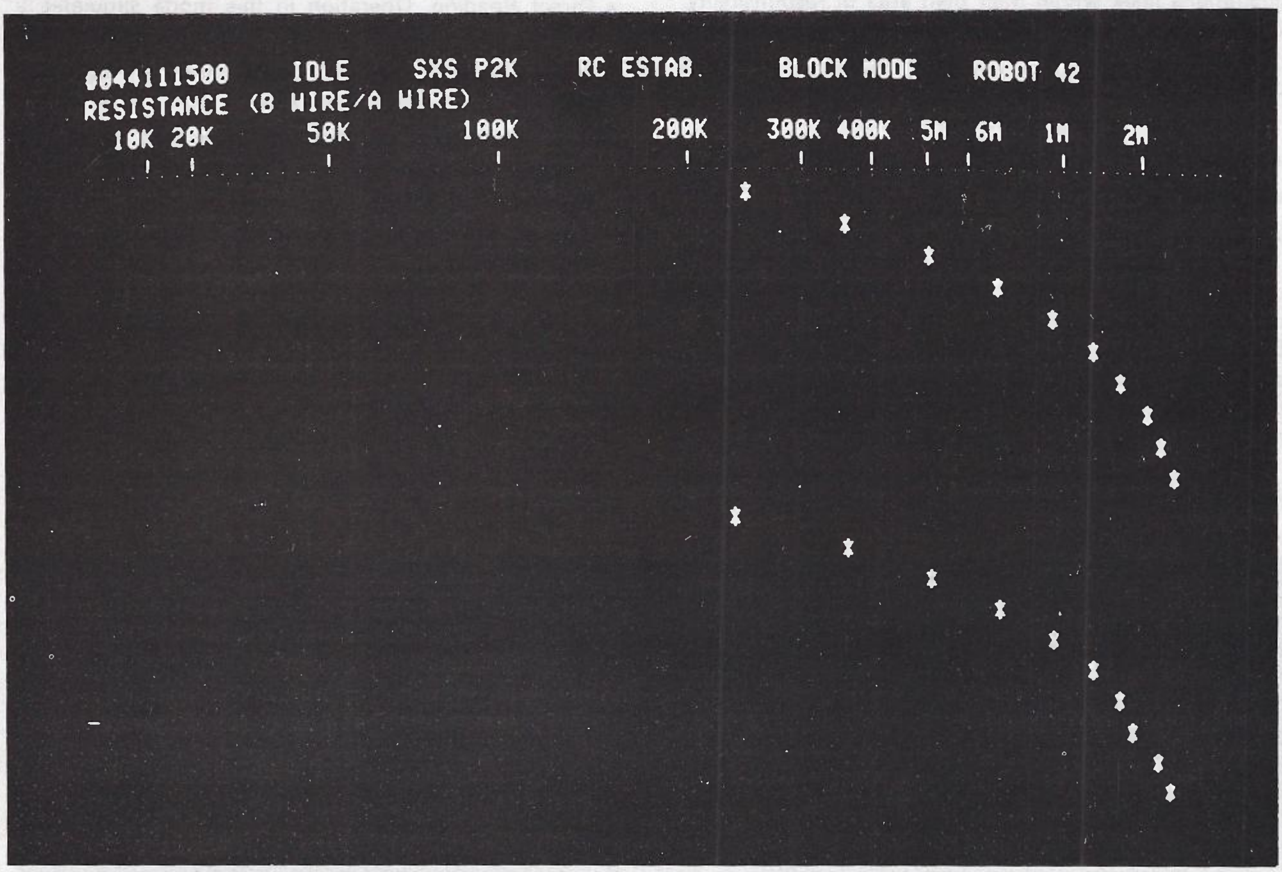


Fig. 14 — Block of Readings (Graphical) Display Mode. This example is of a resistance/capacitance test. The display shows the "b" and "a" wire capacitance characteristics. The dot points are the expected values for a "normal" line and service.

A feature of SULTAN is its comprehensive open-circuit test. The system is calibrated for the distance from the MRT to the main distribution frame. It will give actual capacitance values as well as displaying a literal message indicating that an open is "in the exchange", or otherwise the distance in metres to an open "out of the exchange". Different staff groups handle the clearance of the "outside" faults.

Testing staff can select from the above facilities and utilise them to quickly pinpoint fault conditions.

SULTAN EQUIPMENT

Equipment in an OCC or TCC consists of a minicomputer (Digital PDP 11/24) and peripherals, modems and crossbar rack and relay sets. OCCs and TCCs are co-sited in one or two locations in each capital city. This centralization is because of operation and maintenance support, and power, airconditioning and accommodation considerations. An installation of TCC and OCC equipment is shown in **Fig. 15.**

MRTs consist of printed board assemblies (8 per MRT) mounted in shelves and installed, within an exchange, on a miscellaneous rack. A special MRT has been designed for use in ARK exchanges. It has three additional printed board assemblies and access may be either via dedicated or dial-up links. Details of MRT design, construction and operation will be given in a later article.

An OCC can serve 30 operator positions and 24 TCC links (ie 12 TCCs with duplicated links). A TCC can serve 8 test desk VDUs, 80 MRTs on dedicated data links, plus additional MRTs via dial-up access. The number of MRTs provided in an exchange depends on the size of the exchange. Generally the number of MRTs provided will vary between two (for an exchange with less than 8,000 lines) and five (for an exchange with 20,000 or more lines). In the small, ARK type exchanges it is usual to provide only one MRT.

AREA OF APPLICATION

SULTAN is particularly effective in areas where the technical testing function is concentrated into a few

Fig. 15 — TCC and OCC Equipment at City East Building in Sydney, NSW. The system consoles are in front. Behind these are, from left to right, two OCCs, a modem cabinet and five TCCs. Associated crossbar type racks are to the rear, behind the minicomputer suite.

centres. This occurs in metropolitan areas and some of the larger provincial towns. In this situation, VDU, TCC and data link costs are minimised. Telephone operations in the less populated, rural areas of Australia are organised into decentralised, multi-functional districts. This requires a large number of individual test positions, and SULTAN in its present form is less suited to this application. Implementation of SULTAN has therefore been concentrated, to date, in metropolitan areas.

Telecom has conducted a comprehensive study into country testing requirements. This study included an examination of various ways of economically meeting the country needs. Consideration is now being given to an extension of SULTAN facilities to country areas, using the standard SULTAN robot test device (MRT) but with testing positions and communications controllers that are better suited to a distributed country environment. Extension of SULTAN to the country would enable service assistance operators to obtain test access to those areas. Also the vast improvement in test access and accuracy of technical testing with the introduction of MRTs in the country would produce benefits due to more accurate despatch and the consequent reduction in travelling costs.

IMPLEMENTATION

SULTAN was initially introduced in the form of pilot installations. The pilot FDC/TCC has been operational since November 1981, and the pilot SAC/OCC since June 1983. The pilots provided valuable feedback and

GLOSSARY OF TERMS

ACD — Automatic Call Distribution system. A type of queueing system for incoming calls.

AOM — A type of message switching processor for operational access to AXE exchanges.

ARE — A type of Stored Program Controlled crossbar terminal exchange.

ARF — A type of register and marker controlled crossbar terminal exchange.

ARK — A type of small crossbar terminal exchange for rural applications.

AXE — A type of Stored Program Controlled exchange (mainly digital).

AXE-SULT — Inbuilt test function in AXE exchanges.

DA — Doesn't Answer.

DAF — Doesn't Answer Faulty. One of the several three-alpha codes input by the SULTAN OCC as a result of a check on a telephone service by an operator.

DA Network — A dedicated, decadic network for operators to gain access and determine reasons for "doesn't answer" and "always busy" complaints.

DA Tester — A "go no-go" test device located in terminal exchanges and accessed by the DA Network.

FDC — Fault Despatch Centre. A centre where technical testing is conducted before despatch to appropriate repair discipline, if necessary.

FIR-P — The type of test access equipment used in ARF and ARE type crossbar terminal exchanges.

FLT — Fault. As above for DAF — Doesn't Answer Faulty.

LEOPARD — Local Engineering Operations Processing Analysing and Recording of Data. A computer based system for processing telephone service difficulty complaints. (See Vol. 34/2).

MRT — Microprocessor Robot Tester. The SULTAN robot tester which interfaces with test access equipment in terminal exchanges.

OCC — Operator Communications Controller. Processor controlled equipment that interfaces the SAC operator with SULTAN and LEOPARD facilities.

PABX — Private Automatic Branch Exchange. A commercially available telephone system accessible to and from the PSTN.

PSTN — Public Switched Telephone Network.

RAX — Rural Automatic Exchange. Generally a small step by step terminal exchange.

SAC — Service Assistance Centre. The first contact point for customers experiencing telephone service difficulties.

SLT — Similar to an SNR-P.

SNR-P — A "go no-go" access and test device, located in ARK terminal exchanges, which is accessed via the public switched telephone network.

SRLT — SULTAN Request Line Test. A SULTAN system command code input by an operator to access and check the condition of a "doesn't answer" or "always busy" telephone service.

SULTAN — Subscribers Line Test Access Network.

TA Code — Technical Assistance code. A three-alpha code, input by operators, that pertains to complaints caused by network problems. LEOPARD directs these codes and associated details to a central analysis centre.

TCC — Test Communications Controller. Processor controlled equipment that controls the SULTAN test access and testing function for both operators and technical testing staff.

Test Selector — Test access selector used in step by step type terminal exchanges.

TR Code — Trouble Report code. A three alpha code, input automatically by the SULTAN OCC, or manually by operators, which pertains to the result of the test on the accessed service.

many user-suggested enhancements have been incorporated into the system.

At the time of writing, SULTAN equipment is in operation in the metropolitan areas of the three larger Australian states. In the case of Sydney, the largest metropolitan network, it is expected that by the end of 1984/85, SULTAN coverage of the entire metropolitan area will have been achieved. It is expected that by the end of 1985/86 the metropolitan areas of all states will have been provided with SULTAN facilities.

A SUCCESSFUL INNOVATION

The development of SULTAN represents the successful application of high technology to the customer line testing operation. SULTAN's attributes and potential derive from the power and flexibility of the modern minicomputer and microprocessor.

SULTAN successfully interworks with LEOPARD at the SAC level. The two systems appear to the SAC operator as an integrated testing and fault handling system which is simply and easily operated. These systems, in combination, will enable reporting customers to be provided with a high standard of attention.

At the FDC level, SULTAN makes available a wide range of testing facilities. These provide testing staff with a powerful tool which enables them to perform accurate tests and fault diagnosis to aid the fault repair staff. This results in the provision of a more efficient and effective repair service to the customer.

THE FUTURE

The Australian telephone network is undergoing many changes affecting the ability to perform line and terminal equipment testing. Examples of these changes are:

- The introduction of new Stored Program Controlled local exchanges, with digital switchblock.
- The increasing variety of customer terminal equipment being provided by Telecom, or available from other commercial sources.
- An increasing number of services connected to PABXs. (These lines are currently inaccessible to FDC testing).
- The increased application of pair-gain and radio concentrator systems.
- The expanding use of the customer telephone line for new markets such as data logging and security systems.

SULTAN provides the basic system structure to allow line testing to evolve along with the changing network. Customer line and equipment maintenance is a major part of the operating expense of the network. Since SULTAN is a national standard system, new features can be efficiently integrated into it in order to meet the maintenance needs arising from network and terminal equipment changes.

REFERENCES

1. Ridge, I. T. and Brisbane, O. J.: "LEOPARD — A Computer Based System for Processing Telephone Service Difficulty Complaints"; Telecom Journal of Australia, Vol. 34, No. 2, 1984, pp 157 - 167.
2. Brown, P. A. and Clark, D. W.: "Automatic Call Distribution System — ASDP 162"; Telecom Journal of Australia, Vol. 29, No. 3, 1979, pp 245 - 255.


Imagine a mobile radio that thinks before you speak.
PHILIPS
FM 900

Telecommunications Technology in the Outback

JOHN M. BURTON BE(Hons), BA, Litt.B.

The remote areas of Australia comprise over half of the total area of the Australian continent. These regions contain an estimated population of only 44,000 people, most of whom do not have adequate telecommunications services. It is planned to provide services to customers in both rural and remote areas of the continent by 1990. This overall programme will cost an estimated $400 million which is considerable in relation to the 40,000 services to be provided. The remote area network will rely heavily on the newly developed digital radio concentrator system.

This paper describes a development strategy for the telecommunications network in rural and remote areas and outlines the technologies which are available for use in these areas. Telecom is confident that the technologies described and the plans outlined for rural and remote areas will provide our customers with world standard services at affordable prices.

INTRODUCTION

Part of Telecom's charter is to progressively extend telecommunications services to all people, including those living in remote areas. These areas are characterised by large distances and low population densities. This paper outlines the technology options which are available in rural and remote areas and the likely areas of application of each.

EARLIER PROGRAMMES

Manual Conversion Programme

In 1978 the Commission approved a programme to upgrade all manual services to a standard equal to that of urban services. The main objective of this programme is to provide an automatic and continuous service for all country and rural customers by 1990. As part of the programme, part privately erected (PPE) plant is being replaced by Telecom provided plant. By June 1985, there are expected to be less than 20,000 manual services remaining out of the 100,000 which existed in 1978.

Until 1984, the technology available for customer distribution was mostly cable plant, with some analogue radio concentrator systems (ARCS) and single circuit analogue radio systems (SCARS). By conceiving and initiating the development of a Digital Radio Concentrator System (DRCS), Telecom has now added an important network element for provision of rural and remote services. Approximately 6000 automatic services are expected to be provided by the digital radio concentrator system (DRCS) as part of the manual conversion programme.

Extension of service into remote areas is, in many cases, dependent on the prior establishment of a rural network infrastructure of exchanges and customer radio systems which convert existing manual services to automatic working.

This paper was presented to a seminar "Telecommunications in the Outback" at the Academy of Science, Canberra, Australia.

Remote Area Programme

A study carried out in 1980 identified that out of a total remote area population of approximately 44,000 people, Telecom could expect applications for about 3000 to 4000 services by 1990. The majority of these prospective customers were expected to be in the remote regions of the Northern Territory and Queensland.

The Remote Area Programme was established to make an automatic telephone service with STD and other network facilities available in the remote areas. The means to do this are by extension of the terrestrial network, principally by means of the digital radio concentrator system (DRCS) and to some extent by single circuit, small capacity radio and analogue radio concentrator systems (ARCS).

Telecom at present provides service to a small number of customers in remote areas either by:

- High Frequency (HF) & tropo-scatter radio systems serving exchanges at remote communities, or
- the Telecom HF customer radio telephone service.

In addition, Telecom also has agreements to connect other private systems to the switched telephone network (e.g. the Royal Flying Doctor Service HF Radio network) thus allowing network access to the users of these systems.

In general, the technical performance of the HF radio services is sub-standard. The problem of congestion and availability of service is compounded by a shortage of HF radio spectrum. The Remote Area Programme makes provision for the replacement of these services as well as the connection of new services.

The prospective remote area customers can be broadly grouped into the following categories:

- commercial (mining, tourism)
- settlements (mainly aboriginal communities)
- pastoralist.

Each group has a different set of telecommunications requirements and therefore, to provide facilities economically, it must be recognised that a universal solution is not possible. Each case must be examined to ensure the appropriate technology is used.

NATIONAL RURAL AND REMOTE AREAS PROGRAMME (RRAP)

In August 1982 the Commission endorsed the stated Telecom objective of largely completing the Rural Conversion Programme and the Remote Area Programme by 1990. These programmes entail conversion of the remaining manual services to automatic working, replacement of part privately erected (PPE) lines and provision of modern telecommunications services in remote areas throughout Australia.

The Commission at that time recognised that there were uncertainties in the programmes, a dependence on the availability of funds and the need for a review of the situation should circumstances change.

Following a reassessment of customer demand and a re-dimensioning of the programmes, the two programmes have been combined into a single National Rural and Remote Areas Programme (RRAP), beginning in 1984/85, aimed at extending access to telecommunications services for all Australians by 1990.

Scope of the National Rural & Remote Area Programme (RRAP).

The programme includes the following:

- conversion of manual services to automatic services
- conversion of manual services on PPE lines to automatic services on standard Telecom plant
- upgrading of automatic services on PPE lines to automatic services on standard Telecom plant
- provision of automatic service to applicants in distant rural and remote areas.

When an area is to be first served by modern facilities then the initial system design will make provision for the anticipated 5 year growth in demand.

NETWORK DEVELOPMENT STRATEGY FOR RURAL AND REMOTE AREAS

The telecommunications network can be seen as a mesh of nodes (telephone exchanges) and interconnecting transmission links carrying voice and data traffic.

Until recent times, the Australian telecommunications network was based on analogue technology, with electromechanical exchanges and analogue transmission systems. In worldwide comparisons, this analogue network is regarded as being of high standard.

The current thrust in network development is to develop an "overlay" digital network which will result in major long term economies as well as more effectively carrying a range of data services integrated with traditional voice services.

In urban and more closely settled rural areas the telecommunications network provides many alternate transmission paths inter-connecting between the nodes.

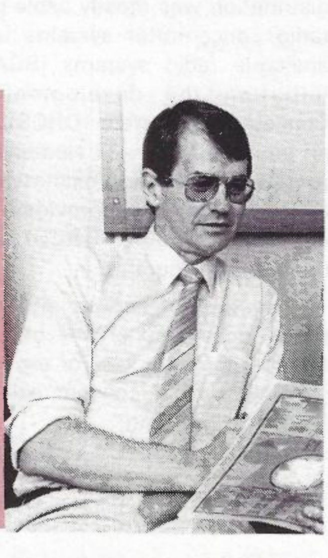
In sparsely populated areas, there are necessarily fewer and smaller nodes and the transmission paths become progressively thinner between the larger and the smaller towns as they extend further out into these areas.

These rural exchanges can serve large areas, with customer distribution costs becoming higher until the point where demand for service is sufficiently high in an area to warrant establishing another exchange and its connecting links back to the higher order exchanges. Telecom, together with L. M. Ericsson, is currently developing a small digital rural exchange (called AXE Rural) which will be available to aid rural network development in the latter half of 1986/87. This exchange will be installed where 60 to 1000 lines are required.

The transmission systems between exchanges become proportionately more expensive per circuit as the routes become longer and thinner. This applies also for long lines from the exchange to customer premises. Hence radio systems have been developed for the customer distribution network (i.e. exchange to customer) allowing larger exchange areas to be employed which help to minimise the costs of establishing a network. The low density of customer distribution in sparse rural and remote areas is such that without radio systems, copper wire technology would only allow relatively small exchange areas. As many customers are out of reach of exchanges, only a limited number of services could be provided in these areas.

The recommended strategy is to extend the existing network initially through the closer, more densely populated areas and subsequently into the more thinly

JOHN BURTON is with the Planning Division in Telecom Australia Headquarters. After a period as a technician in far nothern Queensland and the north west of New South Wales he joined the Telecom Research Laboratories in 1974 as an Engineer working on microwave radio and on the early development of the Digital Radio Concentrator System. In 1979 he moved to Headquarters Planning Division and has since been involved with planning studies associated with the introduction of new technology into transmission networks. He is currently the Superintending Engineer of Transmission Planning Branch.



populated, inaccessible locations. This strategy aims to firstly establish networks in areas of lowest cost per service and proceed to areas of increasing cost per service. Nevertheless, it is recognised that there may be special social, commercial or other strategic or tactical considerations which in the opinion of Telecom management warrant the provision of service earlier than would be normally done on cost and reliability considerations alone.

AVAILABLE TECHNOLOGIES

Cable Systems

Areas within the immediate vicinity of the exchange are more likely to have a cable infrastructure already established and in this case the cost of adding another customer is the cost of extending the existing cable network to the required new customer location. This solution has the advantage of being low in technology and the longest service lifetime of all solutions but has the disadvantage of being distance limited. Also, as the cost of buried cable is proportional to distance, quite high costs can be incurred by cabling widely separated customers.

Analogue Radio Concentrator Systems (ARCS).

The ARCS consists of:

- A base Radio Station. This may be located at the terminal exchange or at a site remote from the terminal exchange.
- Group Exchange Equipment. This equipment is normally located at the terminal exchange.
- A Customer Unit. This unit is located as close as practical to the customer's premises.

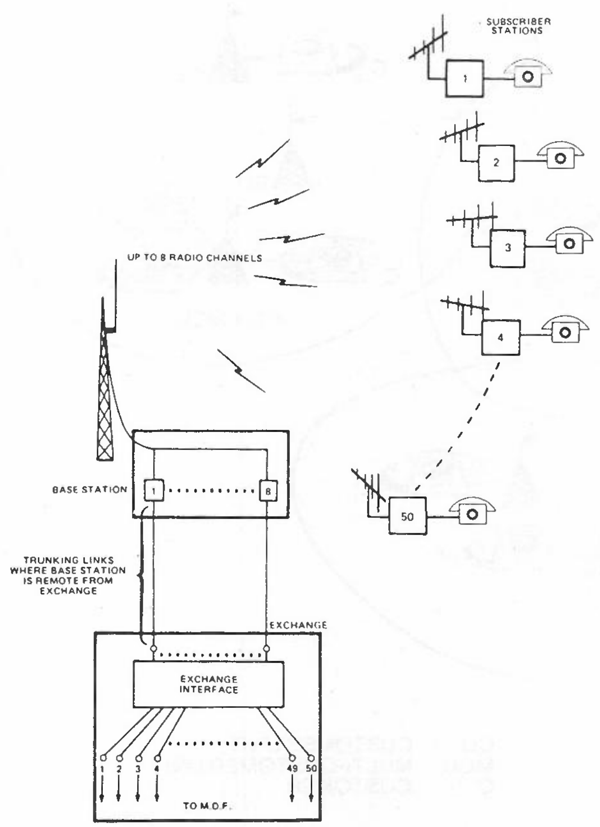


Fig. 1. System Configuration

The ARCS provides a limited number of radio telephone circuits between each service connected to the system and the base radio station. Each service has access to all these radio telephone circuits on a demand assignment basis.

The number of radio telephone circuits to be provided is a minimum of four and a maximum of eight and provision is made to allow an ARCS to be expanded in increments of one. In general a maximum of 50 customers can be connected to an ARCS.

If some customer calling rates are high, lower system capacities will result. Coin telephones and some business telephones may have calling rates much higher than normal and the connection of such services to an ARCS could cause excessive levels of congestion. In these cases, the provision of these high calling rate services by other means, such as VFH/UHF exclusive customer radio systems, is warranted.

A block diagram illustrating aspects of the ARCS design is shown in **Fig. 1**.

In other cases where the base radio station is located away from the telephone exchange, links will be required between the exchange and the base radio station.

The excact nature of these links will depend on distance and location, but normally will be any of the following types:

- carrier systems
- radio links
- physical lines

Typical arrangements are shown in **Fig. 2**.

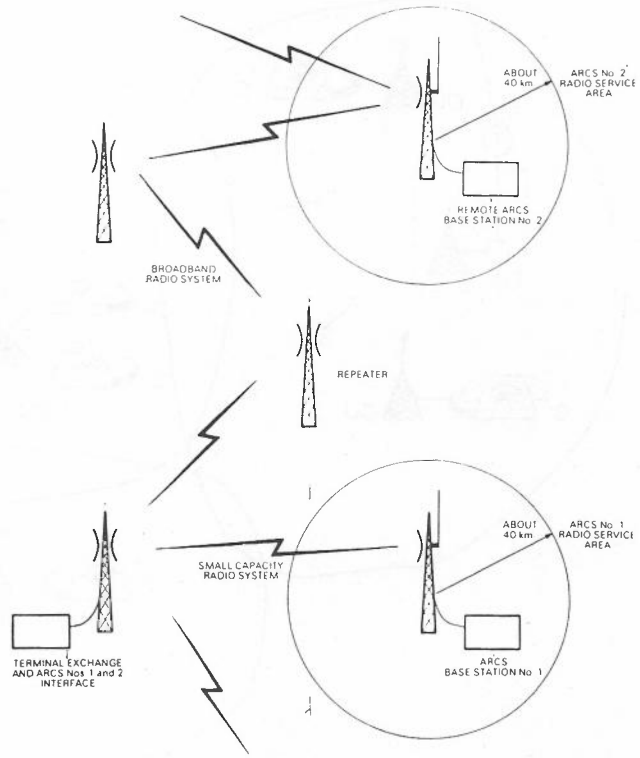


Fig. 2. ARCS Base Stations Remote From Exchange.

Usually the base radio station is centrally located within its radio service area and the customers located within a radio 'line of sight' path. The radio service area covered by a base station is dependent on the height of the antennas above ground. If a radio service area with a radius of about 50 km is desired over a flat terrain and if the customer antenna height is 10m, the base station antenna height must effectively be 60m.

Digital Radio Concentrator System (DRCS)

General

The DRCS is built up with three main building blocks: the Customer Station, the Repeater Station and the Exchange Unit. The Exchange Unit is located at the terminal exchange and individual repeaters extend the system and serve the DRCS customers located in the repeater's service area. The customer stations are located at or near the customer's premises.

The DRCS is dimensioned to carry a maximum of 127 customers although it is planned that for the initial implementation each DRCS should have a maximum of 50-80 customers. This figure will allow the system to accommodate unforeseen patterns in the traffic generated by customers and in the long term will allow the system to provide for additional customers.

The maximum length of a DRCS service will be about 600 km with the maximum number of repeaters in tandem being 13. The early systems will use the 500 MHz band and 1500 MHz systems become available in 1985/86.

Figure 3 shows a hypothetical DRCS network which uses the building blocks described in this section.

Exchange Unit

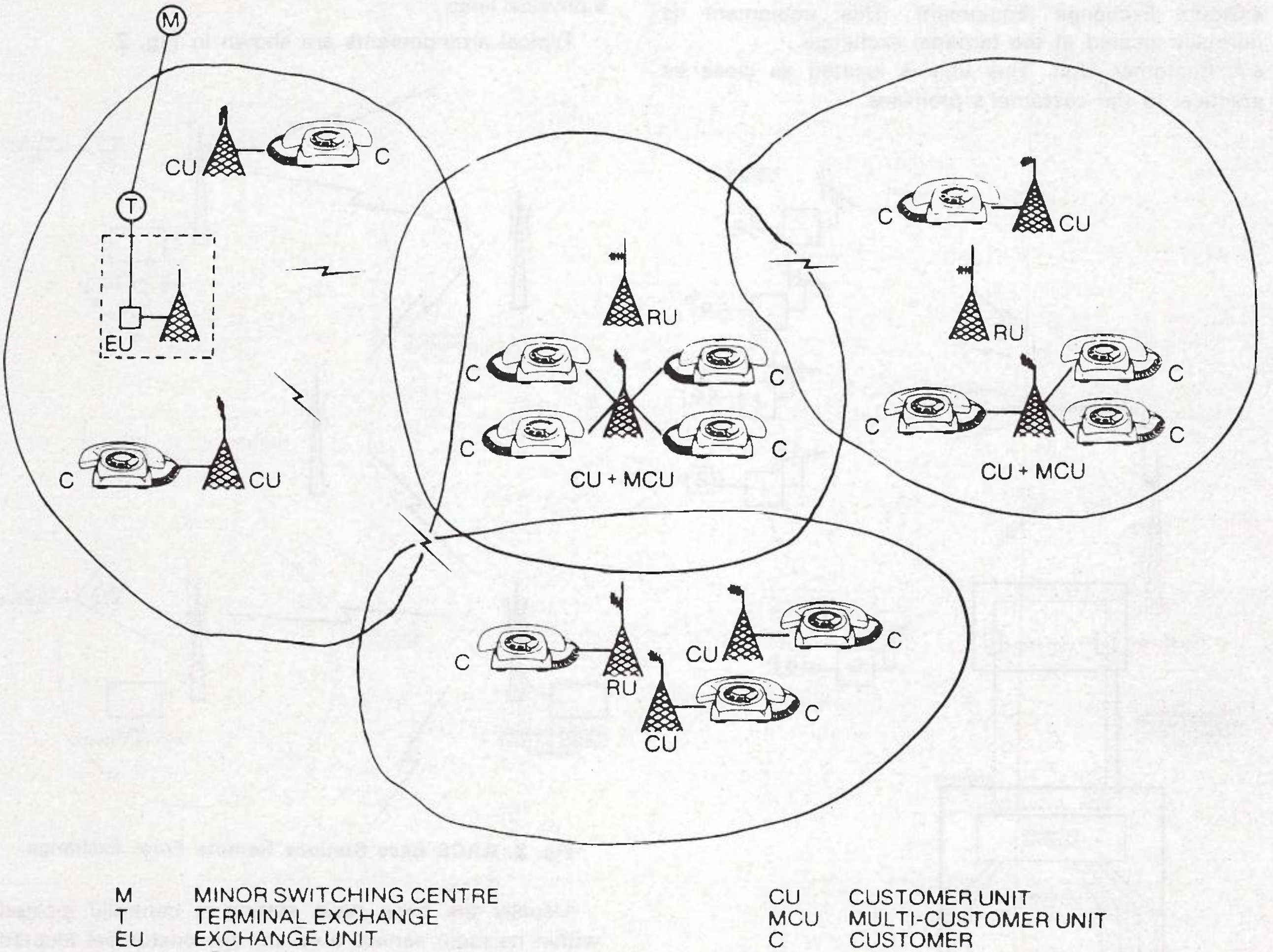
The exchange unit is in two main parts; the concentrator which controls the allocation of the 15 timeslots to the customers and the time division multiplex (TDM) controller which provides signalling control over the radio portion of the system. The TDM controller includes a radio transceiver.

Repeater Unit

The repeater unit receives the 'downstream' signal transmitted by the exchange unit and after regeneration retransmits that signal on a different frequency to serve the customer units within its service area and a repeater further out, if there is one. The signals from the units are also regenerated and retransmitted in the upstream direction towards the exchange unit.

A typical repeater station will consist of three units: a weatherproof cabinet which houses the radio equipment and batteries, a solar array and a mast of suitable height to support the antennae.

There will be at least two antennae for each repeater. An omni-directional antenna will be used for communicating with the customer units in the repeater



M MINOR SWITCHING CENTRE
T TERMINAL EXCHANGE
EU EXCHANGE UNIT
RU REPEATER UNIT

CU CUSTOMER UNIT
MCU MULTI-CUSTOMER UNIT
C CUSTOMER

Fig. 3. Hypothetical DRCS Network

service area and any downstream repeaters (repeaters further down from the exchange). A directional antenna will be used for communicating with the next upstream repeater or exchange unit.

The repeater unit will be housed, along with its associated drop out unit, batteries, etc, in a steel cabinet and this cabinet will be completely shrouded by a vented sunshade. The doors of the cabinet open to form a sunshade. The solar array will be mounted adjacent to the cabinet.

If multi-customer drop out units are required they will be installed in a similar cabinet, with their batteries, battery charging equipment, etc, next to the repeater unit cabinet.

The cabinets will be located near the base of the repeater mast. In some cases the repeater mast will be as high as 90 metres. **Fig. 4** shows a typical repeater configuration.

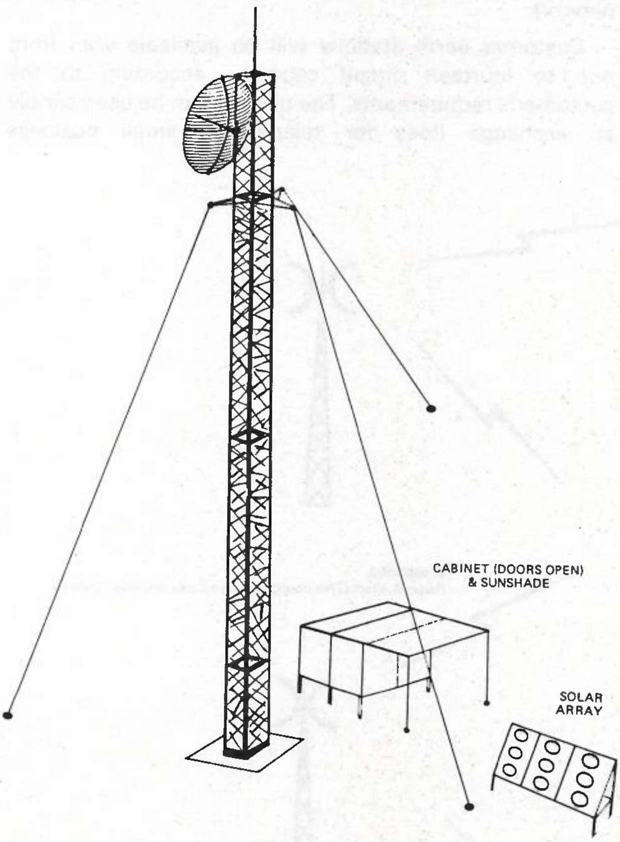


Fig. 4. DRCS Repeater Station

Customer Unit

The customer unit consists of a radio transceiver and one or more customer drop out units, with each customer drop out unit serving one telephone set. The maximum number of drop out units that can be connected to one customer unit or repeater unit is 21.

Customer Station

A customer station will usually consist of a weatherproof pre-wired equipment cabinet to house the DRCS customer unit, batteries and the battery charging controller. There will also be an antenna support and a solar array. **Fig. 5** is a sketch of the typical station assuming a triad mast and a yagi antenna.

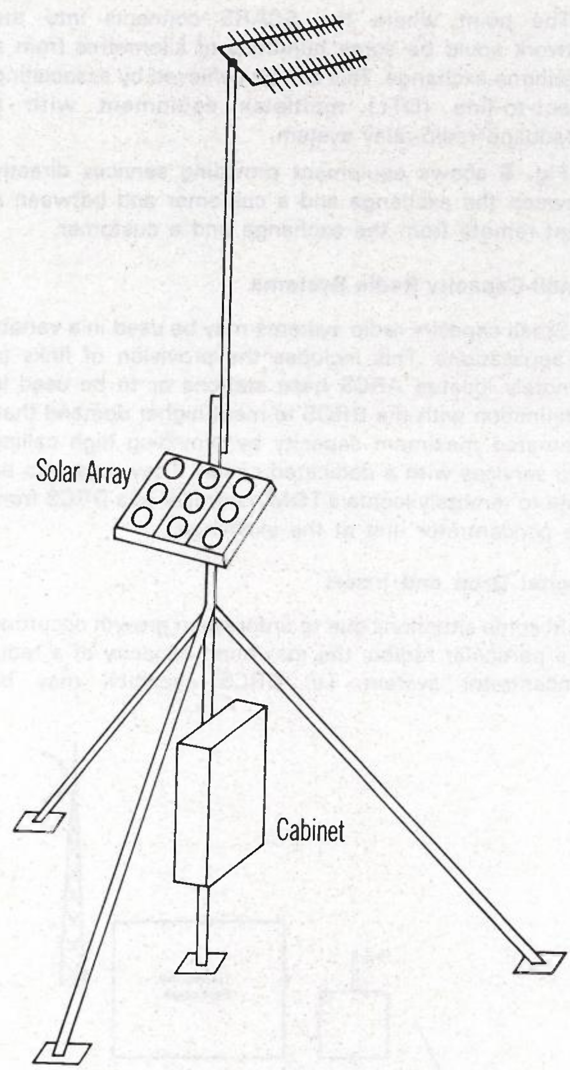


Fig. 5. DRCS Customer Station

Single Circuit Analogue Radio Systems (SCARS)

A SCARS is able to provide an exclusive telephone circuit between a telephone customer and a suitable entry point to the network. This entry point could be a telephone exchange or a suitable point along a radio relay route.

A SCARS consists of:

- a customer unit. This is provided at the customer's premises.
- an exchange unit. This is similar to the customer unit and is provided at the point of entry to the network.
- a repeater unit. This consists of two back-to-back exchange units.

The radio hop length using a SCARS is dependent upon the terrain and the height of the antenna used, typically being about 40 km over fairly flat terrain.

Repeaters are sometimes used with SCARS to extend the service distance from the network connection point. It is desirable that only one repeater be used, i.e. the service should only be extended by one additional radio hop. In typical flat rural terrain this means that a service can be provided 80 to 90 km from the network connection point.

The point where the SCARS connects into the network could be some hundreds of kilometres from a telephone exchange. This can be achieved by associating direct-to-line (DTL) multiplex equipment with a broadband radio-relay system.

Fig. 6 shows equipment providing services directly between the exchange and a customer and between a point remote from the exchange and a customer.

Small Capacity Radio Systems

Small capacity radio systems may be used in a variety of applications. This includes the provision of links to remotely located ARCS base stations or to be used in conjunction with the DRCS to meet higher demand than estimated maximum capacity by providing high calling rate services with a dedicated circuit. They may also be used to remotely lcoate a TDM controller of a DRCS from the concentrator unit at the exchange.

Digital Drop and Insert

In some situations due to unforeseen growth occurring in a particular region, the maximum capacity of a radio concentrator system, i.e. DRCS capacity, may be exceeded. To provide additional services to this region, the provision of a small capacity radio system may be appropriate. In some cases it may be desirable to emanate this system from an existing trunk route at a repeater site. It may be possible to share some of the facilities already established at the radio concentrator repeater sites, i.e. masts, shelters.

National Communications Satellite

The first service via the domestic communications satellite to be offered by Telecom is the Iterra Network Service (INS). This service will provide telephony, data and text facilities, connected to the national switched telephone network.

The Telecom INS service will be provided via a number of customer earth stations and one Main Earth Station located at Bendigo, Victoria. This will provide the interface between the satellite network and the terrestrial network.

Customer earth stations will be available with from one to fourteen circuit capacity, according to the customer's requirements. The circuits can be used simply as exchange lines for telephones, small business

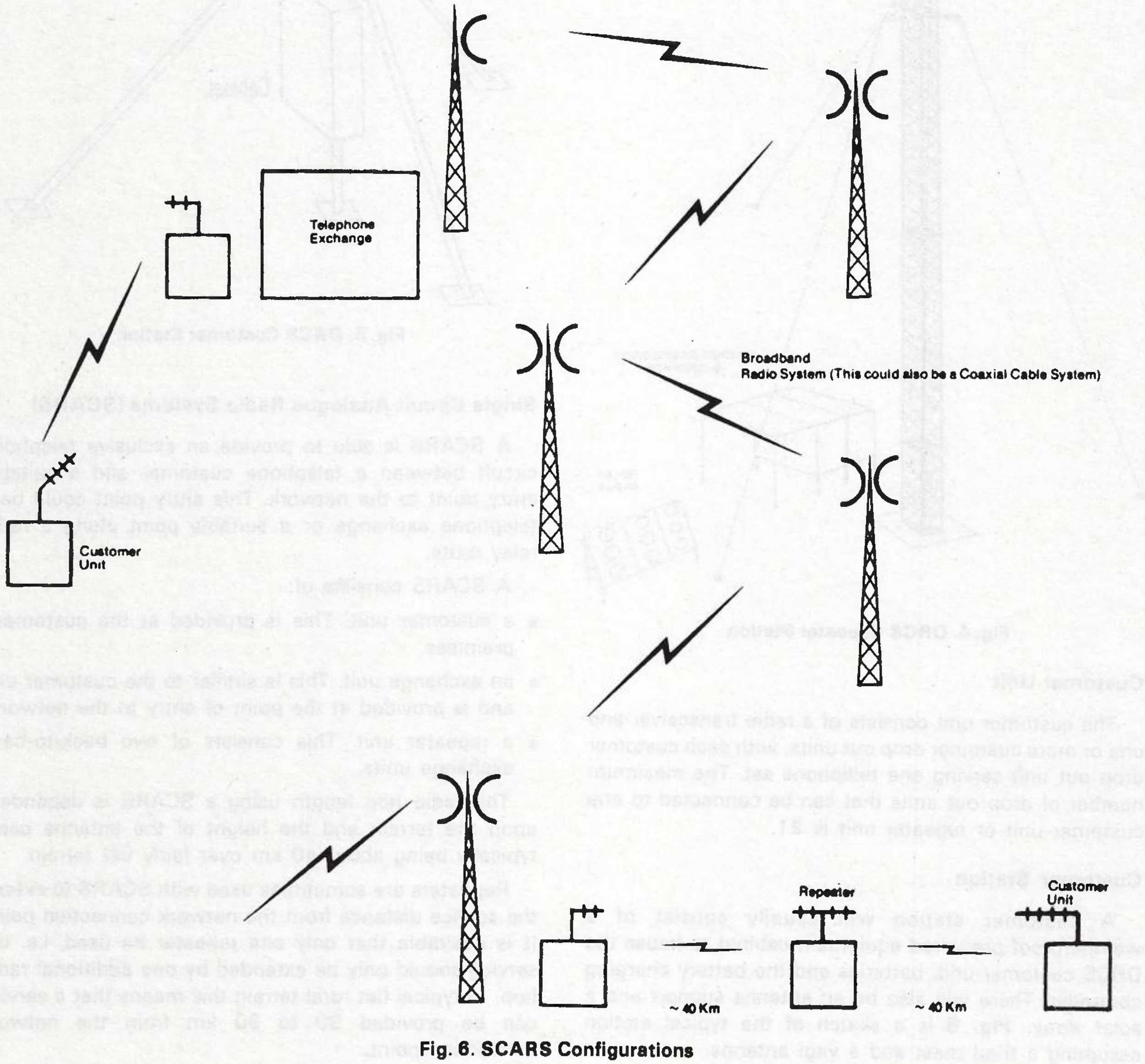


Fig. 6. SCARS Configurations

systems, PABXs and other terminal equipment, or as junction circuits for local telephone exchanges provided by Telecom on a commercial basis.

It should be emphasised that the cost of satellite service precludes its use as the normal vehicle for providing basic remote area telecommunication service. The DRCS offers better performance at cheaper cost in the vast majority of applications but customers who wish to have service in advance of planned network expansion will be able to opt for the satellite service at a cost which reflects its cost of establishment.

POWER SUPPLIES

In many rural areas and most remote areas, reliable 240 V power is not available and alternative means are therefore necessary to provide power for telecommunications plant.

Over recent years Telecom has been a leader in the successful development of solar power to the point where a range of equipments can now be powered by this manner. Some customer radio equipment is already powered by solar systems as is the radio system linking Tennant Creek and Alice Springs.

In general, a solar power supply will be used where a repeater station or customer station is remote from reliable commercial power. This supply will also require batteries with an eight day reserve to accommodate the variation in the seasons and the weather which will influence the energy supplied from the sun.

Where a larger power supply is required Telecom has successfully used diesel engines to provide the prime power. However, such systems are expensive to provide, maintain and support. To address the problems posed by these installations, Telecom has been developing and implementing the use of hybrid power systems using combinations of solar, wind, diesel and battery technologies.

CHOICE OF TECHNOLOGY

Telecom has a range of options available to provide telecommunication services to customers in rural and remote areas. While there is a large number of possible configurations a brief summary is given below:

- Copper cables can provide service to customers within the immediate vicinity of a telephone exchange. As the distance between customers becomes greater, the costs of such provision rises rapidly.
- Single circuit analogue radio systems can provide service to an individual customer located up to about 40 km from a suitable entry point to the national network. This distance may be extended to about 80 km if a repeater is used.
- Small capacity radio systems can provide a link from the existing national network for a variety of purposes. These include links to remotely sited telephone exchanges at small settlements, to link to a remotely sited analogue radio concentrator system or used in conjunction with radio concentrators in general to provide dedicated circuits to high calling rate customers.
- Analogue radio concentrator systems are useful in a number of configurations but particularly where a small cluster of up to about 50 indivdual customers is located within a 40 km radius of the base station.
- Digital radio concentrator systems become increasingly more useful in more thinly populated, inaccessible locations. Such a system is able to provide service to customers located up to 600 km from a suitable entry point to the national network.
- The National Communications Satellite will not be generally available to provide services to rural and remote areas under normal connection arrangements. However, by way of negotiated commercial projects, a range of services tailored to meet customer's requirements will be available including remotely located telephone exchanges.

In general terms the particular technical option chosen will depend upon economic and strategic factors and on the need to satisfy the customer. The basic aim of the telecommunication tools mentioned above is to provide a "transparent" service which will enable the customer to have versatility, wide choice and flexibility in terminal equipment and attachments.

CONCLUSION

By 1990, Telecom aims to have completed a modern, automatic service linking Australians everywhere and we are investing some $400 million to achieve this goal. This involves the conversion of existing manual services to automatic and the provision of services to all isolated people in the remote areas of Australia through the use of the latest techniques.

In order to carry out this programme it is also necessary to concurrently extend the national network to provide the infrastructure to link remotely located telephone exchanges. One such extension will link Thursday Island into the national network by means of a microwave radio system. Another will use optical fibre cable to link Alice Springs to Port Augusta. An incidental benefit of the establishment of these extensions to the national network is the ability to provide telecommunication service to some individual customers, communities or settlements within a corridor along the routes.

Until 1984, the technology most widely used in rural areas to provide for customer service has been cable, although there was some application of radio concentrator and single circuit analogue radio systems in outlying low density areas.

To extend this work into progressively lower density population areas, a range of technologies will be used. Although the digital radio concentrator system becomes the most practical and economically attractive in these more isolated areas, there will be many cases where other technological options will be more appropriate. As a matter of course, Telecom closely monitors technological developments which may provide services to rural and remote areas in a less costly manner. Clearly less costly technologies allow a given programme to be completed sooner. Telecom's basic aim is to provide an economic, efficient and reliable service which enables a wide range of customer telecommunication needs to be satisfied. We are confident that these plans for rural and remote areas will provide our customers with world standard services at affordable prices.

A SURVEY OF FACILITIES AVAILABLE TO CUSTOMERS IN RURAL AND REMOTE AREAS

FACILITY	DRCS	ARCS	SCARS
800 Series Telephone (Colour, Wall Phones, etc)	YES	YES	YES
Touchfone 10 (805)	YES	YES	YES
Touchfone 12 (806 MK 1&3)	YES	YES	YES
Ericofon	YES	YES	YES
Digitel Monitor — Decadic	YES	YES	YES
Digitel Memory — Decadic	YES	YES	YES
Digitel Conf. — Decadic	YES	YES	YES
Digigel Conf. —VF	YES	YES	YES
Gondola — Decadic	YES	YES	YES
Gondola — VF	YES	YES	YES
Telephone Answering Machine Memory — Decadic	YES	YES	YES
Telephone Answering	YES	YES	YES
Machine Memory VF			
Transit Decadic	YES	YES	YES
(Dec + 10)			
Transit — VF	YES	YES	YES
Commander	YES	YES	YES 1
Flip-phone	YES	YES 1	YES
Extension Switch	YES	YES	YES
Hearing Aid Telephone (Amplified)	YES	YES	YES

FACILITY	DRS	ARCS	SCARS
Gliding Tone Caller	YES	YES	YES
Hearing Aid Coupler	YES	YES	YES
STD Coin Telephone	YES	YES 1	YES 2
Parallel, Portable and Alternative Telephones to a Maximum of two Instruments per Service	YES	YES	YES
Intercommunication Telephones	YES	+	+
PABX (Excluding In-dialling Facilities)	YES	+	+
PMBX	YES	+	+
Telex plus Speech	YES	NO	YES 1
Facsimile	YES	YES	YES
Datel			
300 Bit/s	YES	+	+
1200 Bit/s	YES	+	+
2400 Bit/s	YES	+	+
Videotex	YES	+	+

NOTES:

1. Some models provide this facility.
2. Currently under development.

Under investigation.

TELECOMMUNICATION JOURNAL OF AUSTRALIA

GOLDEN JUBILEE — JUNE 1985

CALL FOR PAPERS

The Telecommunication Journal of Australia will be celebrating its Golden Jubilee in June 1985. Three issues of the Journal will be published in 1985. As well as the usual mix of up-to-date articles, each issue will feature a fundamental theme.

Issue 35/1 — March/April — The past 50 years.
Issue 35/2 — July/August — Linking the past with the present.
Issue 35/3 — Nov/Dec — Towards the next 50 years.

The Board of Editors invites you, the reader, to take part in this celebration. Papers suitable for publication include:

- **Historical articles.**
- **The Information Transfer evolution.**
- **The convergence of telecommunications and computers.**
- **The IDN toward ISDN.**
- **Office automation.**
- **Fibre optics.**

Author's guide is available from the Editor-in-Chief, TJA, BOX 4050, G.P.O. MELBOURNE, Victoria 3000, Australia. For further discussions telephone the Editor-in-Chief on (03) 606 7644.

Interworking of Local Area Networks and Public Networks

Eng K. CHEW, B.E., M.Eng. Sc. Ph.D.

This paper reviews the methods for network interworking between Local Area Networks (LANs) and public telecommunications networks. The networking properties of LANs and their characteristic differences from public networks are explained. Basic principles of internetworking are then discussed and used to analyse the key issues associated with LAN — public network interworking. Existing solutions are contrasted. The preferred approach and its current state of development are described. Finally, current research on the interconnection of LANs with the future Integrated Services Digital Network (ISDN) is also briefly mentioned.

1. INTRODUCTION

Local Area Networks (LANs) constitute a class of networks which interconnect a variety of information processing systems by means of an efficient communication system. Typical examples of end-user systems supported by LANs are computers, data terminals, printers and mass storage devices, etc.

LANs may support applications such as file transfer, electronic mail, word processing, remote data base access and high resolution graphical applications, etc. Recent developments indicate that LANs may also be able to support packetised voice and video communications. With these capabilities, LANs are being perceived as basic building blocks for establishing an integrated office environment. Indeed, it is anticipated that widespread use of LANs for automated office applications will become prevalent in the business sector in the future. Associated with these applications will be the need for LANs to interconnect with the public telecommunications networks. This interconnection will enable end-user systems attached to a LAN to communicate with other end-user systems attached to public network(s), and will provide an economical means for linking up geographically separated LANs.

LANs differ from public networks in several aspects, such as network topology, transmission capacity and internal communication protocols. The interconnection of these differing networks can be achieved via a **gateway**. The basic role of the gateway is to resolve the network differences so as to permit communications between users on each of these networks.

This paper reviews and discusses the issues related to gateway designs for interconnecting LANs and public telecommunications networks. The networking properties of LANs and their characteristic differences from public networks are discussed. Basic principles for interconnecting dissimilar networks are reviewed. These are then used to analyse the basic issues associated with LAN — public network interworking. Some existing solutions for LAN internetworking, and a preferred method for LAN — public network interworking are also described together with issues related to this preferred method, such as addressing. Finally, the role of LANs in the future Integrated Services Digital Network (ISDN) environment together with related issues for future research are briefly mentioned.

2. LAN NETWORKING PROPERTIES

A proliferation of LANs is evident throughout the world, with applications occurring in wide-ranging areas, e.g. office automation and automated process control, etc. Many different forms of LAN are now available on the market, each suited to different applications. In general, LANs are characterised by:

- a high transmission bit rate (typically in the order of several Mbit/s);
- a low bit error rate (e.g. less than 10^{-8});
- a restricted geographical area of operation (e.g. a single premises, an industrial site, a university campus, etc., with distance ranging from 100 m to 100 km).

This section will review the basic networking properties of LANs and in particular, will identify those aspects which may impact upon the internetworking capabilities of LANs.

2.1 TOPOLOGIES

Physically, LAN architectures may be characterised by the network topology used to interconnect the various information processing systems. To avoid the need to incorporate complex switching functions in every node (or work station), LANs have tended to use constrained topologies which take the form of star, ring and bus structures (Clark, 1978), **Fig. 1**.

The star network requires a central switching node to which all other end-user systems are attached. The central node performs all necessary routing decisions to interlink local systems which require intercommunication.

The ring and bus topologies avoid the use of the central switching node at the expense of some slight increase in complexity at all other nodes. These result in decentralised networks in which no routing decisions are necessary. In a ring network, messages are passed around the ring, a node at a time. In a bus network, a message flows away from the originating node in both directions to the ends of the bus. In both networks, a message must be appended with an appropriate destination address. The address permits the intended node to recognise and accept the message.

The ring and bus topologies are most commonly used by LANs supporting mainly data applications. The star network is more suited for integrated voice/data applications. A distinction has often been made which refers to the star system as an integrated PABX system rather than a LAN. This distinction is also adopted in the remainder of this paper.

2.2 PROTOCOLS

Logically, LAN architectures may be characterised by the protocol structures which enable the interconnection of dissimilar end-user systems. The lower levels of these protocols are closely influenced by the topologies and other characteristics of LANs, as follows.

Due to the distributed-control nature of LANs, call collision may occur when more than one terminal seeks to gain access, simultaneously, to the single transmission medium for the purpose of system interconnection. To resolve or prevent this media access contention problem, suitable protocols are required. These protocols will arbitrate or control terminal requests to permit an orderly sharing of the transmission medium. They are commonly termed **"media access control"** protocols.

In addition, appropriate means must also be provided which will support a logical link/association between the correspondent terminals. The logical link permits the communicating terminals to exchange information. The required protocols will control the operation of these logical links and are called **"logical link control"** protocols. Finally, suitable functional and procedural means must be provided to move raw data bits and to interface user systems to the transmission (or **physical**) media.

Other LAN characteristics, as enumerated above, also influence the design and functionality of LAN protocols. More specifically, simpler protocols may be used as a result of the high performance achievable through LAN hardware technology (e.g. high transmission rate and low bit error rate). For example, because of the large bandwidth available, communication overheads become non-critical. Thus simpler, but more overhead consuming, datagram protocols (also known as connectionless protocols) become practical for LAN application. Further, the low error rate available between two end systems also means that less complex error control protocols are required in LANs.

Simpler protocols imply simpler processing requirements. This is desirable as the cost of LANs is currently dominated by the nodes. This tendency is quite opposite to that encountered in public networks, where more complex protocols are generally necessary in order to utilise the relatively smaller, but more expensive, communication channel bandwidth cost-effectively. In contrast, public networks rely on the use of appropriate routing algorithms to minimise message transfer delay and maximise message throughput.

2.3 STANDARDS

To prevent a proliferation of different LAN types several national and international standards organisations have been active in formulating LAN standards. The most notable of these include the Institute of Electrical and Electronic Engineers (IEEE) 802 Committee for Local Network Standards, the European Computer Manufacturers Association (ECMA) and the International Organisation for Standardisation (ISO).

In the formulation of these standards, extensive use has been made of the Reference Model for Open Systems Interconnection (OSI) developed by ISO and CCITT (International Telegraph and Telephone Consultative Committee). The OSI Reference Model is a seven layered protocol architecture. It serves as a common framework for the co-ordination of protocol standards development and for placing existing protocol standards into perspective (ISO, 1983).

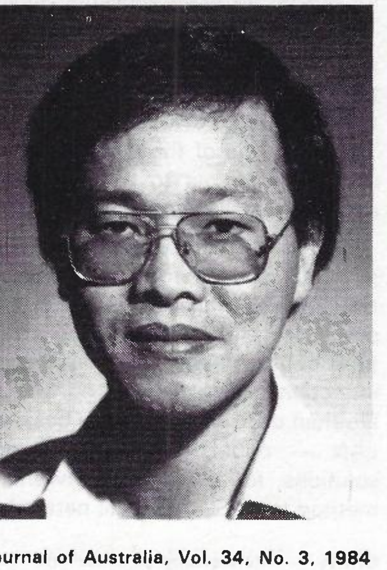
The LAN protocols discussed above may, functionally, be partitioned into three logical layers, starting from the top:

Eng Kiang CHEW received the degrees of B.E. (Elec.), 1972 from the University of Melbourne; M.Eng.Sc., 1975 and Ph.D., 1981 from the University of Sydney. After working for a year with Telecom Australia, he attended the University of Sydney, in 1973, where he also worked as a Tutor in Electrical Engineering. His Ph.D. work (1975-79) was on the modelling and analysis of stored program controlled (SPC) telephone switching systems.

Since joining Telecom Australia Research Laboratories in 1979, he has worked on aspects of SPC switching operations and maintenance, modelling and analysis of the CCITT No. 7 Common Channel Signalling System.

In 1982 he became a Senior Engineer with Customer Access Section where his work was centred on the interconnect arrangements between customer systems, networks and the public networks, especially in an Integrated Services Digital Network (ISDN) environment.

Dr. Chew is currently a Principal Engineer with Business Communication Section where he leads a project on application-oriented services with emphasis on message handling and directory services.



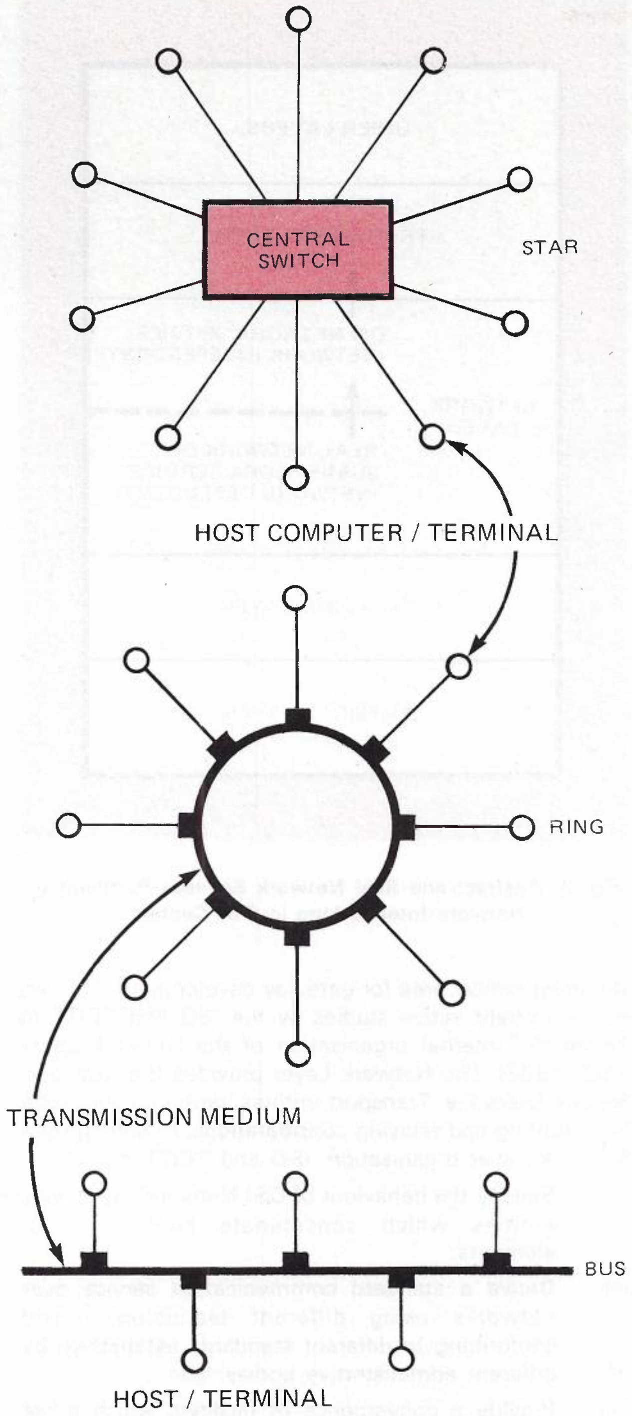


Fig. 1: LAN Topologies.

— Logical Link Control (LLC) Layer;
— Media Access Control (MAC) Layer; and
— Physical Layer.

Indeed, such a three-layered architecture has been chosen by the IEEE 802 Committee as their LAN Reference Model. These layered protocols, collectively, match the specifications of the Data Link and Physical Layers of the OSI Reference Model as shown in **Fig. 2.** Details of the LAN protocol layers can be found in (Myers, 1982 and Duc, 1982). A summary of these is included in Appendix A.

Since intra-LAN operations require no switching or routing, the Network Layer of a LAN, therefore, has essentially null functionality. Further, LANs tend to employ a connectionless protocol in the Data Link Layer. This protocol does **not guarantee** delivery of messages. In order to support guaranteed delivery services, a Transport Layer will be required, which is capable of performing the error recovery, sequencing and flow control functions, etc. To this end, a Transport Layer protocol standard has been specified by ECMA as part of their intra- and inter-LAN interworking standards (Sideris, 1982). The Data Link and Physical Layers of the ECMA standards are compatible with those of IEEE 802. Both the ECMA's and IEEE 802's proposed LAN standards are being considered within ISO for the development of international LAN networking standards. Standards for the other OSI layers are still being developed.

3. PUBLIC NETWORKS

Various types of public telecommunications networks are available, e.g. packet switched network (PSN), public switched telephone network (PSTN), circuit switched data network (CSDN), etc. These networks are basically service dedicated and they co-exist as separate networks. In the framework of the OSI Reference Model, these networks may be modelled by the lower three layers, namely Network, Data Link and Physical Layers.

LANs are basically packet switched data networks. As such they would interwork suitably with data networks, especially packet networks. In what follows, discussions on LAN — public network interworking are based on the assumption of a PSN, although the principles may also be applicable to CSDN. (The use of a leased telephone circuit or Digital Data Service to interlink remote LANs directly is not regarded as an LAN — public network interworking issue in this paper.)

At present, PSTNs worldwide are rapidly evolving from analogue to digital networks and, in the longer term, into ISDNs which incorporate both packet and circuit switching facilities (Duc and Chew, 1984). The means for interconnecting LANs to the ISDN and the role played by LANs in such a multi-service environment will also be addressed in this paper (Section 6).

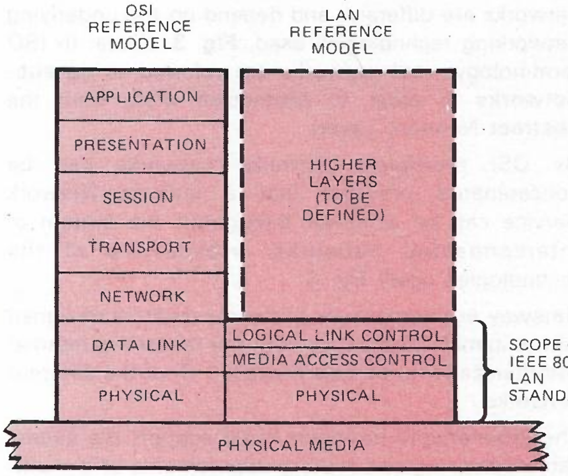


Fig. 2: Architectural Relationship Between OSI and LAN Reference Models.

4. INTERNETWORKING PRINCIPLES

The interconnection of networks, with different protocols and dissimilar addressing means, is a complex problem. With the increasing need, worldwide, for dissimilar networks to inter-operate (either between public-public, private-private or private-public), this problem is becoming critical. Recognising this and in order to avoid the proliferation of many different ad-hoc solutions for internetworking, both the ISO and CCITT have begun work to develop some general principles for network interworking from which a general internetwork gateway architecture can be derived. This architecture can then be used as a common framework to define appropriate strategies for different interworking conditions.

This Section reviews the current development status of an ISO-proposed internetwork gateway architecture, and explains the basic concepts of naming/addressing and other issues related to network interworking. The application of the gateway architecture to LAN-PSN interconnection is discussed later in this paper.

4.1 INTERNETWORK GATEWAY ARCHITECTURE

Typically, network access and intranetwork protocols can be modelled with the lower three layers of the OSI architecture. Networks with different access and intranet protocols (as in LANs and PSN) will thus possess different network services. (These may also be different from the **OSI Network Service** provided by the standard Network Layer to the Transport Layer). To interconnect such dissimilar networks a gateway must be used, which will mask or resolve these differences to achieve network compatibility.

Network interconnection permits communication to take place between application processes (e.g. computer programs) residing in host computers and terminal systems of different networks. This means a globally unique naming and addressing scheme is also required which enables an appropriate connection path to be set up for interprocess communication over multiple networks.

The specification of an internetwork gateway architecture therefore should take into account the following:

(a) The real network services (Layers 1-3) of dissimilar networks are different, and depend on the underlying networking technologies used, **Fig. 3.** (Note: In ISO terminology, **real** networks are referred to as **sub-networks** in order to distinguish them from the **abstract** Network Layer).

(b) By OSI principles, dissimilar networks can be concatenated provided that a uniform Network Service can be achieved throughout the system of interconnected networks, irrespective of the technologies used, Fig. 3.

(c) Gateway or internetwork protocols must be designed with minimal interference with the respective internal communication protocols (Layers 1-3) of the different networks.

(d) The internetwork protocols must support the necessary addressing and routing requirements of a multi-network environment.

These considerations imply that the Network Layer is

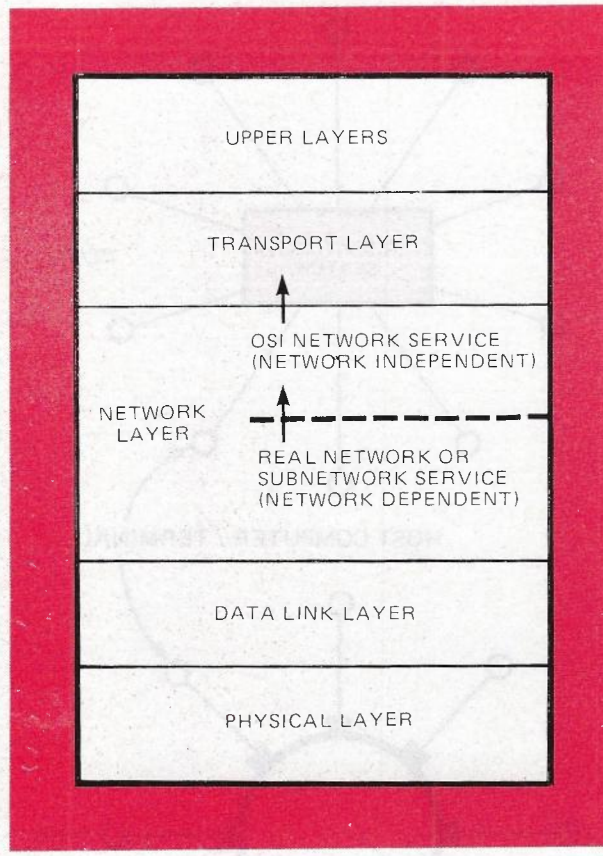


Fig. 3: Abstract and Real Network Services Pertinent to Network Interworking in OSI Context.

the most critical area for gateway development. This led to the current active studies by the ISO and CCITT to define the internal organisation of the Network Layer (ISO, 1982). The Network Layer provides the Network-Service users (i.e. Transport entities) with independence from routing and relaying considerations. In defining the Network Layer organisation, ISO and CCITT aim to:

(i) Specify the behaviour of OSI Network Layer relay entities which concatenate communication elements;

(ii) Derive a standard communication service over networks using different technologies and conforming to different standards established by different administrative bodies; and

(iii) Provide a convergence of facilities which make cost-effective use of currently available networking products.

The resultant Network Layer, therefore, comprises three sub-layers (see **Fig. 4**). These are: (3a) **network-specific** (ns), (3b) **network-dependent convergence** (ndc), and (3c) **network-independent convergence** (nic) sub-layers. The internetwork relay and routing functions are modelled as a separate entity residing in sublayer (3c).

The (ns) protocols are part of a specific network's internal protocols. The collective purpose of (ndc) and (nic) protocols are, conceptually, to mask the peculiarity of each constituent network in order to provide a uniform Network Service throughout the system of concatenated networks.

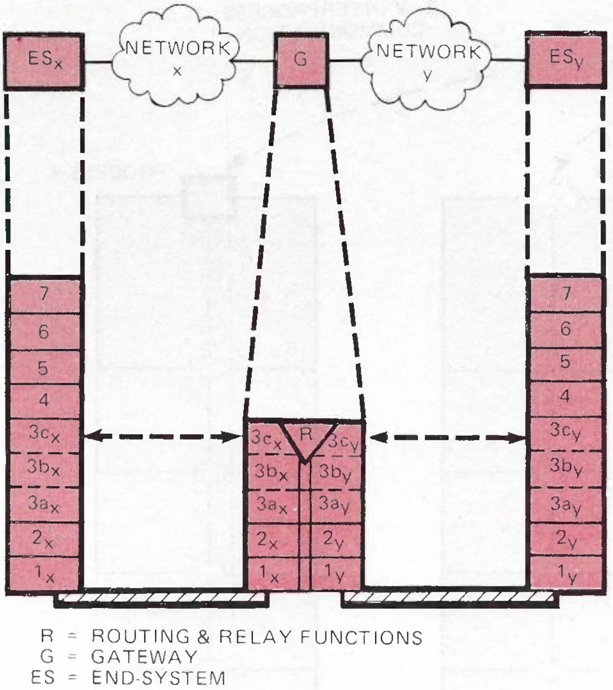


Fig. 4: ISO — Proposed Internetwork Gateway Architecture.

In particular, the (ndc) protocols are required to **relate,** by enhancement or muting of the service provided by the (ns) protocols, to that required by the (nic) protocols. The purpose of the (nic) protocols is then to remove any remaining network-dependent variability, by means of network-independent protocols, so as to provide a uniform appearance of the OSI Network Service. The (nic) protocols may, therefore, be absent if the (ns) and (ndc) protocols, together, can support the uniform Network Service required. This would then result in a simple Sublayer (3c) which performs mainly internetwork relay and routing functions.

While the ISO-proposed Network Layer organisation is still under further study and refinement, the sub-laying concept used is generally accepted by most ISO members. The application of the ISO-proposed internetwork gateway architecture to LAN — public network interconnection will be discussed later.

4.2 NAMING AND ADDRESSING

As indicated above, the ultimate purpose of network interconnection is to provide interprocess communication capabilities across a multi-network environment. In the framework of the OSI Reference Model, the Transport Layer with the support of the underlying uniform Network Service provides a reliable interprocess (IP) communication system (also known as Transport Service) to the application processes of end-user systems.

To establish a logical association between two application processes, the originating process (e.g. a program) need only **name** the destination process (e.g. file server) with which it intends to correspond. The name must somehow be mapped into an appropriate **address** at which the recipient process may be found. The destination address will subsequently be used by the IP communication system to determine an appropriate (perhaps optimal) **route** to reach the recipient process.

The IP communication system defines a set of **"sockets"** (i.e. Transport Service Access Points — TSAPs) through which application processes may obtain communication (Transport) service. Each "socket" has a unique address, known as the Transport Address. To communicate a process must attach itself to a "socket". Thus communicating processes may be able to refer to one another via their Transport Addresses, see **Fig. 5.**

Transport Addresses are related to Network Service Access Point Addresses and must be globally unique. This is commonly achieved by means of a hierarchical addressing scheme. In the multinetwork environments Transport Addresses would therefore generally consist of a **network number,** a **host number** and a **port** assigned by the host computer (Tanenbaum, 1981). To this end, an International Numbering Plan, known as X.121, has been standardised by CCITT for the worldwide, unique identification of data terminals (or hosts) connected to the **public** data networks. The applicability of X.121 to LAN — public network interconnection has not yet been fully resolved and will be discussed in Section 5.

4.3 OTHER RELATED ISSUES

Beside the gateway functions discussed above, other related issues must also be resolved before a coherent internetworking strategy can be defined. These include: packet fragmentation, flow control, accounting or charging, and access control (Tanenbaum, 1981, Lidinsky, 1982).

Packet Fragmentation may be required at the gateway where the interconnected networks possess different transmission capacities and hence different maximum packet sizes. Its basic purpose is to break large internet packets into smaller fragments which can be carried by the network of lower transmission capacity.

Flow Control is a procedure through which a pair of communicating entities regulates traffic flowing from source to destination. Such a mechanism is necessary at the gateway in order to protect one network from being overloaded by the other. Dissimilar flow control strategies used in each constituent network will further complicate the design of the procedure.

Charging for inter-network traffic is an important issue. The public network needs mechanisms for service charging while the LAN users need simple procedures for verifying the accuracy of public network provided accounting.

Access Control is needed permitting a network to exercise control over the type and rate of traffic entering or leaving the network. The control capability may extend from metering or monitoring to barring of specific traffic types.

5. LAN — PUBLIC PACKET SWITCHED NETWORK INTERWORKING

The above review of the networking properties of LANs and public packet switched networks (PSN) has revealed that:

(a) LAN nodes interoperate without intermediate routing while PSN nodes do. Thus, unlike PSNs, LANs have essentially a null Network Layer.

(b) LANs tend to operate in Connectionless mode while PSNs in Connection-oriented (e.g. X.25) mode.

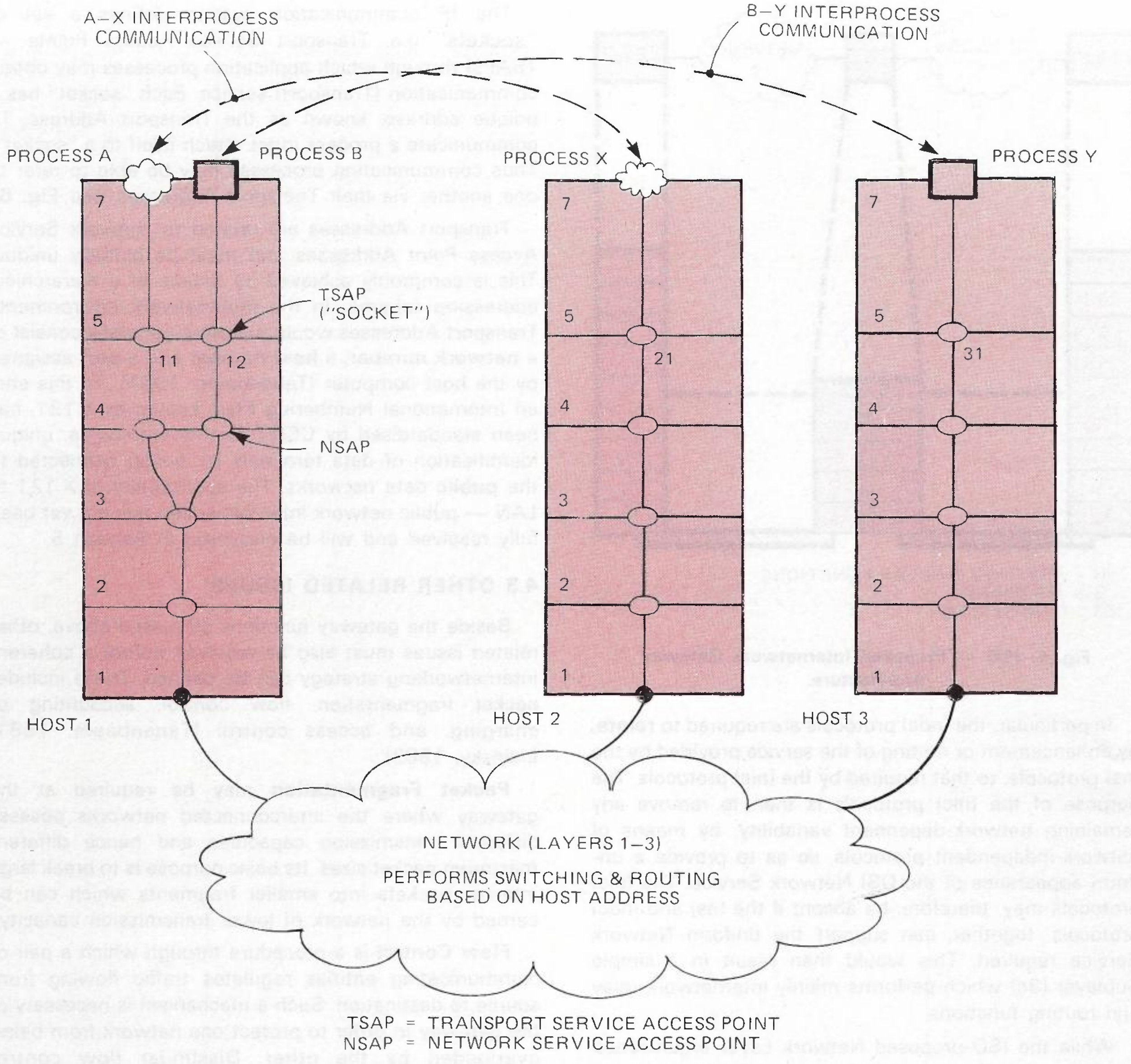


Fig. 5: Identification of Application Processes in OSI Architecture.

(c) LANs employ higher speed transmission media (M-bit/s) compared to PSNs (kbit/s).

Each of these contrasting properties impact differently on the internetwork gateway design considerations. These are analysed in turn as follows.

5.1 ADDRESSING CONSIDERATIONS

A result of Property (a) is that node addressing is a Data Link Layer function in LANs but a Network Layer function in PSNs. By the internetworking principles above, LAN nodes and the associated gateway must therefore incorporate a Network Sublayer (3c) so as to interwork with the PSN.

An Internet addressing scheme used in the Network Layer will be hierarchical, based on the X.121 standards. Furthermore, to permit unique identification of LAN hosts in multinetwork environments it will be necessary to devise a suitable means for mapping the global internet addresses at the Network Layer to the Data Link Layer addresses used within an LAN for unique host identification. These issues are considered below.

X.121 as presently specified, consists of 14 decimal digits: the first four digits denote the data network identification code (DNIC) and the remaining ten digits the network terminal number (NTN) of the host computer. The DNIC was originally intended to be used for public network identification only. However, with the worldwide proliferation of private data networks, including LANs, it becomes clear that in order to facilitate the interconnection of these private networks to the public networks, X.121 needs to be modified to extend its addressing capability to private networks as well.

One scheme which could be accommodated by X.121, currently under revision in CCITT, is as follows, **Fig. 6** (CCITT, 1983). A specific DNIC code could be assigned to a group of private data networks connected to public data networks within a country. When applied to private networks, a private data network identification code (PNIC) is assigned to each private data network contained within the group of private networks identified by a specific DNIC. All PNICs consist of six digits. Hence the address format for private networks is DNIC (4 digits) + PNIC (6) + NTN (4). One problem with this scheme is

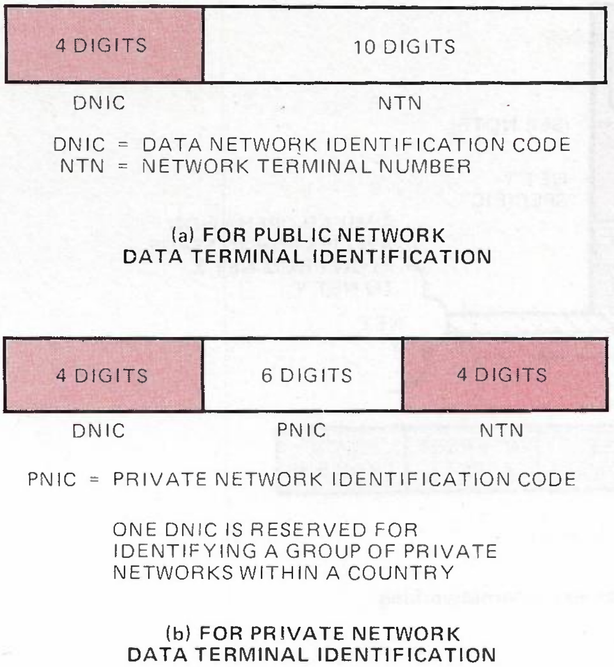


Fig. 6: Use of CCITT X.121 Numbering Plan.

the limited address space (10,000) for terminal identification within a private network. Other schemes are also possible, (CCITT, 1983). Detailed discussion of these schemes is beyond the scope of this paper. An account of recent ISO/CCITT progress on the study of Network Layer addressing requirements can be found in (Al-Tarafi and Chew, 1984).

The application of modified X.121 (i.e. DNIC + PNIC + NTN) to LAN — public network interconnection requires some clarification. The host identity NTN is a Layer 3 internet address and is assigned by the LAN (or private network) administrator. However, for intra-LAN operation only Layer 2 addresses are needed for unique host identification. These Layer 2 addresses are also subject to standardisation by IEEE 802 (Myers, 1982). A proposal which allows two different host addressing schemes to be used is being studied in IEEE 802. It offers users the choice of 16-bit addresses for isolated networks, known as network-specific host addresses, or 48-bit addresses for worldwide unique addresses. Obviously, the Layer 2 and Layer 3 addresses must be compatible or mappable if a LAN is to support both intra- and inter-network operations.

Based on the proposed IEEE 802 addressing standards for LANs, two options exist for internet addressing (Lidinsky, 1982). The first method follows the normal convention of hierarchical addressing as in modified X.121, whereby the host numbers associated with PNIC (i.e. LAN) are assigned locally by the LAN administrator. Using this approach isolated LANs with short Layer 2 addresses, i.e. 16-bit, could still be interconnected via the public network. However, a suitable address translation mechanism must be incorporated in the Network Layer to translate the locally assigned NTN (Layer 3 address) to an equivalent 16-bit host number in Layer 2. Further, as the 16-bit address is network-specific a new host number must be reassigned, under this scheme, each time a host moves from one LAN to another.

To avoid address translation, a globally unique or absolute address may be assigned to a host independent of the LAN to which it is connected. In this manner, the host will be portable, requiring no new host number as it is moved from network to network. This is the motivation behind the flat numbering concept, which results in a 48-bit address field. This scheme was originated by Xerox for unique host identification in its Network System (NS) architecture (Dalal, 1982). The NS architecture consists of an interconnected system of Ethernet LANs, capable of supporting point-to-point, multicast and broadcast communication. As the 48-bit host number is globally unique it can be used directly as part of the hierarchical internet address field in Layer 3. As host numbers in Layer 3 and Layer 2 use identical code, address translation therefore would not be necessary with this method.

From the viewpoint of the internetwork gateway architecture discussed in Section 4.1, the internet addressing function, address translation function and routing function are all part of the Network Sublayer (3c).

5.2 INTERNETWORK PROTOCOLS

The interworking of a Connectionless (CL) LAN with a Connection-oriented (CO) PSN can be supported by means of a CL or a CO internetwork protocol (Postel, 1980). These protocols are briefly reviewed below.

A **CL internet protocol** treats each packet transmitted by a user-process independently as a datagram. This occurs in sublayer (3c) of the Network Layer. In each network this internet datagram is, however, conveyed using network-specific protocols (see **Fig. 7**). The CL protocol provides no flow control, error handling, packet sequencing, etc. As no logical connection is required, neither the hosts nor the intermediate gateways need to record state information about the messages sent. Thus the CL internet protocol is relatively simple to implement.

Several basic characteristics of CL internet protocols are worth noting:

(a) As the services provided by these protocols are very basic, sublayer (3b) of the general gateway architecture (Figure 4) would be likely to be null in most cases (Lidinsky, 1982, Dalal, 1982).

(b) It requires no changes in the intranet protocols of the networks it interconnects, and it can be used irrespective of the type of service (CL or CO) provided by the individual networks.

(c) The sublayer (3c), also commonly known as an Internet Sublayer, performs mainly routing/relaying, and fragmentation/reassembly functions. Other functions such as congestion control, charging, etc., may also be included in this sublayer. This sublayer needs to be implemented both in the gateways and the terminals in different networks.

(d) Since it offers no flow control, error control and sequence control, etc., it is essential to support these CL internet protocols with a highly efficient Transport Layer, such as that specified by ECMA (Sideris, 1982).

As a result of its simplicity, the CL internetworking approach is most suited to the interconnection of a diverse range of different networks. It has been widely used in

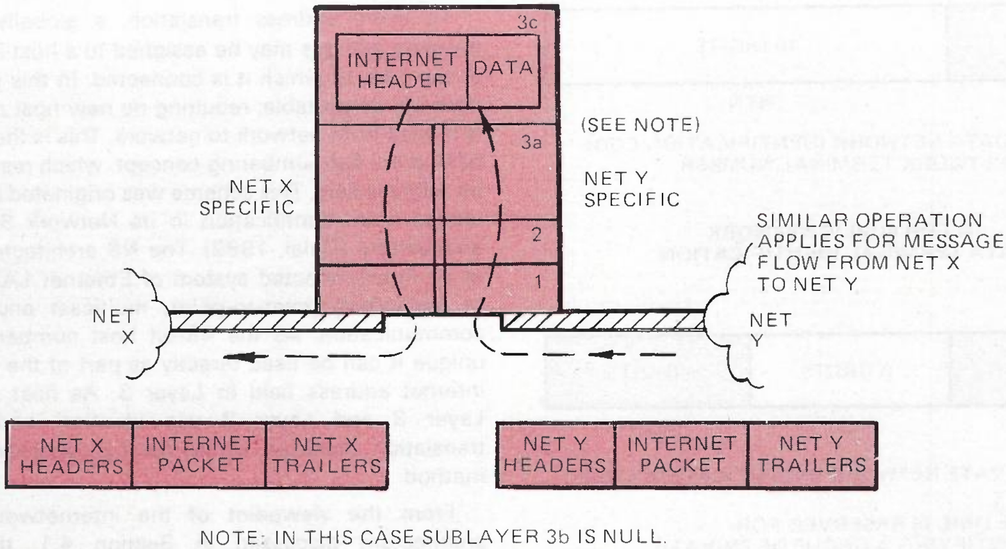


Fig. 7: Operation of Connectionless Internetworking.

the ARPANET experiments (Postel, 1980) in Xerox's internetwork architectures including the PUP (PARC UNIVERSAL PACKET) Protocol and the Network System architecture (Dalal, 1982). Both the PUP and NS architectures involve the interconnection of multiple Ethernet LANs. The US National Bureau of Standards' (NBS) Internet Protocol (Callon, 1981) is also based on the CL approach.

CO internet protocols are based on virtual circuit concepts. This means a series of concatenated intranetwork and internetwork virtual circuits must first be set up end-to-end between the corresponding end-user systems before user data may be transferred. This internet approach is therefore commonly used for interconnecting virtual-circuit packet networks, as exemplified by the X.25 based public PSNs. An example of a CO internet protocol standard is X.75, which has been defined specifically for public network interworking. Modification of the X.75 is necessary if its application is to be extended to private — public network interworking. However, such a proposal may not be readily acceptable to CCITT. An alternative is to utilise X.25, which specifies the interface between a host computer or DTE (Data Terminal Equipment) and a packet node or DCE (Data Circuit-terminating Equipment). However, X.25 may require enhancement with sublayers (3b) and/or (3c), in order to provide the necessary internetwork functions. This is further discussed below.

5.3 X.25-BASED GATEWAY

Proposals have also been made by various workers (Lidinsky, 1982, Symons et al., 1982, Elden, 1981) to use X.25 as an interim standard for interconnecting LANs to the public PSN. This necessitates the design of an X.25 host which appears as a LAN node but acts as a gateway to the PSN for the other LAN nodes.

From the PSNs viewpoint the X.25 host may be regarded as a standard X.25 DTE (Elden, 1981) or a gateway (Lidinsky, 1982, Symons et al., 1982). In the former case the X.25 host would have a single host number (i.e. NTN) and hence subaddressing is necessary in order to uniquely identify the LAN nodes connected with it. With the X.25 host treated as a gateway, the LAN would be assigned a PNIC number and its associated nodes with NTN numbers. In this context, based on the gateway architecture model in Section 4.1, the X.25 protocols need to be enhanced with sub-layers (3b) and/or (3c). In particular, the internet sub-layer (3c) may adopt either a CO or a CL internet protocol. Similarly, the LAN protocols also need to incorporate sublayer (3c) and an LAN-dependent sublayer (3b), as shown in **Fig. 8.**

Adopting the CL approach would require that a virtual circuit be set up for the transmission of the internet datagrams. This virtual circuit may be left open permanently or for a fixed period. Alternatively, a separate virtual circuit could, in principle, be opened with each internet datagram to be sent. However, this would seem to counteract the simplicity of the datagram approach and may cause degradation of performance of the PSN (Callon, 1981). Silimar to this approach an interim solution for the interconnection of remote LANs, with compatible upper layer protocols (including 3c), over an X.25 network is now commercially available (Benhamou and Estrin, 1983).

The advantages of the CL approach is the relative simplicity of the sublayer (3c) functions. However, the justification of opening a virtual circuit either permanently or for a long period to serve as a conceptual "pipe" to transfer datagram internet traffic is not immediately obvious. This may depend on the average internet packet size used, the amount of internet traffic generated by LAN hosts and most importantly, the tariff structure of the PSN.

The use of CO internet protocols in conjunction with the underlying X.25 protocols would appear logical since the internetwork virtual circuit will be supported directly by the X.25 packet level. The internet packets will also be able to make direct use of the flow control, packet sequence control facilities of the packet level. Protocol translation would be required, particularly if terminal to

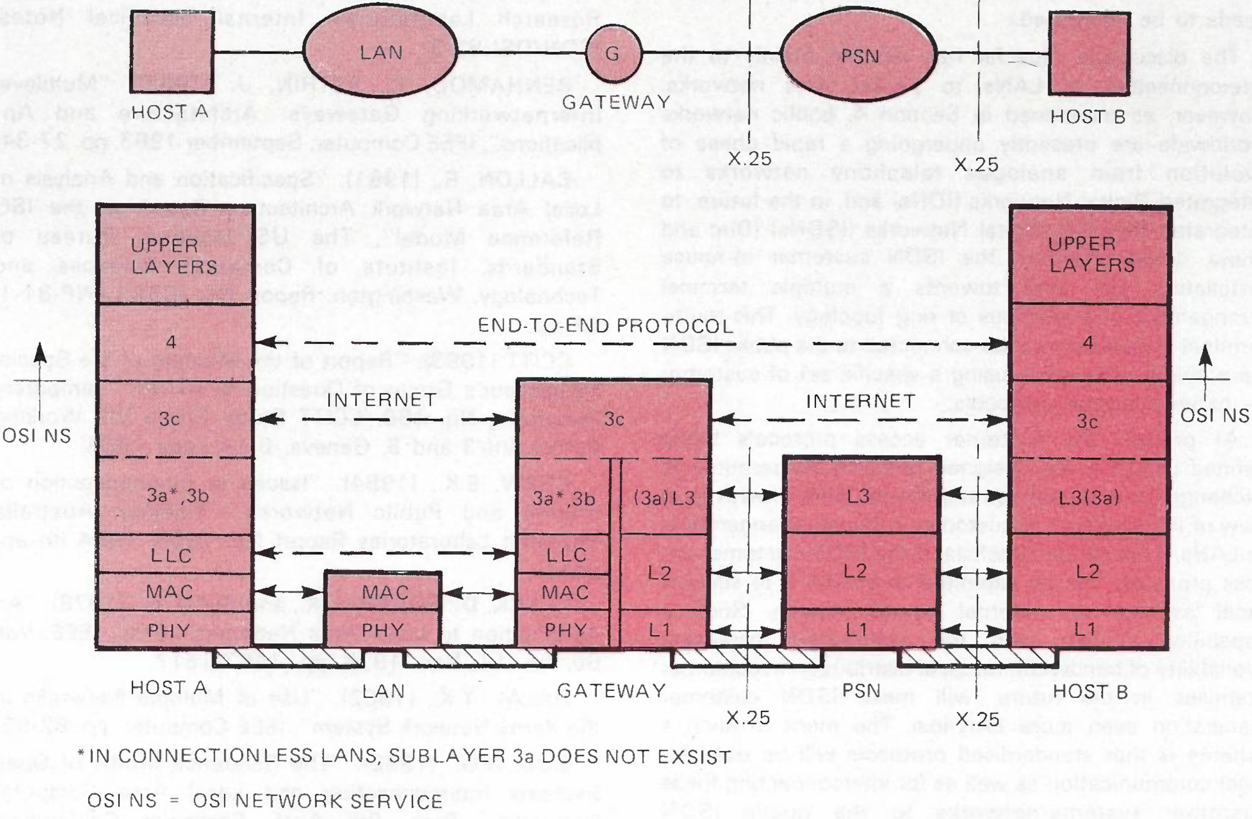


Fig. 8: X.25 Based Gateway for LAN-PSN Interconnection.

host communications across different networks are to be supported via the X.25 gateway. Further study of this approach must take into account the evolution of X.25 specifications towards providing the OSI Network Service Standard. More detailed technical discussion of the X.25-based gateway issues can be found in (Chew, 1984).

5.4 IMPACT OF TRANSMISSION RATE DIFFERENCES

Problems may arise when LANs attempt to inject more traffic to the PSN than can be handled satisfactorily, because of the marked difference in transmission speeds in LANs and the PSN. Firstly, there is the issue of flow control and congestion control whereby the LAN traffic must be restricted, as appropriate, by the PSN in order to protect itself from traffic congestion. Traffic congestion if uncontrolled can spread throughout the PSN thus affecting other users of the public network.

Flow control strategies at the gateway would differ depending on the internetworking approach used. In the case of the CO approach, variable window size control may be used. Flow control in the CL approach would be more primitive or non-existent. A common method is to discard internet packets if the gateway or the destination network is unable to receive them. In some applications (Dalal, 1982) the gateway may be able to inform the souce, via an error message, of the reason for discarding the packets. In general however, a stricter flow control as per the CO approach may be required on the LAN in order to more effectively prevent network congestion in the PSN and to avoid excessive loss of frames in the LAN due to gateway rejection. This implies that LANs would need to employ CO mode of operation internally so as to achieve successful internetworking (Lidinsky, 1982). Where the gateway performance is limited by the speed of the X.25 link, use of multiple links and its attendant technical issues need to be considered and analysed (Benhamou and Estrin, 1983).

6. FUTURE RESEARCH DIRECTION

An X.25-based gateway, which requires LANs to internally employ a Connection-oriented mode of operation is the preferred method for LAN — PSN interconnection. Further study on the specification of such a gateway is required and should include the following:

(a) Detailed specifications of the Connection-oriented OSI Network Service and the associated sublayer functions which permit LANs and PSN to be concatenated.

(b) A suitable modification of the X.121 international numbering scheme to support private networks interworking with public data networks. (See for example (Al-Tarafi and Chew, 1984) for the recent CCITT/ISO status on the study of this matter).

(c) Technical solutions to support terminal-to-host communications across the gateway.

Work is currently in progress within the ISO and CCITT to incorporate a **connectionless** Network Service specification to the OSI model. Possible impact of this work on LAN gateway architectures in general also needs to be addressed.

The discussion thus far has referred mainly to the interconnection of LANs to packet data networks. However, as mentioned in Section 4, public networks worldwide are presently undergoing a rapid phase of evolution from analogue telephony networks to Integrated Digital Networks (IDNs) and, in the future, to Integrated Services Digital Networks (ISDNs) (Duc and Chew, 1984). Further, the ISDN customer in-house installation will tend towards a multiple terminal arrangement in a star, bus or ring topology. This multi-terminal installation will be connected to the public ISDN via a single access link using a specific set of customer — network access protocols.

At present the customer access protocols being defined in CCITT are designed primarily for terminal to exchange (or external) communication only. However, in view of the similarity of customer in-house arrangements to LANs, it would be beneficial if the ISDN customer access protocols can be exploited to enable it to support **local** as well as external communication. Such a capability coupled with the anticipated increasing availability of bandwidth for local distribution in customer premises in the future, will make ISDN customer installation even more LAN-like. The merit of such a scheme is that standardised protocols will be used for local communication as well as for interconnecting these customer systems/networks to the public ISDN (Blackwell and Chew, 1983).

Another issue also currently being considered in CCITT relates to the support of commercial LANs in the ISDN customer installation. In particular, solutions are being sought as to how ISDN customer access interfaces may be used with these LANs. With this approach the LAN — ISDN gateway protocols would then be entirely based on the standardised customer access protocols.

7. CONCLUSIONS

Protocol compatibility up to the OSI Network Layer is a major issue for the interworking of LANs and public packet switched data networks. To this end, the ISO-proposed internetwork gateway architecture can be used to define a suitable connection-oriented X.25-based gateway to interlink these networks. However, more work is required before the detailed gateway protocols can be fully specified.

Extension of the CCITT X.121 numbering plan to accommodate private network requirements is also needed in order to facilitate LAN-public network interworking. This is being formulated in the CCITT and ISO, and standards are expected to become available by the end of 1984.

As public networks are evolving towards ISDN, issues related to the interconnection of LANs to ISDN also need to be carefully investigated in the future.

8. REFERENCES

AL-TARAFI, A.H., CHEW, E.K., (1984): "Issues and Implications of Naming and Addressing in a Multiservice Environment", Telecom Australia Research Laboratories Report No. 7706, 1984 (to appear).

BLACKWELL, D.M., CHEW, E.K., (1983): "Local Communications over the D-channel", Telecom Australia Research Laboratories, Internal Technical Notes, ISDN/OSI-83-3.

BENHAMOU, E., ESTRIN, J. (1983): "Multilevel Internetworking Gateways: Architecture and Applications", IEEE Computer, September 1983, pp. 27-34.

CALLON, R., (1981): "Specification and Analysis of Local Area Network Architecture Based on the ISO Reference Model", The US National Bureau of Standards, Institute of Computer Sciences and Technology, Washington, Report No. ICST/LANP-81-1, 41 pp.

CCITT (1983): "Report of the Meeting of the Special Rapporteur's Group of Question 4, 41/VII", Temporary Document No. 186, CCITT Study Group VII, Working Parties VII/3 and 5, Geneva, 6-14 June 1983.

CHEW, E.K., (1984): "Issues in Interconnection of Private and Public Networks", Telecom Australia Research Laboratories Report No. 7603, 1984 (to appear).

CLARK, D., POGRAM, K., and REED, D., (1978): "An Introduction to Local Area Networks", Proc. IEEE, Vol. 66, No. 11, Nov. 1978, pp. 1497-1517.

DALAL, Y.K., (1982): "Use of Multiple Networks in the Xerox Network System", IEEE Computer, pp. 82-92.

DUC, N.Q., (1982): "The Reference Model of Open Systems Interconnection and Local Area Computer Networks", Proc. 9th Aust. Computer Conference, Hobart, pp. 321-338.

DUC, N.Q., CHEW, E.K., (1984): "Evolution Towards Integrated Services Digital Networks", TJA, Vol. 34, No. 2, pp 137 - 144.

ELDEN, W.L., (1981): "Gateways for Interconnecting Local Area and Long Haul Networks", Local Networks and Distributed Office Systems-Online, London, pp. 391-406.

ISO/TC97/SC6, (1982): "Internal Organisation of the Network Layer", ISO/TC97/SC6 N2613.

ISO/TC97/SC 16, (1982): International Standard No. 7498, "Data Processing-Open Systems Interconnection-Basic Referrence Model", An earlier version also has appeared in Computer Networks Vol. 5, 1981, pp. 81-118.

LIDINSKY, W.P., (1982): "LANs Interworking and Public Networks", Symposium on Local Area Networks, James Conran Pty. Ltd., Sydney, Australia.

MYERS, W., (1982): "Toward a Local Network Standard", IEEE Micro, pp. 28-45.

POSTEL, J.B., (1980): "Internetworking Protocol Approaches", IEEE Transactions on Communications, Vol. Com-28, No. 4, pp. 604-611.

SIDERIS, G., (1982): "World Nears Local-net Standard", Electronics, pp. 79-80.

SYMONS, F.J.W., ELLERSHAW, J.C., PARK, J.L., (1982): "Experiments at the Telecom Research Laboratories in the Interworking of Local Area Networks with Public Data Networks", Symposium on Local Area Networks, James Conran Pty. Ltd., Sydney, Australia.

TANENBAUM, A.S., (1981): "Computer Networks", Prentice-Hall, Englewood Cliffs, N.J.

APPENDIX A: A SUMMARY OF IEEE 802 LAN PROTOCOL LAYERS

Logical Link Control (LLC) Layer

This layer supports two types of link operations; Connectionless and Connection-oriented.

In Connectionless operation, frames are exchanged without the need for establishing a logical connection. The frame exists as a "datagram" consisting of, basically, the message itself plus the **full addresses** of the originating and the destination nodes. In this mode, frames are not acknowledged, nor are there any flow control or error recovery procedures.

In Connection-oriented operation, a logical or virtual circuit connection (or Data Link Layer connection in OSI concepts) must be first established before frames may be exchanged. In the data transfer phase of the operation, frames are delivered in sequence. Flow control and error recovery procedures are also provided.

As discussed earlier, the Connectionless approach is simpler but requires greater protocol overheads. However, by exploiting the high performance of the LAN hardware technology it can be made attractive. Consequently, this mode of operation is a basic feature of most commercially available LANs.

Media Access Control (MAC) Layer

To meet the variety of application requirements for LANs, IEEE 802 has specified two access methods for the MAC Layer:

— CSMA/CD (Carrier Sense Multiple Access-with Collision detection);
— Token passing.

CSMA/CD is a probabilistic technique for accessing the transmission medium while the token passing is deterministic (see Myers, 1982 and Duc, 1982 for details). The MAC protocols relate closely to the network topologies of LANs. While both CSMA/CD and token passing can be used on a bus structure, only token passing is applicable to a ring structure. In fact, the relationship of the nodes in a token-passing bus LAN is logically a ring structure.

Architecturally, the MAC layer performs some of Data Link and Physical Layer functions of the OSI Reference Model.

Physical Layer

As in the OSI Reference Model, the Physical Layer provides the means for transmitting and receiving raw data bits. These functions are media independent. In practice, LAN specifications must also include an additional interface sublayer, commonly known as a media access unit, which bridges the Physical Layer to the transmission media. The sublayer is media- and modulation-dependent and provides the appropriate electrical and mechanical characteristics to interface the user end-system to the transmission media.

Information Transfer News Item

Churchill Fellowships Offered

Each year, the Winston Churchill Memorial Trust offers opportunities, by the provision of financial support, to enable Australians from all walks of life to undertake overseas study, or an investigative project, of a kind that is not fully available in Australia. This opportunity is provided in furtherance of Sir Winston Churchill's maxim that: "with opportunity comes responsibility."

There are no prescribed qualifications, academic or otherwise, for the award of a Churchill Fellowship. Merit is the primary test, whether based on past achievement or demonstrated ability for future achievement in all walks of life.

The value of an applicant's work to the community and the extent to which it will be enhanced by the applicant's overseas study project are important criteria taken into account in selecting Churchill Fellows.

The Fellows come from all walks of life — archaelogy, medicine, blacksmithing, agriculture in all its forms, every branch of science, the performing arts — no field of endeavour, no matter how unusual, is excluded. About 50 Australians are selected each year.

Successful applicants normally go overseas for about ten weeks and visit about two to four countries in pursuit of their studies. The Trust pays their air fares and a living allowance while overseas, as well as tuition fees and a family allowance if this can be shown to be necessary.

If you feel that you could bring back to Australia knowlege and skills which you cannot obtain here, why not ask for further information by writing to the address shown in the accompanying advertisement. Or perhaps you have a friend or associate whom you think could qualify?

It could give you the opportunity of a lifetime!

1986 Churchill Fellowships for overseas study

The Churchill Trust invites applications from Australians, of 18 years and over from all walks of life who wish to be considered for a Churchill Fellowship to undertake, during 1986, an overseas study project that will enhance their usefulness to the Australian community.

No prescribed qualifications are required, merit being the primary test whether based on past achievements or demonstrated ability for future achievement.

Fellowships are awarded annually to those who have already established themselves in their calling. They are not awarded to students or for basic study, nor for the purpose of obtaining higher academic or formal qualifications. Details may be obtained by writing to:

The Winston Churchill Memorial Trust (2)
GPO Box 478
CANBERRA CITY ACT 2601

Completed application forms and reports from three referees must be submitted by Thursday 28 February 1985.

TACONET: Telecom Australia's Computer Network

PETER FLANAGAN

Telecom Australia's computer network, TACONET, is facing a number of challenges due to the need for the network to enable connection to Honeywell largescale mainframes and minicomputers, its rapid growth and newly introduced IBMC (FACOM) facilities. A Network Plan has been prepared, focussing upon the issues and defining projects required for achievement of an integrated network.

Major activities include connection of low speed lines and connection to both FACOM and Honeywell host computers. A brief history of the network as well as its future development are included.

A SHORT HISTORY

Early Beginnings with the PMG

Telecom was still a part of the Postmaster General's Department when its first computer was installed in 1963. The Control Data 160A was only the second CDC computer installed in Australia. It has such technical features as paper tape input and output, with a magnetic tape drive and 150 line per minute printer added later. It used a 12 bit word length with a memory cycle time at 6.4 usec. By today's standards, it was about as powerful as a desk top microcomputer, but about 100 times as expensive. It was used in the Research Laboratories to:

- Provide general purpose computer services to small scale engineering and scientific studies.
- Test algorithms to be used on larger computers.
- Control hardware used in experiments.

The machine and its operators have been quite resilient. The 160A is still in use, currently at the RAAF base, Laverton, training apprentices in computer techniques.

CDC 160A

In 1965, the first non-scientific computer was purchased. This machine, a Honeywell 1800, was devoted to the then important business tasks of the PMG: revenue collection and stock control. These were seen to be most efficiently processed in a batch fashion, given relative costs and the available technology.

Large data files were held on magnetic tapes and were regularly updated from transactions which were also prepared on tape, both magnetic and paper. This was the best method that the technology of that time could support. Efficiencies arose from the centralised Data Transcription Units (DTUs) where Data Processing Operators, *en masse*, keyed data from source documents on to the minicomputer that would ultimately prepare the computer tape.

It was a time when computers were expensive and labour costs relatively cheap. Data communications protocols were primitive and terminals expensive. For the tasks that the H1800 and the later H8200s could not perform, Computer Bureaux were sought. These were selected for their ability to support individual projects, however small those projects might be. At any one time, the PMG would have contracts with about a dozen companies.

H8200

Even with all of the facilities available to us, very little of the work had any networking component. Most of the jobs were run from card decks carried by hand (courier) from PMG premises to the appropriate computer centre.

Eventually, experience with bureaux such as CDA, CSA, CAS and IBM showed that there was more that the Information Systems Department could offer.

More projects were being assessed as suitable for automated processing techniques and, as the price of processing fell, more potential applications could justify the investment. In 1972, the PMG decided that it would be a suitable time to seek new computer equipment that would support timeshare access, as well as the traditional batch processing. Tenders were called in 1973 to supply such a capability.

INTRODUCTION OF ON-LINE TERMINALS

The successful tenderer was Honeywell, but their new computers were not compatible with the earlier H1800/H8200s which were still in use. This event bears some comment because it is not a typical instance in the computer industry. In the early 1970s, the computer divisions of both RCA and General Electric (GE) were forced out of business, largely due to the release of the IBM 360. GE sold out to Honeywell who then decided to replace their own 8200 series with the GE 6000 series. In 1975 a H66/80 was installed in the Clayton computer centre in Melbourne with a H66/60 installed in Sydney in 1977.

The PMG, now Telecom, by that time, had the ability to configure timeshare terminals using a simple teletype protocol. Moreover, Honeywell provided new Video Display Terminals (VDTs) which used a bi-synchronous protocol, sending blocks of data at a time, rather than individual characters. Batch terminals were also available. These could be used to transmit DTU tapes instead of transporting them. Substantial savings were made by having telephone bills out sooner, and by having more up-to-date information on which to make operational decisions.

Other users found that they could achieve economies by obtaining minicomputers that could interface to quite diverse computer networks as batch devices. Access to Telecom's internal network, as well as external bureaux could now be integrated and the service levels and price of each could also be compared. Telecom's internal network was christened — TACONET (being an acronym for Telecom Australia COmputer NETwork).

TACONET started small; by 1976, it supported about 100 user terminals and 300 VDTs in the DTUs spread across Australia. Most of the DTU output reached TACONET via the Honeywell 700 series batch devices (also known as Level 3s in TACONET parlance). The Level 3s are high performance network nodes allowing the printing of batch jobs, file transfers, terminal concentration, along with some local processing capability. The last two facilities are not used by Telecom due to capacity constraints on the Level 3s.

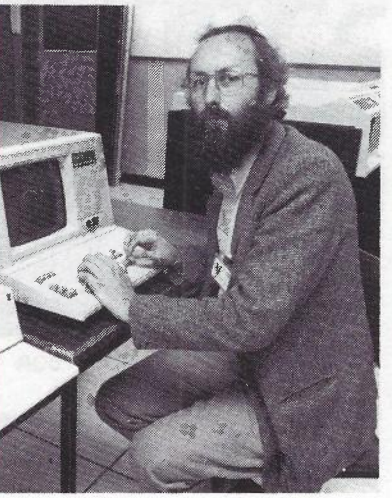
DPS 8

FURTHER INTERWORKING REQUIREMENTS

The network grew. The first on-line system, Staff Pay, went national to be followed, in 1978, by the first LEOPARD District. The LEOPARD system is related to the holding of customers' service records, fault reporting and restitution. The average network growth of 50% per annum was exceeded in each of the first 3 years (1975-

PETER FLANAGAN joined the Australian Post Office as a Cadet Computer Systems Officer in 1975 after graduating as a Bachelor of Science from Melbourne University. Later that year, he returned to the Information Systems Department. In addition to the BSc, he then held a Graduate Diploma in Data processing from Caulfield Institute of Technology.

He spent four years in the provisioning of computer terminals and negotiation of computer service contracts. In this period, he completed his Graduate Diploma in Business (Administration) at Swinburne College of Technology. Transferring to a newly created position of Manager — Network Planning in 1982, he worked with other officers on the Network Plan. He is now in the Systems Planning Branch of the Information Systems Department, Headquarters where he is responsible for strategic planning activities associated with end user and main processing facilities of Telecom's internal computer network, TACONET.



1978). The major limitations to an even higher growth were shortages of three important items. These were:

- Capital to invest in additional projects;
- Trained staff to evaluate opportunities and develop new projects;
- Trained support staff to make this high rate of network growth viable.

From these small beginnings TACONET now supports about 3500 terminal devices and 750 DTU workstations. As the network grew, more powerful processors were installed. It was evident that a major constraint was the number of terminals that could be configured onto one computer system. Much effort has been expended in trying to avoid the problems of applications spread over more than one machine, and users requiring multiple terminals to access the multiple networks.

In addition to the 4 Honeywell networks (two based on North Sydney and two based on Clayton), there are other users requiring to access data or applications on different hosts. These users include those with Wang Wordprocessing systems, those connected to the new FACOM computer (IBM compatible) and the Service Orders project, using Honeywell DPS 6 minicomputers.

To achieve these fine ambitions of:

- A high level of interworking allowing any legitimate user to access any computer system;
- Greater productivity from support staff and better availability, reliability and performance from the network

a number of projects have been developed as components of an overall Network Plan for TACONET. This Network Plan will now be explained in detail.

PREPARATION OF THE PLAN

All major projects requiring development or support on TACONET in the next three year period were surveyed. The source of this information was based on documentation supplied to the Information Management Group (a high level corporate strategy committee). The survey was conducted during May/June 1983 and covered the three year period of the Plan to end 1986. It involved the use of both questionnaires and personal interviews. Information was sought from the following:

- HQ Project Managers within the Systems Development Branch of the Information Systems Department.
- Project Managers in State Information Systems Branches.
- User Services Groups in both HQ and State Administrations.
- HQ Departmental Computer Co-ordinators.
- Operations Sections at the Computer Centres.

In addition, the 1983/1984 Capital Works Programme was examined to confirm and clarify information for these sources.

Comparisons of past predictions with actual growth were also undertaken. A period of rapid growth was evident. It was the beginning of a new era in user awareness and expectation as major new projects were developed and introduced.

The Network Plan has a number of objectives:

- To develop a communications network for TACONET

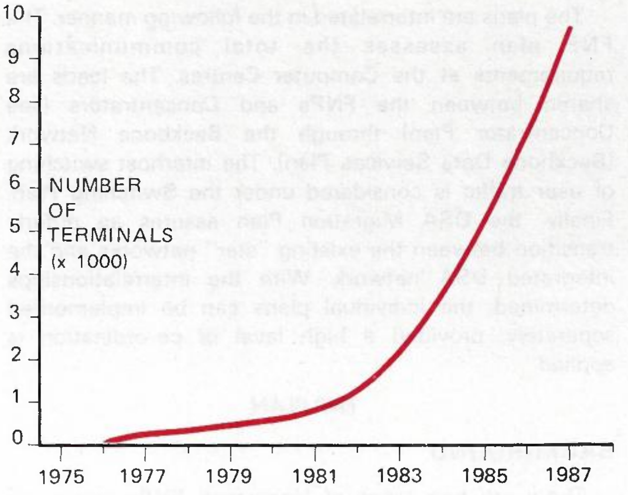


Fig. 1 illustrates this rapid growth.

based on Honeywell's Distributed Systems Architecture (DSA);

- The introduction of Honeywell DPS 6 minicomputers as Level 3 network nodes;
- The introduction of concentration for interactive terminals using Honeywell Datanet 8 communications processors installed in capital cities;
- The gradual migration from the older style Datanet 6661/6678 Front end Network Processors (FNPs) to Datanet 8s as the DSA (DNS) software permits;
- The introduction of high speed DDS services for the Backbone network;
- The use of AUSTPAC for dial-up access to TACONET mainframes.

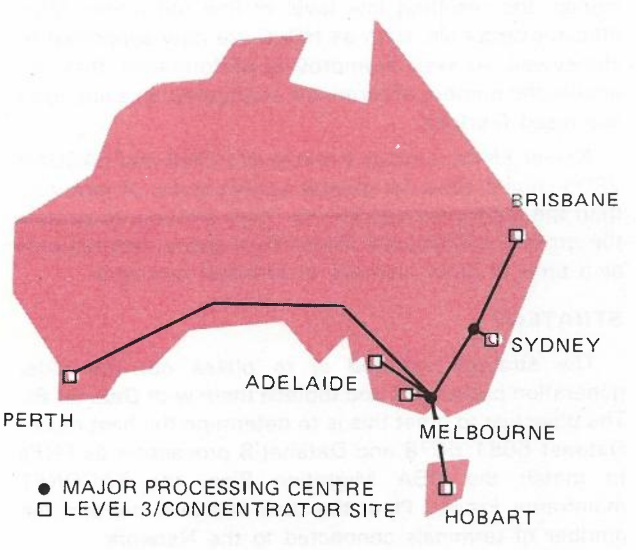


Fig. 2. Schematic Diagram of TACONET.

The Network Plan consists of six sub-plans.

- Front end Network Processor (FNP Plan);
- Concentrator Plan;
- Level 3 Plan;
- Backbone Data Services Plan;
- Switching Plan;
- DSA Migration Plan.

The plans are interrelated in the following manner. The FNP plan assesses the total communications requirements at the Computer Centres. The loads are shared between the FNPs and Concentrators (see Concentrator Plan) through the Backbone Network (Backbone Data Services Plan). The interhost switching of user traffic is considered under the Switching Plan. Finally, the DSA Migration Plan assures an orderly transition between the existing "star" networks and the integrated DSA network. With the interrelationships determined, the individual plans can be implemented separately, provided a high level of co-ordination is applied.

FNP PLAN

BACKGROUND

There are two types of Honeywell FNPs in use on TACONET:

- The current generation Datanet 6661/6678s running NPS software for interactive traffic and GRTS II software for batch traffic;
- DSA Datanet 8 running DNS software.

With 50% per annum growth of TACONET terminal numbers predicted to continue for at least the next three years, the requirement to configure more lines into the computer centres will also increase. Currently, on the average, about 4 VDUs are configured on to each 4800 bps synchronous leased line. Some isolated locations would have only 2 or 3 terminals on a line. Some larger projects have more than 4 terminals per line, depending on the load generated by each terminal and the agreed response time for that project. The current target is 6 to 8 terminals per 4800 bits/sec synchronous leased line.

It is a function of the communications protocol that causes the resulting low level of line utilisation. More efficient protocols, such as HDLC are now supported by Honeywell. As well as improving performance, they will enable the number of terminals configured on a line to be increased fourfold.

Newer FNPs, such as Honeywell's DN8 and FACOMs 2806 should allow far greater connectibility of terminals than the old Honeywell 66XXs. They will help to contain the growth in Computer Room floor space requirements at a time of rapid increase in terminal numbers.

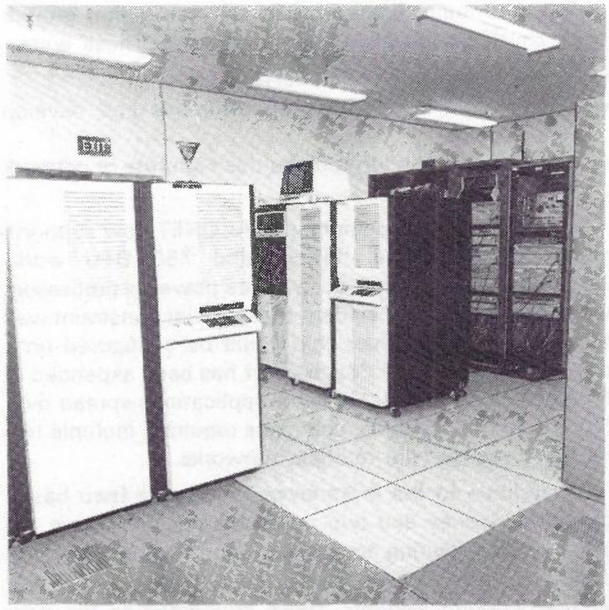
STRATEGY

The strategy adopted is to phase out the older generation processors and replace them with Datanet 8s. The objective to meet this is to determine the best mix of Datanet 6661/6678 and Datanet 8 processors as FNPs to match the DSA Migration Plan, the TACONET mainframe Facility Plan, the user terminal mix and the number of terminals connected to the Network.

CONCENTRATION PLAN

The use of Datanet 8s as concentrators will, by putting the communications processing closer to the users, reduce the traffic on the Backbone Network and reduce long haul line costs. Between June 1983 and June 1986, the numbers of FNPs (plus concentrators) will increase by 40%. In this same period, terminal numbers will increase by 200%.

Concentrator sites are planned for Brisbane, Adelaide,



Datanet 8 6661s and Monitoring Equipment.

Perth and Hobart. Each Datanet 8 can be configured to concentrate up to 80 low speed user lines. Each concentrator site will commence operation with two Datanet 8s, with more to be added as the load increases.

LINKS

Initially, each of the Datanet 8 Concentrators will be connected to the TACONET hosts by a single 48 Kbit/s Datel link with a shared backup link at the site. When growth justifies the expenditure, a second Datel link will be added to each concentrator whilst retaining the shared backup line. When DDS becomes available, the two links to each concentrator and the single backup line will be converted. The backup line will be used to support all concentrator and Level 3 links to that particular host. If the Backbone Data Services Plan determines a requirement for fixed connection (as opposed to logical connection) to multiple hosts, then multiple backup lines will be required.

A link failure would only give a marginal decrease in performance on a heavily loaded Datanet 8. The use of Intelligent Matrix Switches (IMS) will allow rapid reconfiguration in the event of a complete Datanet failure. As no single Datanets will be installed on any site, each could be used to backup the other. It is perceived that this arrangement will provide an improvement in the availability of systems to their users.

The connection to additional hosts would initially be provided via the primary links between the hosts. The reason for this arrangement is that, initially, the network should be kept simple and its operational characteristics carefully observed. When experience is gained in network control, direct links to other hosts can be provided. This will improve response time and provide alternative paths during periods of congestion.

OPERATION

It is envisaged that the Concentrator will normally be unattended except for powering the device on and off, which will require manual intervention. The Central Site will have facilities to perform the software boot-up and configuration changes of remotely located concentrators. Statistics of the daily operation will be collected in a log file at a designated host computer. If located near a Level 3 Centre, some assistance will be available to the central site staff should human intervention be required.

BACKUP

As previously discussed, the use of duplicate lines and Datanets will provide backup against processor and line failure. The normal service procedure triggered by TACONET network control staff will resolve interruptions. The nature and duration of such interruptions is expected to be similar to that experienced with Central Site FNP outages. A significant improvement is expected in the trunk and DPC components of line failures. The use of DDS for the primary links will yield automatic long haul line backup as an added bonus.

LEVEL 3 PLAN

The first step already undertaken, has been to upgrade existing Honeywell 716 equipment to provide a HDLC communications protocol. The result of this has been a 50% increase in throughput and, consequently, an increase in Level 3 capacity.

Some of the H716 equipment was installed in 1975. These minicomputers are now at the end of their economic life, and at capacity. They are being replaced during 1984 by Honeywell DPS6s. These have additional features currently under evaluation including:

- IBMC Interworking (as a SNA terminal cluster controller, remote batch facility and file transfer device).
- Access to Honeywell hosts as a DSA node.

BACKBONE DATA SERVICES PLAN

This plan is designed to reduce the costs and improve the reliability of TACONET's communications lines. Deficiencies in the existing network were considered in conjunction with future project requirements.

CURRENT SITUATION

The two major Data Processing Centres (DPCs) currently serve a large number of low speed lines. Although most have a reasonable number of terminals and/or are multipoint services, a significant part of the intercapital component is duplicated by other lines. This represents a low level of line utilisation.

This situation is having an impact on exchange and line capacity. There are additional costs in providing engineering services, FNP ports and long haul channel capacity. Management of the network is also becoming increasingly more difficult.

THE PROPOSAL

A reduction in the large number of long haul low speed lines is to be achieved by the use of regional concentrators. The use of high speed Digital Data Services (DDS) facilities will improve the overall system performance.

"Bursty" error on 48 Kbit/s Datel lines can give rise to mysterious equipment failures that cannot always be attributed to the true source. In addition, major outages can give rise to downtime extending over half a working shift. That DDS bearers are automatically backed up will yield increased uptime for the Concentrators.

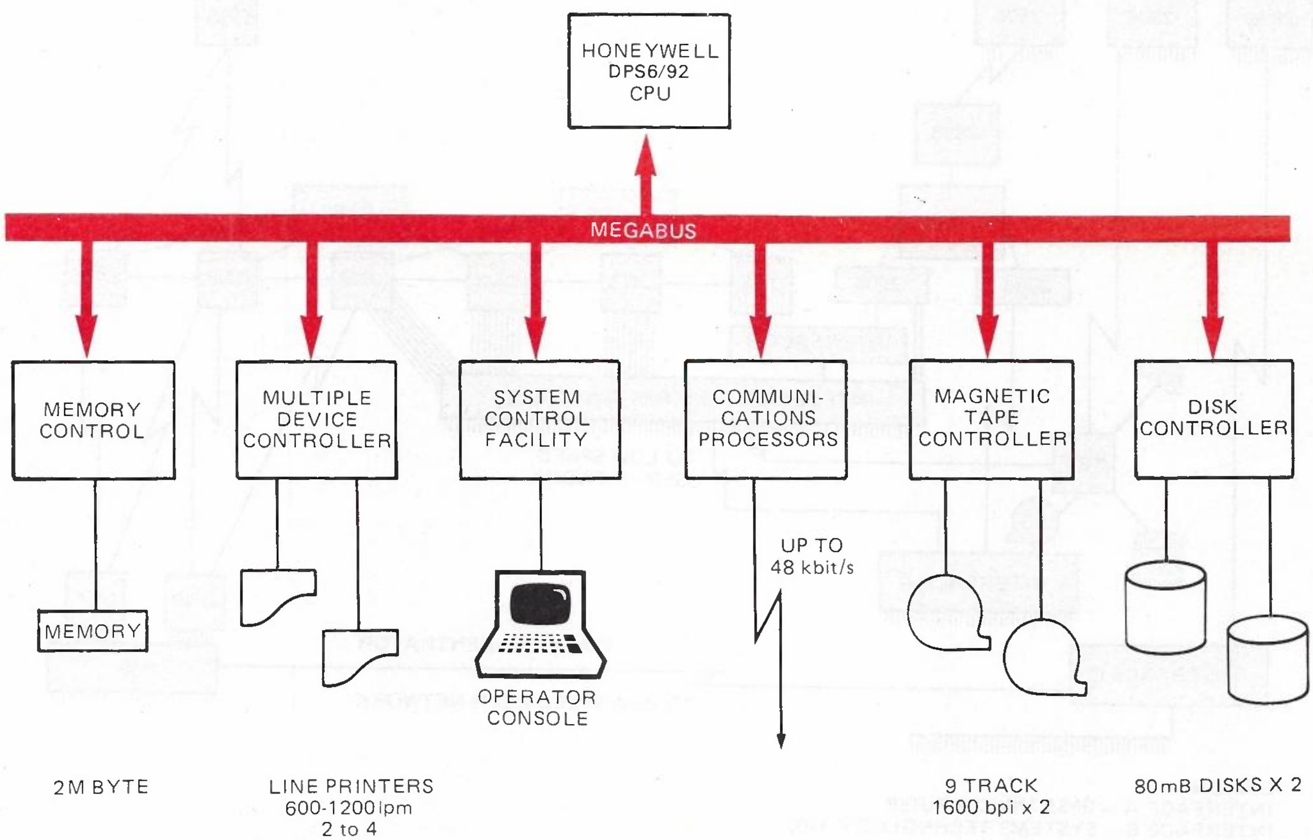


Fig. 3 shows a typical Level 3 configuration.

Furthermore, DDS will have a lower bit error rate as well as a higher Mean Time Between Failure (MTBF).

Initially, by local Telecom arrangement, DDS will be only used by TACONET for the Concentrator-Host links. The local user-to-concentrator line will remain Datel until DDS has an extensive multipoint facility.

SWITCHING PLAN

This plan seeks to develop a network which will provide the flexibility to allow an authorised user to access multiple applications, available on different hosts. This will be achieved without the cost and inconvenience of separate terminals or separate lines.

Some switching capability is currently available through use of the Alternate Host Facility available under NPS. This can only be provided to a limited number of terminals with a somewhat restricted functionality — it is limited to hosts resident at the same site. Use of this facility reduces FNP capacity significantly.

Under the proposed DSA network, there are two alternative methods of providing this flexibility without major loss of capacity:

- **DSA/DDS**

The regional concentrators would eventually be connected via dedicated DDS lines to DN8 FNPs. Datel lines would be used at first. Terminals would be connected to either Concentrators or directly to FNPs by low speed lines. Switching would be provided by one or more of the following:

- The concentrators, where there are multiple data lines connecting terminals to FNPs;
- The FNPs, either by multiple host connections or by switching traffic via communication lines to other FNPs;
- The insertion of dedicated switching DN8s into the network.

The DSA/DDS solution, in effect, provides TACONET with its own dedicated packet switched network capability. This may be interworked with AUSTPAC.

- **DSA/AUSTPAC**

In this method, Telecom's public packet switched network, AUSTPAC, provides the connection between the concentrators and the FNPs. All user terminals would need to be connected to DSA nodes, ie., concentrators, to be able to connect to AUSTPAC. This use of AUSTPAC would not be exclusive. Both level 3-to-host and host-to-host traffic would have to be handled by dedicated DDS links. This is because their line utilisation would be too high to warrant AUSTPAC.

DSA MIGRATION PLAN

The objective of this plan is to migrate terminals to a DSA network as quickly as resources will permit. This

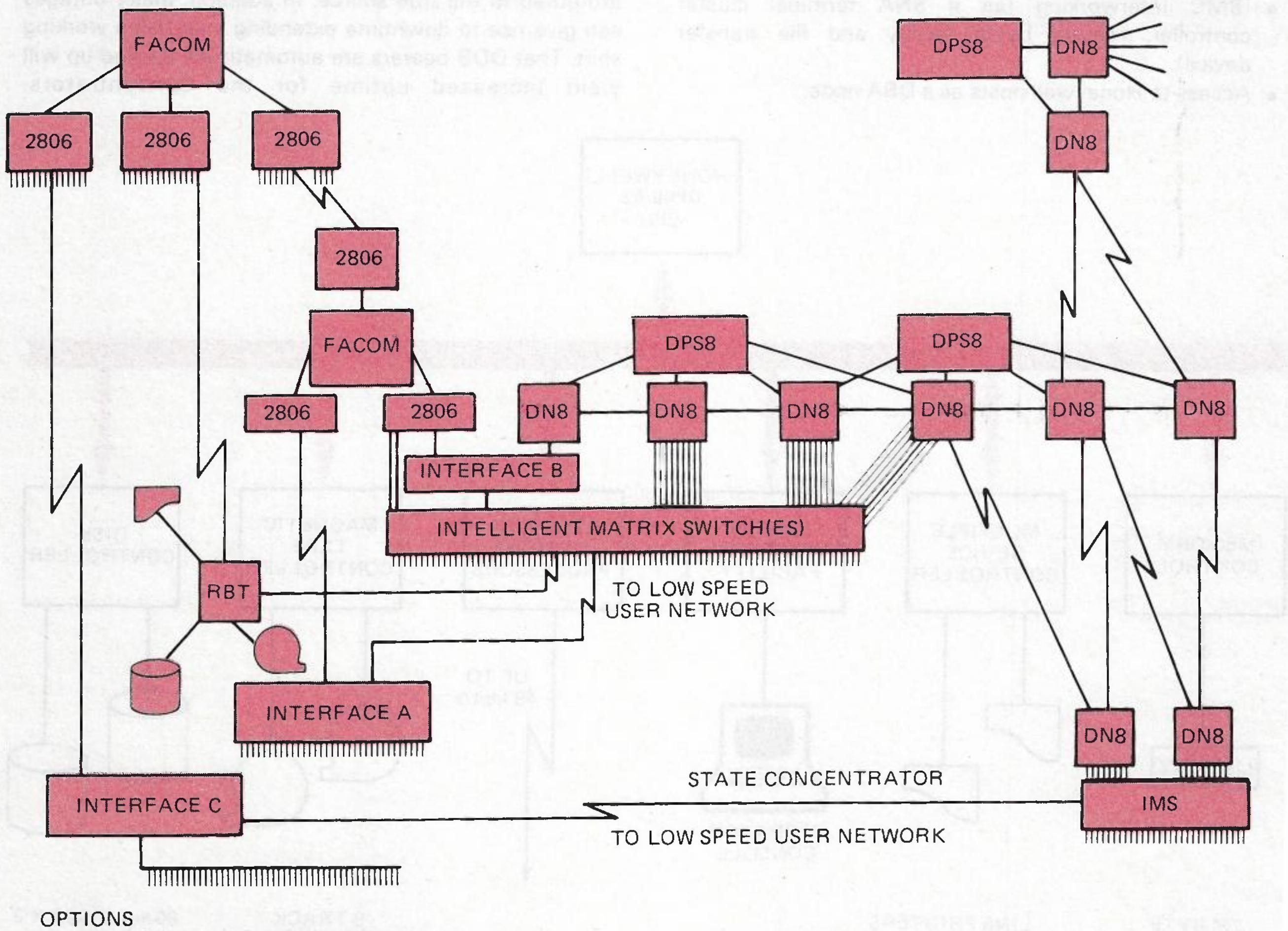


Fig. 4 then outlines the form of the network proposed.

will be a difficult task as the new Honeywell DNS software is quite different to that currently in use.

Implementation of a DSA network requires, amongst other things, the introduction of Datanet 8s as FNPs to the TACONET (Honeywell) mainframes. This can only be achieved as fast as the evolution of both DNS (the Datanet 8 operating software) and Telecom's application software permit.

The first version of DNS tested showed incompatibilities with some of the timeshare terminals used on TACONET. A number of activities have been undertaken to make the terminals and communications software more compatible with each other. This is leading to a staged introduction of DSA that should be completed in mid-1985.

A number of new features of DSA will be used immediately. One, already in use, is the ability to access more than one Honeywell host from the one user terminal. The demand for such access is high, but its availability is restricted by the small amounts of DN8 installed capacity. This facility will reduce the duplication of terminals and lines and its use will be independent of the Switching Plan.

NETWORK MANAGEMENT AND CONTROL

The form and mode of operation of Network Management and Control are being formulated. Issues which will be considered are:

- The form of the Network Management and Control function;
- The area of responsibility for this controlling function;
- The roles of DPCs, the ISBs and HQ Networking Group in the Network Management function;
- Data requirement from the network for effective management;

TABLE 1

A SUMMARY OF MAJOR COMPONENTS OF THE NETWORK

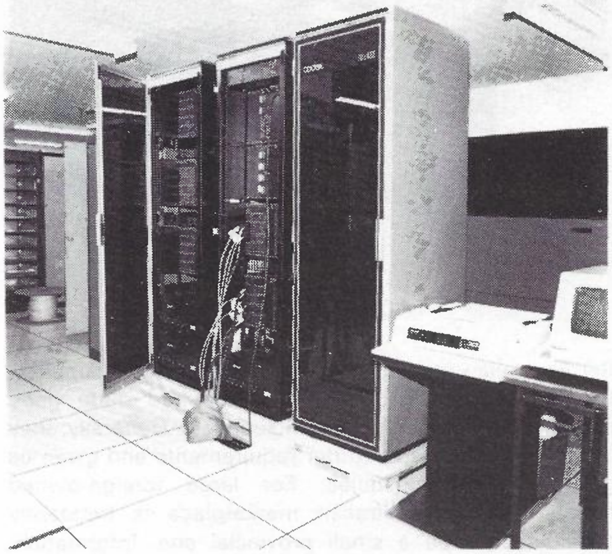
as at 30 June

	1983	1984	1985	1986
Operational FNPs				
66XX	26	21	16	0
DN8	1	8	20	26
Concentrator Remote DN8	0	0	7	12
Level 3				
H716	8	7	0	0
DPS 6	1	3	6	6
Primary Links (Intersystem, Level 3 and Concentrator)				
48 Kbit/s	7	18	25	37
9.6 Kbit/s	3	6	7	6
Secondary Links (note that, by second quarter 1986, no secondary links will be interstate)				
4.8 Kbit/s/9.6 Kbit/s	425	652	963	1,238

- Tools requirement for the analysis of this data;
- Facilities to monitor performance of the network, including the detection of network faults.

Some work has already been undertaken in this area.

A more responsive service, at lower cost, will be available to the users of TACONET. Major network components will be automatically backed up with faults identified by instrument rather than having to wait for someone to phone in.



IMS

IBMC INTERWORKING

The integration of the networks connected to the IBMC and Honeywell hosts will be a long term goal. Currently, there is no readily accepted, cheap, flexible and reliable method of allowing VIP7750 terminals access to an IBMC network, nor 3270 BSC and SNA devices access to a Honeywell network. A number of trials have been proposed to evaluate different techniques.

A trial, using a DPS6, is being undertaken at present to test the facility of interconnection of a SNA (FNA)/Honeywell network. The DPS6 facility is claimed to offer terminal concentration, remote batch and file transfer facilities. This is shown on Figure 4 as Interface A.

Another trial underway uses a protocol converter that converts asychronous terminals into SNA protocol. A decision will be made soon as to whether it would be worthwhile to provide a system whereby Honeywell VIPs can be made to emulate IBM 3278 terminals with SNA communications. This facility is represented as Interface B.

NEW TERMINALS FOR TACONET

Significant advances have been made in the ergonomics of Video Display Terminals in the last few years. Better phosphors for the display, matte screens with tilt facilities and separate, movable, low profile keyboards have all made terminal use easier on the eyes as well as the hands.

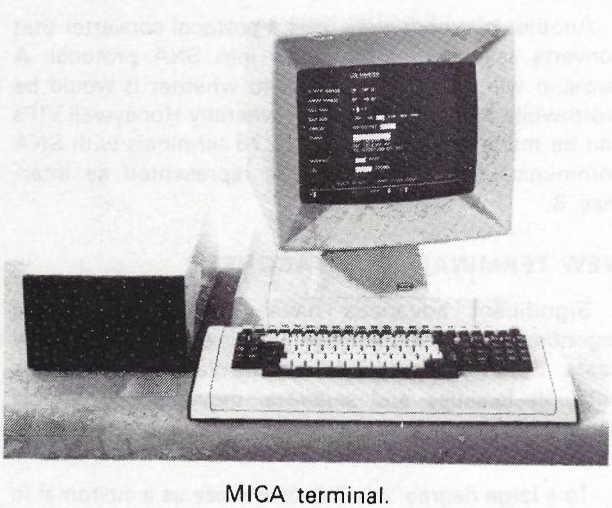
To a large degree, it is Telecom's size as a customer in

FACOM M180N

the Australian marketplace that has caused its suppliers to improve their product. We have had quite good experience with our Australian suppliers. Generally, they have been responsive to our requirements and given us good delivery schedules. For large foreign-owned companies, the Australian marketplace is frequently considered to be a small provincial one. Information, products and assistance are slow in coming. No matter how concerned the Australian staff are, they are restricted by their parent companies' policies.

Over the next year, the widespread introduction of a new terminal facility will commence. The MICA V200 series provides local microcomputer facilities and, with its local area network capabilities, a very sophisticated resource sharing system will be available to users. In addition, it has the ability to emulate both Honeywell and IBM terminal types.

A cluster of terminals could access any TACONET host (Honeywell or FACOM) with different terminals performing local processing or holding host sessions. From moment to moment, numbers accessing one or other host type could change without causing system



MICA terminal.

difficulties. The MICA product is presented on the Network diagram, Figure 4, as Interface C.

GLOSSARY OF TERMS

BSC is an IBM synchronous terminal protocol analogous to Honeywell VIP 7750. It allows transfer of data in blocks, rather than character by character (asynchronous). It is up to 20% more efficient than asynchronous and provides better error detection and correction facilities.

Datanet 8 — The Honeywell data concentrating minicomputer used in conjunction with DSA.

DSA (Distributed Systems Architecture) — This architecture allows a multinode private packet switched network, multiple host access to individual terminals and the use of Datanet 8s as concentrators.

DTU (Data Transcription Unit) — This is an installation where operators key data from source documents onto a magnetic tape for later entry to a computer system.

IBMC (IBM compatible) — A description of the type of computer equipment that can execute application systems designed for IBM computers. Telecom has initially obtained its IBMC capability from Fujitsu's FACOM range.

IMS (Intelligent Matrix Switch) — A computer controlled switching module that allows automatic and remote monitoring and switching of backup components in the event of system or component failure.

"LEVEL TERMS"

"Level 1" means the computer equipment required for a Data Processing Centre which performs the main processing associated with all applications support, eg., interrogation, updating, and maintenance of records, analyses of data, calculating and report generation. These functions form the major part of the total processing load and require large, versatile computing and data storage facilities with the ability to call and execute, in multiprogramming mode, a large number of program modules. This function is provided by Honeywell H66/80, DPS8 and DPS88 (soon to be introduced) computers and their associated directly connected peripherals.

"Level 2" means the compputer equipment required for a Communications Front-End Network Processor which can perform editing, registration (input and output) and the control of data input and output pools and queues. They control communication and Level 3 centres and the remote on-line collection and dissemination of data. They may also control flow of transactions to and from the associated main processing centre (Level 1). This function is provided by Datanet 6661s, 6678s and the new Datanet 8s together with the associated directly connected peripherals and communications equipment.

"Level 3" means the computer equipment required for a Communications Centre which can perform media conversion, may perform preliminary data editing as well as printing, data compression and expansion, and provides a communication interface with Level 2 equipment. This function is provided by Datanet 700s and the newer DPS6s and their essential directly connected peripherals and communications equipment.

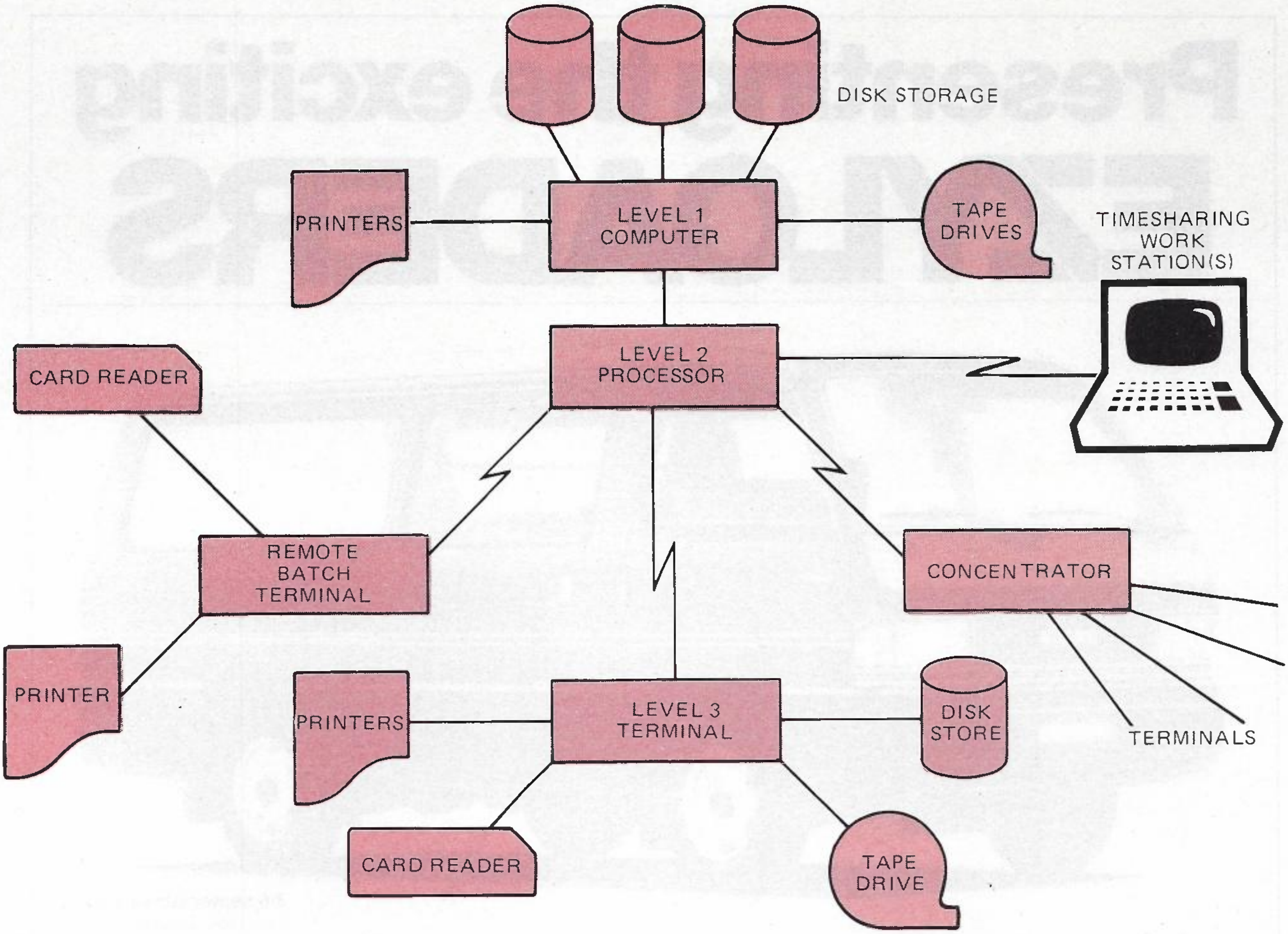


Fig. 5. Illustration of Use of Level 1, 2 and 3 Equipment.

SNA (System Network Architecture) — An IBM system which allows the use of a high level bit-oriented communications protocol, SDLC, and the ability to communicate between multiple nodes. It is older than DSA and possesses many of its features.

VIP 7750 the Honeywell character oriented, synchronous protocol, used on about 3,000 of Telecom's computer terminals.

REFERENCE

1. T. J. Poussard et al "An Introduction to the Australian Digital Network (DDN)", TJA, Vol. 31/1, 1981.

New Standard Telephone

F. M. DOYLE, B. Eng. (Comm.)

Telecom Australia is introducing a new range of standard telephones to replace the existing dial telephone instruments. This article discusses the background to the introduction, the design of the instruments, the launch strategy and future trends in telephone instrument design.

The new standard telephone incorporates a transmitter of novel design, the 20E electronic transmitter, and this is also described.

BACKGROUND

The instruments in Telecom's dial telephone range, Colorfone (table instrument) and Wallfone were introduced in 1963 and 1971 respectively. These telephones have since satisfactorily fulfilled the major requirements for a standard telephone range, namely low purchase cost and high reliability.

During recent years however, an increasing number of telephone instruments have become available in Australia, the majority of which have been imported. These telephone instruments generally offer facilities and features not available in Telecom's dial telephone range. Customer awareness and acceptance of enhanced facilities on basic telephone instruments has thus been increased.

The facilities now considered essential on basic instruments include push-button dialling and last number redial (LND). These facilities must however be offered on a product with acceptable performance and reliability and at a reasonable cost to the customer.

In 1977 Telecom introduced a range of push button telephones known as Touchfone. Later versions of these instruments offered LND and thus met the facility requirements mentioned, but due to restraints on mechanical and circuit design, the instrument cost was relatively high. For this reason, the original Touchfone range was introduced as a premium product with increased customer charges for installation and rental. The Touchfone as originally introduced could therefore not be viewed as the replacement for the dial telephone range.

It was obvious that a new range of telephone instruments was required to replace the dial telephone range.

NEW STANDARD TELEPHONE?

Several options were available in the search for the replacement of the dial telephone range. These included the purchase of an "off-the-shelf" telephone design (probably an overseas product), design of a new range of telephone instruments, or re-design of an existing telephone design. Many factors influenced the final decision as indicated below.

To offer modern facilities to rental telephone customers and meet strong competition in the now deregulated additional telephone sector, it was evident that the New Standard Telephone (NST) needed to be available as soon as possible. This timing constraint made the design of a new range of instruments undesirable due to the intrinsically long lead time from design conception to instrument production.

Production of the existing dial telephone range supports a large manufacturing base in Australia. The result of local design and manufacture of the instruments has ensured that the maximum level of local content has been attained. It was considered unlikely that a telephone design of overseas origin, even if ultimately produced in Australia, could maintain this level of local content.

The dial telephone range is, to many people, a tangible symbol of Telecom. Significant departures from the existing styling of the instrument range could therefore lessen Telecom's "presence" in the market. The NST should therefore be up-to-date in styling whilst still remaining readily recognisable as belonging to Telecom.

After consideration of all influencing factors, the successor to the dial telephone range was determined. The instruments chosen are known as Touchfone (Fig. 1) and Wallfone (Fig. 2) and are redesigns of the existing Touchfone push button telephone and dial Wallfone.

Fig. 1 The New Touchfone

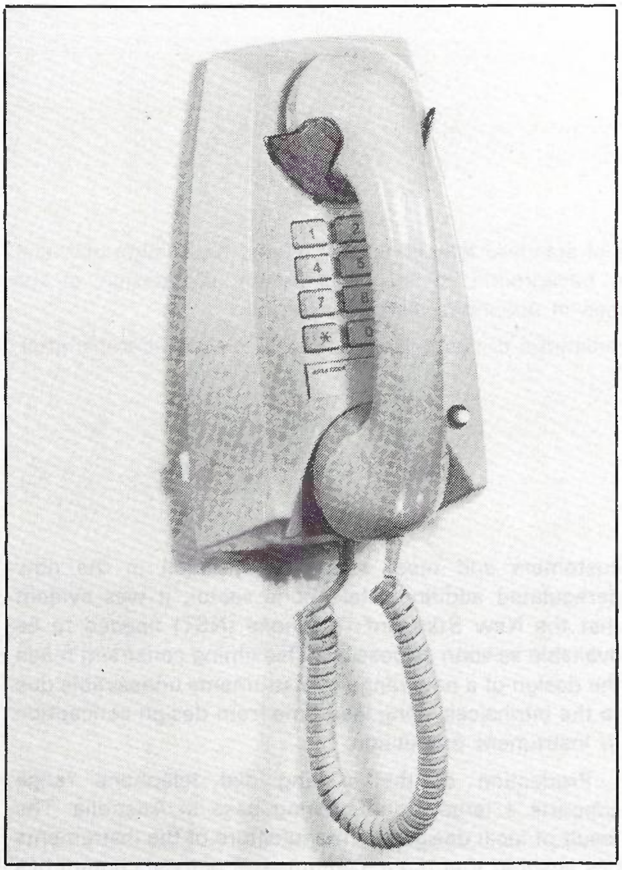


Fig. 2 The New Wallfone

TOUCHFONE

As mentioned earlier, the later versions of the existing Touchfone met the facility requirements chosen for the NST but high cost precluded the adoption of the product in that form. The redesign of the product therefore concentrated on cost reduction techniques.

Redesign of the Touchfone was mainly performed by Standard Telephones and Cables (STC) Australia Pty. Ltd., the traditional manufacturer of the Touchfone product. Cost reduction initiatives fell generally into two areas, namely the use of lower cost components and subassemblies and the employment of more cost effective manufacturing and assembly techniques.

Telephone Components

The two major component changes introduced are the replacement of the original bunched contact type push button keyblock (see Ref. 1) with a keyblock of "rubber mat" construction and the replacement of the traditional electromechanical telephone bell with an electronic tone caller.

The rubber mat push button keyblock used in the new Touchfone is similar in construction to keyblocks now in common use in many items of electronic and telecommunications equipment. The function of the keyblock contact is extremely simple. Each key has associated with it a dome of rubber material which has on its underside an area of conductive material. These domes are formed together into a mat. When any key is pressed the respective dome collapses causing the area of conductive material to make electrical connection to a contact area on the back plate of the keyblock. This electrical connection is decoded by the dialler circuitry of the telephone to determine the relevant key press.

The rubber mat construction provides excellent tactile feedback to the user due to the light pressure required to actuate a key whilst retaining the desirable "collapse action" response of the earlier keyblock designs. Additionally, the construction lends itself to extremely good life and environmental performance with average keyblock life in excess of one million operations per button.

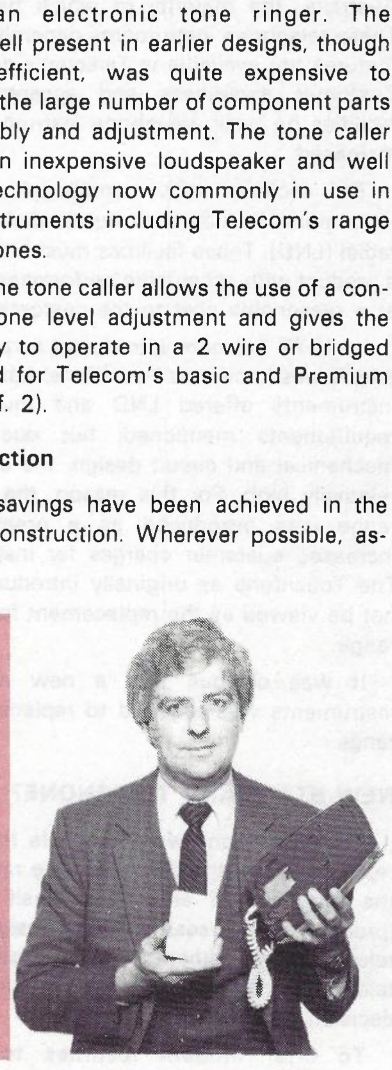
The other significant component change is the introduction of an electronic tone ringer. The electromechanical bell present in earlier designs, though acoustically very efficient, was quite expensive to manufacture due to the large number of component parts and intricate assembly and adjustment. The tone caller replacement uses an inexpensive loudspeaker and well proven electronic technology now commonly in use in many telephone instruments including Telecom's range of Premium Telephones.

The inclusion of the tone caller allows the use of a continuously variable tone level adjustment and gives the telephone the ability to operate in a 2 wire or bridged mode now standard for Telecom's basic and Premium Telephones (see Ref. 2).

Telephone Construction

Significant cost savings have been achieved in the area of telephone construction. Wherever possible, as-

FRANK DOYLE joined Telecom in 1975 after graduating in Communications Engineering at Royal Melbourne Institute of Technology, and has since been involved in most areas of basic telephone engineering. He is currently responsible for the engineering and procurement aspects of the New Standard Telephone.



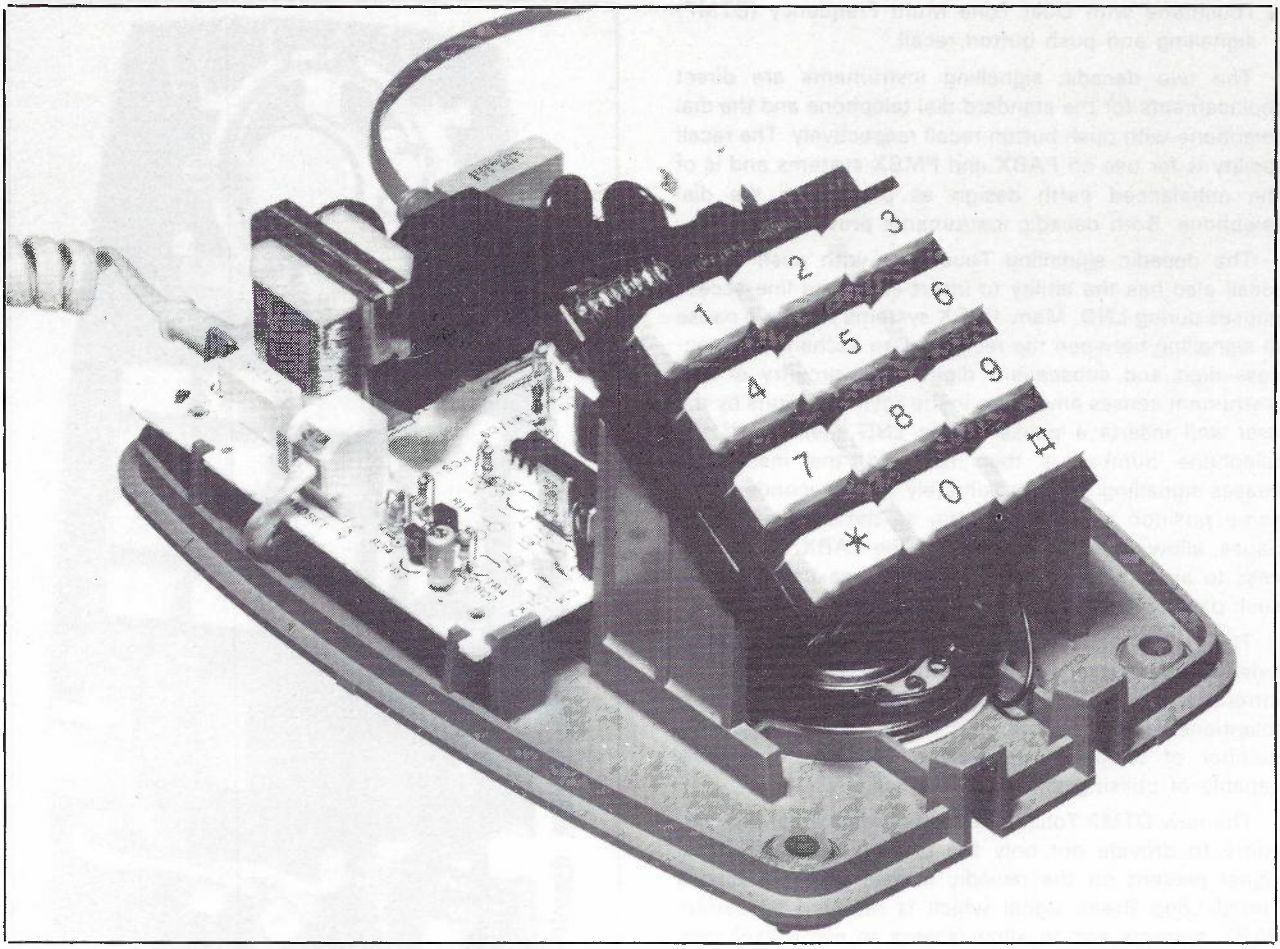


Fig. 3 Touchfone Construction

sembly time has been reduced by replacing traditional assembly techniques using screws and multiple connection of components with "clip-together" assembly and mass termination.

The telephone base has been significantly redesigned. The traditional metal base plate has been replaced with a complex moulded plastic assembly. This plastic base plate incorporates lugs and a captive screw for assembly to the telephone case and also provides mounting for the telephone keyblock, printed circuit assembly (PCA) and tone caller loudspeaker. The keyblock is mounted on vertical pillars and is held in place by the telephone case. The PCA and tone caller loudspeaker are both secured by moulded plastic clips (see Fig. 3).

The PCA has been designed to allow the maximum use of automatic component insertion equipment and to reduce telephone assembly time. The traditional telephone PCA used large numbers of "quick connect" lugs for connection of the telephone line, handset, dial and bell. Each conductor from these sources required individual connection. The Touchfone PCA has only four connectors, one each, of the Western Electric modular type, for the telephone line and handset cords, a multiway ribbon connector for the push button keyblock and a two way connector for the tone caller loudspeaker.

The telephone PCA incorporates all of the components required for telephone transmission, dialling and the electronic tone caller. Earlier versions of the Touchfone PCA mounted only those components associated with the transmission circuit, with the dialler circuit separately located on a second PCA mounted behind the push button keyblock. The use of a single PCA further reduces unit cost.

The incorporation of all of these component and assembly modifications in the Touchfone has also considerably improved the maintainability of the product. The maintenance aspects of both the Touchfone and Wallfone are discussed later.

The stated aim of the redesign of the Touchfone was to allow the new Touchfone to be offered at an equivalent price to the existing dial telephone. The significant modifications described above have virtually attained this objective. Indeed, if the existing dial telephone price is increased by the amount required to incorporate 2 wire working, which is now considered essential, the Touchfone and modified dial telephone prices are almost identical. This pricing allows the Touchfone, with the facilities and features desired, to be offered to Telecom's customers at an attractive rental.

Touchfone Products

The Touchfone range is made up of three products:

- Touchfone with Decadic signalling.
- Touchfone with Decadic signalling and push button recall.

- Touchfone with Dual Tone Multi Frequency (DTMF) signalling and push button recall.

The two decadic signalling instruments are direct replacements for the standard dial telephone and the dial telephone with push button recall respectively. The recall facility is for use on PABX and PMBX systems and is of the unbalanced earth design as present in the dial telephone. Both decadic instruments provide LND.

The decadic signalling Touchfone with push button recall also has the ability to insert exchange line access pauses during LND. Many PABX systems require a pause in signalling between the receipt of an exchange line access digit and subsequent digits. The circuitry of this instrument senses any pause in the keying of digits by the user and inserts a pause in the LND memory. If the telephone number is then redialled, the instrument ceases signalling for approximately three seconds at the same position in the digit train as the original keying pause, allowing sufficient time for the PABX to gain access to an available exchange line. A maximum of two such pauses may be inserted in each telephone number.

The DTMF signalling instrument is a redesign of the existing Touchfone DTMF telephone (see Ref. 3). The introduction of a DTMF instrument in Telecom's standard telephone range is timely due to the rapidly increasing number of telephone exchanges and PABX systems capable of utilising this signalling system.

The new DTMF Touchfone incorporates additional circuitry to provide not only the unbalanced earth recall signal present on the decadic instruments, but also a Timed Loop Break signal which is required by certain PABX systems and to allow access to some exchange based facility packages such as Easycall. The instrument is designed to automatically sense the recall signalling system required and no Telecom initialisation or customer switching is required.

The LND facility is not available on the new DTMF Touchfone. At the product design stage there was no DTMF signalling integrated circuit available which provided this facility. Future integrated circuits or signalling systems will offer LND and these are foreshadowed in a later section. Fortunately, most modern PABX systems offer LND as a standard system facility and the DTMF Touchfone will therefore be able to access this facility.

WALLFONE

Redesign of the dial Wallfone to become part of the NST range once again emphasised the need for cost minimisation. The new Wallfone needed to include push button signalling similar to that provided in the Touchfone. Wherever possible, circuit and component commonality was stressed.

Initial design work was performed once again by STC Pty. Ltd. and detailed mechanical design was carried out by Amalgamated Wireless Australasia (AWA) Ltd. The final design incorporates many of the components present in the Touchfone including the push button keyblock, the tone ringer loudspeaker, the handset body and handset cord, and the majority of the PCA components (see Fig. 4).

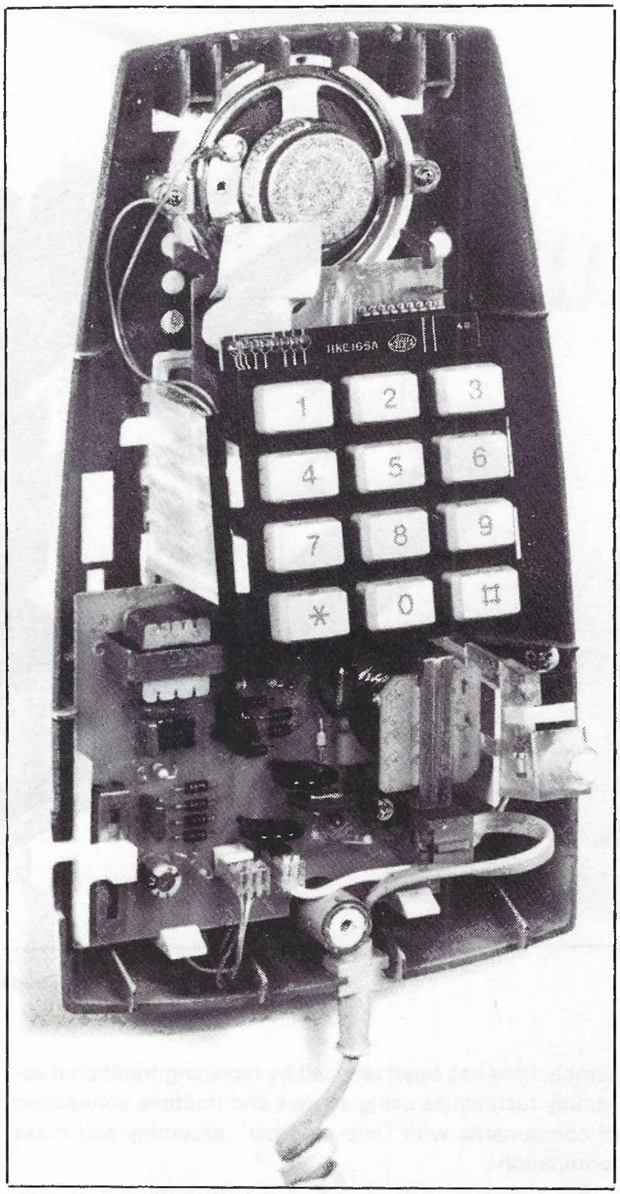


Fig. 4 Wallfone Construction

The circuitry of the Wallfone products is identical to that of the respective Touchfone products. Space limitations within the Wallfone case have required the PCA layout to be modified. Connections to the PCA have been reduced in keeping with the design philosophy of the Touchfone, and identical connectors have been used for handset termination and keyblock and tone ringer loudspeaker connection.

Two exciting innovations have been included in the new Wallfone. The first relates to the manner in which the Wallfone is physically mounted and connected to the exchange line. The existing Wallfone design required the telephone to be permanently attached to the wall with the exchange line connected via screw terminals on the telephone PCA. The new Wallfone design utilizes a wall mounting plate for both mounting and line termination.

The Wallfone wall plate (see Fig. 5) is the same shape and size as a standard electrical power outlet. A standard telephone socket is permanently fixed to the surface of the plate and exchange line termination at the socket is carried out in the normal manner. The wall plate has four recesses, two at the top of the plate and one on each side

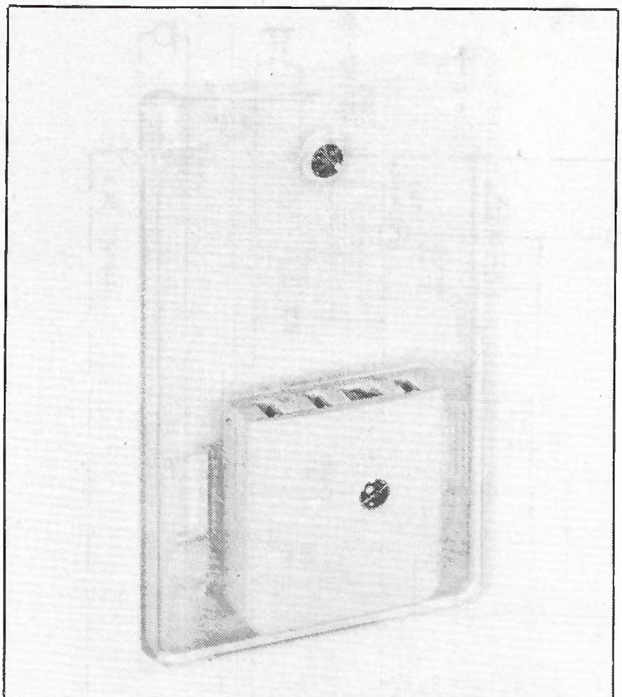


Fig. 5 Wallfone Wallplate

of the telephone socket. These recesses mate with four mounting fingers on the rear of the Wallfone. Incorporated into the base of the Wallfone is a standard telephone plug which mates with the socket on the wall plate. The Wallfone is mounted by locating the four fingers on the rear of the telephone with the recesses on the wall plate and pushing downwards. When in place the telephone is solidly mounted and electrical connection is complete.

The introduction of this mounting technique will allow prewiring of Wallfone installations using standard electrical fittings and practices, and will also provide instrument portability which obviously was not possible with the existing design. In circumstances requiring secure fixing, a small plug will be supplied with each Wallfone which can be inserted in the base of the Wallfone to prevent removal. Since this modification will require disassembly of the telephone case, both fitting and removal will need to be performed by Telecom. It is not expected that many installations of this type will occur.

The other innovation in the new Wallfone is the inclusion of a continuously variable tone level control. The original dial Wallfone design had no bell level control, the absence of which caused quite a deal of customer dissatisfaction. Recent versions of the dial Wallfone did provide a "mute" control which offererd two levels only of ring signal, either full ring or rattle, but this was considered only a partial solution.

The new Wallfone has identical tone caller circuitry to the Touchfone. Tone caller loudness control is provided by a slider potentiometer located on the lower left hand side of the telephone. Inclusion of this facility should increase customer satisfaction with this aspect of telephone performance.

The signalling options present in the Wallfone range are identical to those in the Touchfone range, including LND on the decadic products and the auto sensing unbalanced earth recall and timed loop break facilities on the DTMF product.

TELEPHONE CIRCUITRY

As stated earlier, the circuitry of each product in the Touchfone and Wallfone ranges is identical. The following comments relating to the Touchfone circuit are therefore also applicable to the Wallfone circuit.

The circuit diagram of the basic decadic Touchfone is shown in Fig. 6.

The shaded aea of the diagram shows the tone caller circuitry. When the telephone is on hook, incoming ring present on the exchange line terminal is rectified by the full wave bridge and presented to IC1 which generates two fundamental tones which are alternatively output to the loudspeaker. The fundamental tones and switching frequency are determined by the circuitry associated with the IC.

The remainder of the circuit provides the dialling and transmission functions and is actuated when the telephone is off hook. The transmission circuit of the telephone is virtually identical to that of the existing dial telephone with the anti-sidetone coil T2 and the balance network consisting of capacitors C10 and C11, resistors R18 and R19 and varistor AR2. One important change is the introduction of transistor TR7 to limit the "clicks" heard at the receiver during dialling. This function is performed in dial telephones by way of a dial "off-normal" contact and by a relay in the later Touchfone design. Removing the need for a relay in the new Touchfone design has saved considerable cost.

The dialling function is controlled by IC2 which performs the keyblock data decoding and decadic pulse generation. The components associated with IC2 set the required power supply and timing for the IC.

The circuits of the decadic Touchfone with recall and the DTMF Touchfone are similar to that of the basic Touchfone except for the incorporation of different dialler IC's and minor circuit variations to accommodate those IC's. A detailed circuit description for all of these products is included in Ref. 4.

To those familiar with recent trends in telecommunications technology, it may be surprising to see a transmission circuit of classical design present in the new Touchfone rather than a design using one of several new IC speech circuits. Detailed costing of the two techniques however, indicated that the discrete type of transmission circuit is currently still cost effective. Further comment on future trends will be made later.

ELECTRONIC TRANSMITTER, 20E

Coincident with the introduction of the Touchfone and Wallfone range, a new type of telephone transmitter is also to be launched. The new transmitter known as the 20E is an electronic replacement for the traditional carbon granule transmitter design present in the current dial telephone range.

The carbon granule transmitter suffered from several problems including reduced send level on long lines, a tendency over a period for the granules to "pack" together further reducing the transmitter sensitivity and

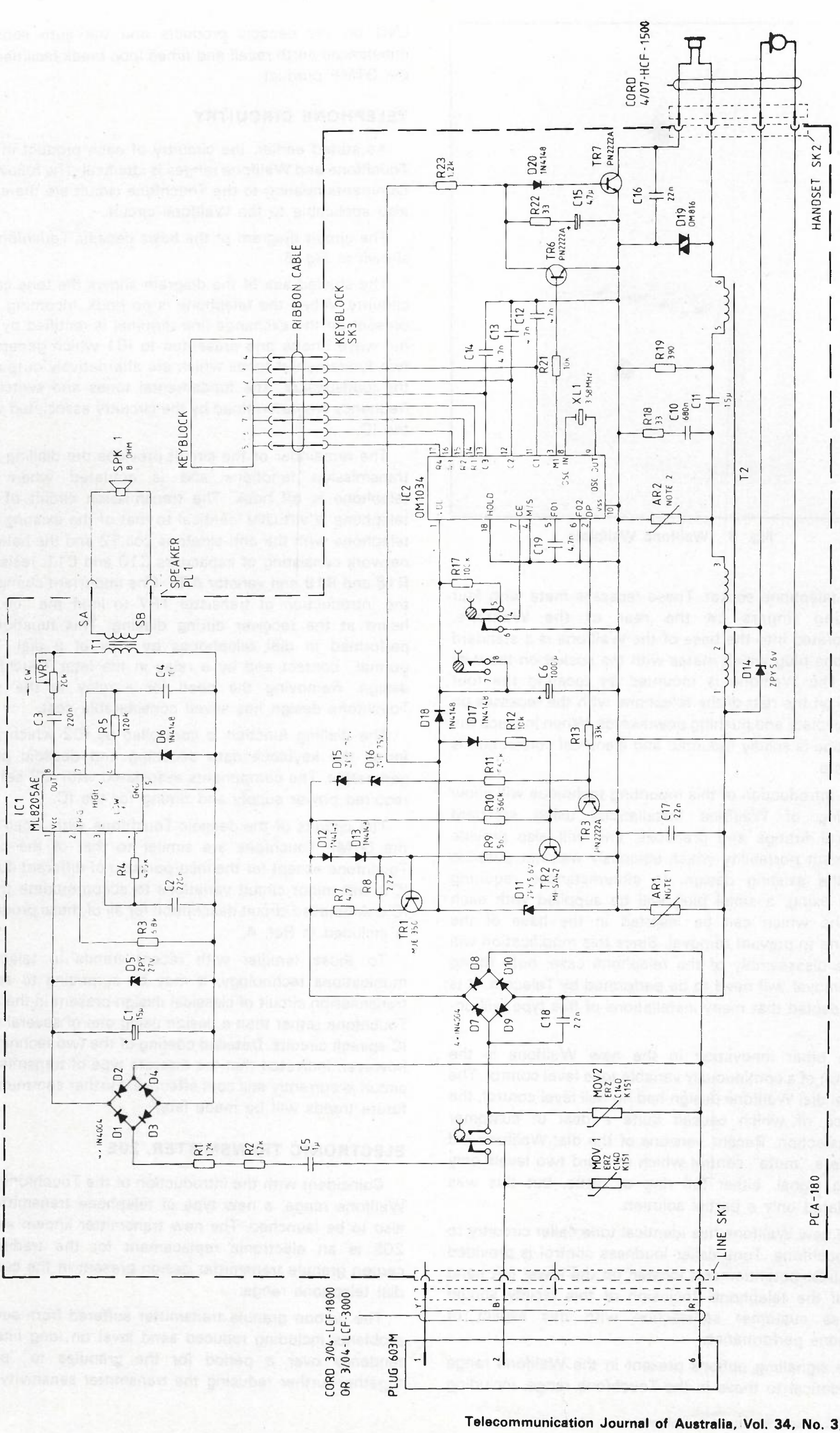


Fig. 6 Telephone Circuit

also transmitters often generated a crackling noise called "frying" caused by minute arcing between granules. The reduction in sensitivity caused by packing of the granules was particularly evident in Wallfones because the vertical mounting of the handset reduced the "rotation" of the handset during use. The handset is horizontally mounted on the table telephone and the "rotation" of the handset as it is lifted to the ear causes agitation of the granules which reduces the packing effect.

The combination of these factors caused the transmitter to have one of the highest replacement rates of any component in the dial telephone. In any case, the low send level on long lines was in itself sufficient reason to seek a replacement for the carbon transmitter.

In order to obtain a satisfactory replacement for the carbon transmitter, tenders were invited in 1977 for the design and development of an electronic transmitter to meet a specification prepared by Telecom. This specification drew upon studies performed by the Telecom Research Laboratories and detailed the electrical and mechanical properties required and the desired life and environmental performance. The transmitter was designed to fit directly into the existing handset and to function satisfactorily in the majority of telephone installations. NEC Australia was awarded the contract to perform the detailed design work that has resulted in the 20E design.

The 20E transmitter (see Fig. 7) comprises a moving coil microphone with an amplifier and associated componentry mounted on a small PCA. The microphone and PCA are mounted in a plastic housing with a pressed aluminium front cover. The microphone amplifier is an IC designed specifically for the 20E transmitter by NEC in Japan.

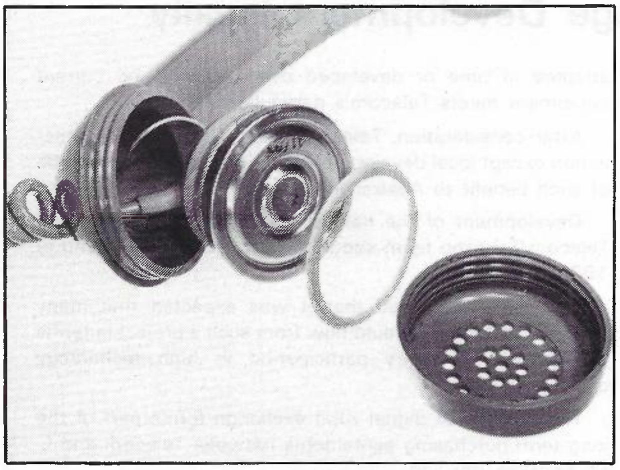


Fig. 7 20E Transmitter

Initial testing and a subsequent field trial of some 10,000 transmitters uncovered two significant problems; there was susceptibility in some locations to radio frequency interference (RFI), and there was high frequency feedback or howling when the telephone handset was placed face down on a hard surface. The RFI problem has been overcome by coating the plastic housing with an electrically conductive resin which is connected to one of the transmitter terminals. The howling effect present on a small number of installations required acoustic modification to alter the frequency response of the transmitter.

Annual requirements for the 20E transmitter are estimated to be well in excess of one million pieces. Local manufacture of the transmitter will be shared by NEC and AWA who have both recently commissioned highly automated manufacture and assembly areas specifically for the 20E transmitter. The proportion of local content in the transmitter has also been increased by the establishment of Philips Industries (Australia), in South Australia, as a second source of the amplifier IC. The development of this local second source was achieved by Telecom initiative with the co-operation of both Philips and NEC, with the result that this IC is the largest volume IC produced in Australia.

The inclusion of the 20E transmitter in the NST range will not only provide enhanced transmission performance on all lengths of exchange line, but will also significantly reduce the maintenance effort required during the operational life of telephones. The new transmitter will also be available for use in the maintenance of the existing dial telephone range and will be fitted to all dial telephones during reconditioning.

LAUNCH STRATEGY

In excess of one million telephones are issued each year from Telecom stores to satisfy requirements for telephone connections and maintenance. The launch of the NST needed to be planned so as to minimize the risk of major disturbances to the continuing supply of telephones.

It was decided that a sequential programme of individual State launches would provide the lowest risk strategy with the ability to control deliveries and stocks of all items. The launch of the Touchfone commenced in September 1984 in South Australia with subsequent State launches occurring in October, November and December. The Wallfone range sequential launch was timed to commence in February 1985.

Prior to each State launch, stocks of the NST range needed to be established at a level consistent with individual instrument usage. The required national stock level of the NST is in excess of two hundred thousand telephones in State main stores and district stores.

Maintenance of the existing dial telephone population will continue to be carried out using dial telephones. Since no new dial telephone production will occur after the introduction of the NST, these instruments will only be available from the national telephone reconditioning programme performed by Telecom Workshops in each State. Stocks of dial telephones will be held in each State at a level consistent with maintenance usage.

MAINTENANCE OF THE NST

The design of both the new Touchfone and Wallfone instruments took into account the maintainability of the products during service. The modular construction of both Touchfone and Wallfone will permit simple field replacement of faulty components and subassemblies.

Of particular importance is the ability to replace the instrument PCA in the field. Due to the large number of connections present on the existing dial telephone PCA, field replacement of this item was rare and a replacement telephone was therefore required. The new Touchfone and Wallfone PCA's will be available for field service. If a telephone fault is diagnosed in the PCA, it can be replaced simply. Faulty PCAs will be repaired and re-issued for maintenance. Significant cost savings will result from these practices.

FUTURE TRENDS

The new Touchfone and Wallfone are vital elements of Telecom's strategy for the provision of basic telephone services to all customers. The facilities present on these instruments and the attractive rental should ensure a continuing favourable market share.

Nevertheless, development of potential enhancements to the new Touchfone and Wallfone is already underway. Major facilities under study for the future are abbreviated dialling and the ability to switch between decadic and DTMF signalling.

Abbreviated dialling provides the customer with the ability to dial frequently called telephone numbers by pressing only two keys. Telephone numbers are stored in memory by the customer and can be changed at will. This facility is particularly attractive to business customers due to the ease of use and speed of dialling.

The addition of switchable signalling to the NST will be of great benefit to Telecom due to the significant reduction in the number of items required to be held in store to satisfy various installations. At the time of installation the instrument can be set to the appropriate signalling mode and will require no customer initialisation or modification.

These two developments could be combined into one instrument, thus satisfying most customer installations.

Other future possibilities include the use of active transmission circuits with low cost transducers or indeed the development of the so called "one chip" telephone with all of the active circuitry required incorporated in one IC. Thought is also being given to variation of the case design to allow the one telephone to serve in both table and wall installations.

These developments will greatly assist Telecom in the continued provision of high quality telephone instruments to service customer demand and to maintain the strong position in the telecommunications market in Australia gained by Telecom with the introduction of the new Touchfone and Wallfone.

REFERENCES

1. Alderson, G. J., "The 'Touchfone 10' Push Button Telephone"; Telecom Journal of Australia, Volume 28, No. 3, 1978.
2. Trebilco, W. J. and Lew, W., "Technical Aspects of Premium Telephone Introduction"; Telecom Journal of Australia, Volume 34, No. 2, 1984.
3. Rendle, A. A., "Touchfone 12"; Telecom Journal of Australia, Volume 29, No. 3, 1979.
4. Telecom Australia Technical Publication — TPH0980; "Touchfone (New Standard Telephone)" Issue No. 1, April 1984.

Information Transfer News Item

Telecom encourages Exchange Development locally

Telecom Australia and L. M. Ericsson Pty. Ltd. are co-operating to develop locally a Small Digital Rural Exchange (SDRX) for the Australian telecommunications network.

A Telecom spokesman said today that Telecom needed a small digital rural exchange for installation in Australia's telecommunications network beginning late 1987.

"We want exchanges for our country customers which will provide economic, flexible and up to date services with the quality, reliability and network attributes needed to meet the demands of a modern society, in line with those provided for our city customers," he said.

He noted that the Chairman of the Australian Telecommunications Commission had earlier this year stated that Telecom would be encouraging local design and development in the telecommunications field.

The spokesman further commented that the project fits in well with Telecom's commitments and objectives which stated that Telecom is 'committed to fostering a vigorous communications manufacturing and development capability in Australia'.

Development of such an exchange will enable Australia's network to be further improved and expanded using one family of equipment, designed by L. M. Ericsson and supplied by them to Telecom since 1978.

There will be long term benefits for Telecom resulting from the design experience gained in a unique area of telecommunications. Although other designs could be adapted in time or developed over a period, no current equipment meets Telecom's particular needs.

After consideration, Telecom has decided that no other action except local development of this equipment would be of such benefit to Australian industry.

Development of the new exchange design by the joint Telecom/Ericsson team should be completed by the end of 1986.

The spokesman said that it was expected that many national advantages would flow from such a project in terms of Australian industry participation in high technology development.

The new small digital rural exchange forms part of the long-term purchasing agreements between Telecom and L. M. Ericsson Pty. Ltd.

L. M. Ericsson expected to sell the new exchange design overseas.

Telecom will earn royalties on sales which are expected to be quite high. Telecom's network expertise is well respected internationally and its recommendation of the new exchange should provide Australia with a marketing advantage.

The spokesman said that the cost of development over a three year period was approximately $6.5 million.

Issued by: **Telecom Australia**
Headquarters,
Melbourne.

TADMAR — A Telephone Traffic Data Base

K. P. CORDING, ARMIT

This article describes the traffic data base application TADMAR which has been developed as an integral part of a new generation of traffic data acquisition processing and analysis system to meet Telecom needs during the 1980s. Some of the concepts and application of data base management techniques which have been applied to TADMAR are also described.

INTRODUCTION

Today the Australian telephone network serves approximately 5.5m subscribers connected to some 5500 telephone exchanges interconnected through over 100,000 traffic routes. It is this network which is Telecom's greater asset and revenue earner. In order for Telecom to be well positioned in the telecommunications market, it is a prime objective of Telecom that this network continues to provide up-to-date telecommunication facilities at an economic price consistent with an appropriate quality and level of service.

In order to assist in achieving these objectives two major activities need to be carried out. Firstly the monitoring of the performance of the current network (and its augmentation where required to meet prescribed levels of service or performances) and secondly, the forecasting, planning, design and installation of additional plant or new facilities to meet some future demand.

Knowledge about when, where and how much traffic flows in this network is vital to the proper supervision and planning of the future network and it is the task of the traffic engineer to collect, analyse, forecast and distribute this traffic information throughout the organisation to assist achieving these objectives.

As outlined in Ref. (1) a series of new computer based systems are being developed to meet Telecom's needs for providing traffic information during the 1980s. **Fig. 1** shows the interrelationship of these various systems which can be broadly subdivided into Traffic Data Acquisition Systems (TDAS) and Traffic Data Base (TDB) systems.

This article describes the traffic data base system Traffic Data Management Analysis and Reporting (TADMAR), which is designed to run on a CDC CYBER series computer under the NOS operating system, and is the third in the series about Traffic Measurements during the 1980s. Previous articles in this series are described in Ref. (1), Ref. (2).

HISTORICAL BACKGROUND

Traffic Engineering in Telecom have been applying computers to the processing and analysis of traffic data since the late 1950s. With the introduction of the crossbar network in the early 1960s, Telecom for the first time embarked on the national development of a traffic data gathering system and supporting processing system. Ref. (3), Ref. (4).

The traffic data gathering system known as TDE (Traffic Data Equipment) was designed to collect traffic occupancy data from ARF and ARM exchanges and traffic dispersion data ARF exchanges. The output from TDE was traffic data collected on either paper tape or magnetic tape and then subsequently processed by the TRA (Traffic Recording Analysis) system on Telecom H8200 computer. The TRA system operated in batch mode to provide a number of predetermined hard copy output reports and files of traffic statistics that could be used in subsequent traffic analysis and forecasting processes.

The TDE/TRA system was first put into national operation in 1975 and whilst it is expected that the TDE hardware will remain in ARF/ARM exchanges for the life of these exchanges it is planned that the TRA system will be replaced during 1984/85 as it no longer meets the needs for the processing of traffic data.

In the early 1970s, a national study into the applications of computers in telecommunication planning identified the need for the establishment of a permanent base of comprehensive traffic data derived from TRA to support the many network planning processes. Ref. (5). However, at about this time, it was recognised that the current practices of traffic measurements in exchanges once every 2-3 years was too infrequent, due to such factors as daily, weekly and seasonal variations in traffic volume and dispersion pattern, changing subscriber demand forecasts resulting from changes in economic climate etc. These factors coupled with the future introduction of new SPC technology all led to the need for the development of a new set of traffic acquisition and processing systems to meet the business and technical needs of the 1980s.

SYSTEM DESIGN OBJECTIVES AND CONCEPTS OF TADMAR

In 1979 following the identification of the need to establish a national traffic data base, an all States Working Party of Traffic Engineers together with an external consultant team from Control Data Australia was

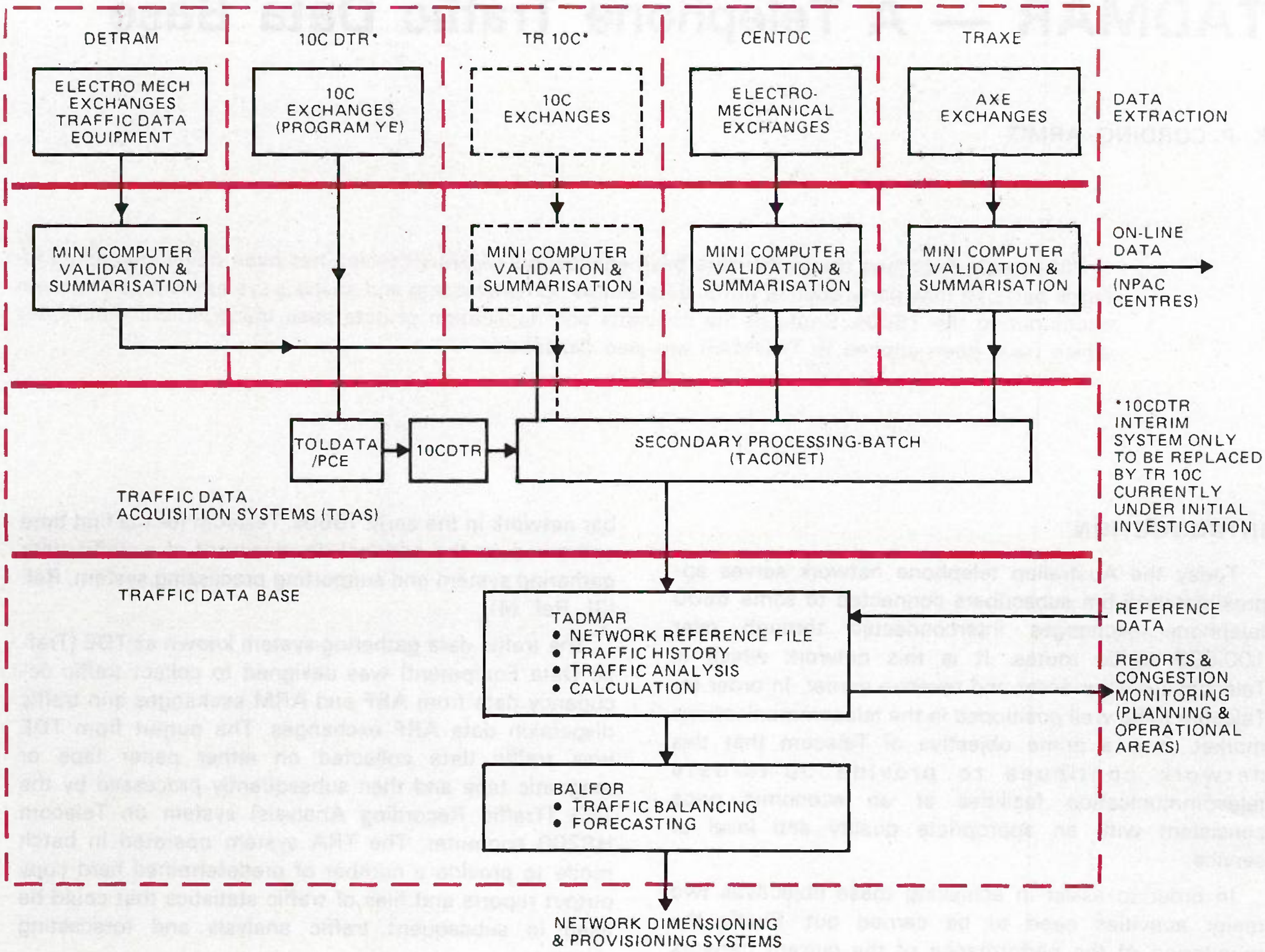


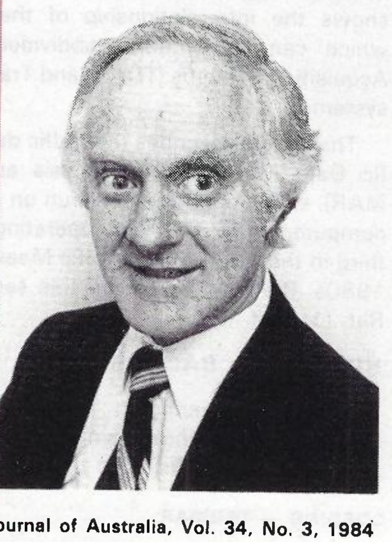
Fig. 1. Traffic Data Acquisition and Processing System. An Overview.

established. The initial task of this Working Party was to produce a system design specification for TADMAR.

Design objectives established during the initial phase of specifications, and based on experience with the previous generation of traffic processing systems, included the following considerations:

- as traffic data is a corporate asset it should be widely available, timely, and in a form required by both technical and business managers at a State and Headquarters level.
- the data base should have high integrity and be secure commensurate with the worth and cost of collecting the data. (The all-up cost of collecting and processing traffic data for the switched telephone network is currently in the order of $12-$15M p.a.)
- the system should be user driven.

Kelvin Cording joined the Postmaster General's Department as a technician-in-training in 1958 and initially worked at the Research Laboratories. He then completed a Diploma in Communication Engineering and Post-graduate Diploma in Mathematics at RMIT in 1964 and 1976 respectively. From 1965-1971 he worked as a Class I and Class II Engineer in the Victorian Traffic Engineering (Country) Division and was concerned with traffic data acquisition and processing and network design and dimensioning. In 1972 he was promoted Engineer Class III in the Headquarters Planning Mechanization and Techniques Section where he was involved in the development of national traffic data base systems. Currently he is Engineer Class IV in the Traffic Engineering Section responsible for the development of new national traffic acquisition and processing systems.



- user procedures should be capable of being used in a flexible way.
- users to be able to generate their own user reports as required.
- the system should be of robust design and responsive to changes in technology and business needs and with an ability to easily add additional procedures as required.
- the system should incorporate as far as possible modern computer hardware and software concepts and techniques.
- consideration to be given to the use of suitable Data Base Management System (DBMS) package.
- ample interfaces should be provided to other computer or manual systems or processes.
- cognisance should be given to the level of experience in the use of computer techniques by users of the system.

Coupled with these design objectives there were certain other characteristics about the data that had to be considered:

- very large volumes of data must be collected to ensure the information is statistically reliable.
- the data manipulations and computations are complex.
- traffic forecasting methods require a considerable history of past traffic measurements.
- data in the data base is reasonably volatile.

INFORMATION MANAGEMENT FACILITY (IMF) DBMS

Following investigations in USA and Europe during 1979 by the consultant team, a DBMS package known as IMF (Information Management Facility) was identified as a suitable package to assist with the implementation of TADMAR. IMF was of advanced design and well suited for use in an engineering environment since it provided considerable flexibility in data base structure, a 'prototyping' capability and an associated information analysis methodology. IMF is in fact an early implementation of a fourth generation DBMS and is based on the work of Nijssen. Ref. (7).

This package, then known as EDMS (Evolutionary Database Management System), was being used by the French National Oil Company **ELF-AQUITAINE** to hold data associated with oil exploration seismological studies. The problems of processing data for these studies exhibited many of the characteristics of those identified in the processing of traffic data collected in a telecommunications network, i.e., very large volumes of data that require further complex manipulations and analysis by engineers at some later stage.

DATA BASE CONCEPTS

Before outlining the TADMAR system in more detail, it is worth considering some of the concepts of computerised data base techniques and DBMSs.

Firstly, it is useful to define a data base — A data base may be defined as a collection of interrelated data stored together, without harmful or unnecessary redundancy, to serve one or more applications in an optimal fashion; data are stored so that they are independent of programmes which use the data; a common and controlled approach is used in adding new data and in modifying and retrieving existing data within the data base. One system is said to contain a collection of data bases if they are entirely separate in structure.

The traditional approach to the development of computer applications is shown in **Fig. (2a)** where a separate set of data files are developed for each required application. The concept of a data base **Fig. (2b)** is to produce a single set of data files that can be accessed by more than one application.

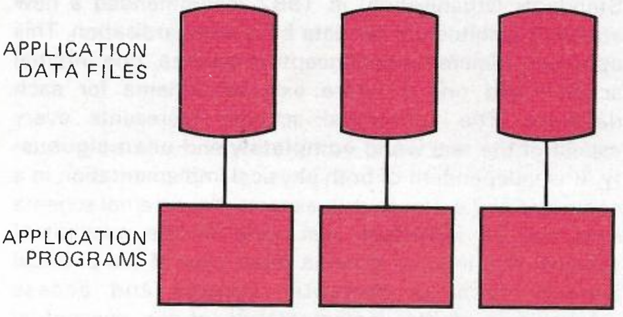


Fig. 2A. Traditional Approach.

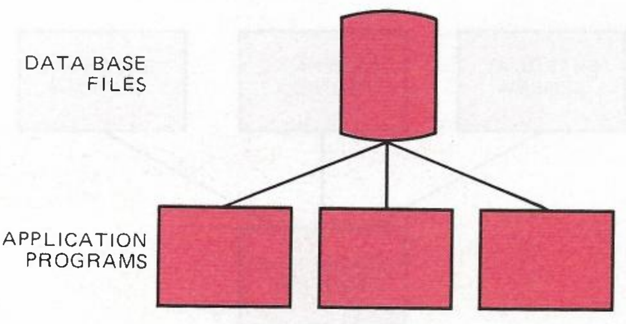


Fig. 2B. Data Base Approach.

These concepts are not new and for many years computer software manufacturers have been developing and marketing software packages known as DBMS that can be used to assist in setting up records of data and their interrelationships within a data base system. Examples of some of these DBMS packages available at the time of TADMAR system specification were being developed are contained in **Fig. 3.** However, over the last few years, there has been a rapid increase in the number of DBMS products being offered in the market place.

SYSTEM	VENDOR	APPROX NO OF USERS
IMS	IBM	600-900
IDS	HONEYWELL	425
DMS 1100	SPERRY UNIVAC	250
TOTAL	CINCOM SYSTEMS INC	1,100
SYSTEM 2000	MRI SYSTEMS CORP	200
ADABAS	SOFTWARE AG	200
SOURCE: R. G. ROSS — DATA BASE SYSTEM		

Fig. 3. Typical DBMS Products.

Whilst some of these products have been on the market for a number of years they have been used with varying degrees of success. One of the difficulties in the use of DBMS has been lack of suitable methodologies and techniques to translate from the "real world problem" into an efficient computerised data base model.

Throughout the 1970s the I.F.I.P. (International Federation for Information Processing) devoted considerable effort into developing and improving the concepts and techniques of modelling the real world into DBMS systems. This work involved not only an examination of the architecture of DBMS but also suitable methodologies for information system design using these DBMS.

As a result of this work the ISO (International Standards Organisation) in 1982 recommended a new standard architecture for data base standardisation. This approach requires one conceptual schema, one internal schema and one or more external schema for each database. The conceptual schema represents every aspect of the real world **completely** and **unambiguously**. It is independent of both physical implementation in a computer and external view aspects. An external schema describes an individual user view of the conceptual schema. The internal schema takes care of the physical aspects such as computer storage and access mechanisms of the implementation of the conceptual schema. The IMF DBMS has been implemented using this three schema approach as illustrated in **Fig. (4)**.

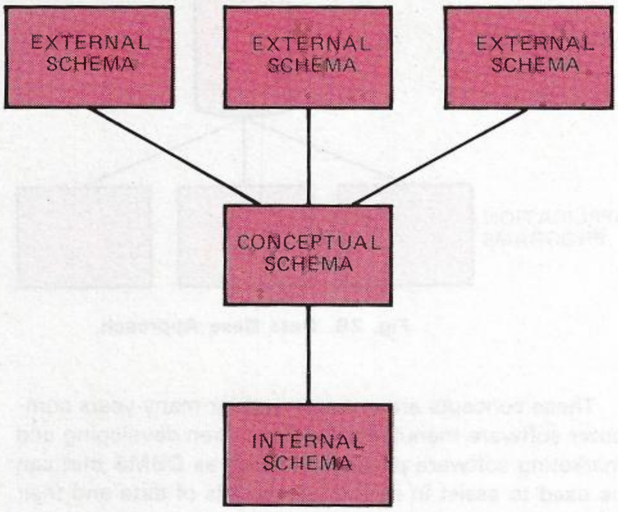


Fig. 4. Three Level Database Architecture.

TADMAR OVERVIEW DESCRIPTION

TADMAR is basically an on-line information management system consisting of an information base together with appropriate procedures to maintain the information base. In addition auxiliary procedures and reports may be developed and incorporated into TADMAR by both Headquarters and State users as required.

TADMAR is a **subject data base** of traffic and trunking information about the whole national switched telephone network and is made up of about thirty subsystems.

As illustrated in **Fig. (5)** TADMAR may be considered in four broad sections viz:

a. Information Data Bases;
b. Inputs and Data Base Updates;
c. Control Data Base;
d. Outputs, Reports and Application Programmes.

THE INFORMATION BASE

The information base consists of two separate data bases implemented in IMF and a set of random access files. The first IMF data base is made up of what is called the Network Reference Area (NRA) and contains a model of the trunking of all exchanges in the public switched network through which traffic flows. The second IMF data base is made up of two parts; the Historical Data Area (HDA) and Study Index Area (SIA). The HDA contains important traffic statistics on routes such as TCBH traffics, grades of service etc. This information is kept historically, for use in activities such as traffic forecasting etc. The SIA provides management details about all traffic studies loaded into TADMAR from TDAS; such details as when studies were made at particular exchanges, whether detailed information is on-line or off-line, the status of processing through TADMAR etc. It should be noted the NRA, HDA and SIA are on-line data bases.

The Study Data File (SDF) is a large random access file, one of which is created for each traffic measurement study. SDFs are created each time a detailed traffic measurement is generated by DETRAM, TRAXE or 10CDTR (or TRA) or from Daily traffic recording measurements generated by CENTOC or TRAXE. A typical SDF created by a measurement of 2000 circuit groups from CENTOC would contain about 40Mbytes whilst a detailed study from DETRAM of 230 circuit groups would result in a SDF of approximately 4Mbytes.

The SDF contains detailed traffic data down to the half-hour level and is kept on-line only during times when detailed traffic analysis at this level is required or when having to produce reports containing traffic at this detailed level e.g. production of 24 hour traffic profiles.

On occasions when SDFs are off-line, details of where data can be found is contained in the SIA.

INPUTS AND DATA BASE UPDATING

There are two input streams to TADMAR viz:

- Network Data.
- Traffic Data.

Network data about the trunking of exchanges is prepared as a computer file and submitted to the network data input validation subsystems. These subsystems contain a set of user specified tables against which the syntax and some of the data values of the input network data may be validated before being loaded into the NRA and HDA data bases.

Before traffic data from TDAS can be loaded into the information base, it is necessary that TADMAR knows details about the network of exchanges, circuit groups etc., that are being measured. Data is extracted from the NRA and compared with that contained on the traffic input files. The traffic input subsystems also reformat the input files from TDAS into a more suitable form to create SDFs.

DATA BASE UPDATES

Network data transaction files that are successfully validated together with any validated SDFs are grouped together to update the NRA, HDA and SIA in one "bulk update" operation. As the HDA, NRA and SIA are normally on-line they are firstly copied to tape, for security

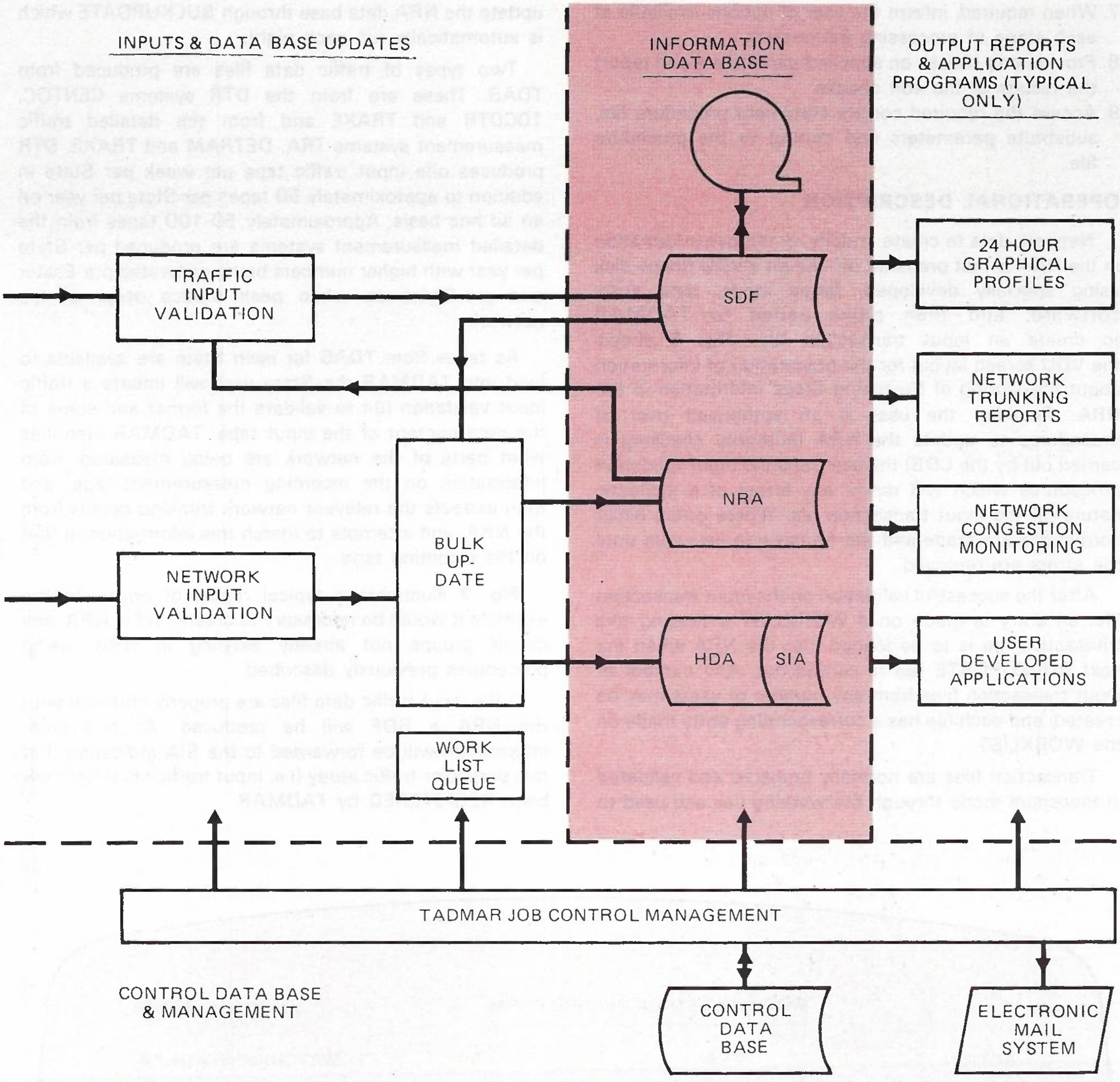


Fig. 5. TADMAR — Simplified Overview Diagram.

purposes, prior to being updated. In the event of a software or hardware failure during the update process these data bases may be recovered from tape.

CONTROL DATA BASE (CDB)

The Control Data Base (CDB) is the operational heart of TADMAR and provides a wide range of functions and control as well as providing a "User Friendly" front end to users. The CDB is implemented as a separate IMF data base.

TADMAR consists of a number of procedures that may be invoked under user control, and it is the CDB that controls the operation of these procedures. These activities include:

1. Identify the user and the selected procedure.
2. Validate the user for access to selected procedures and data bases. Some data base housekeeping and software maintenance procedures are only available to selected users.
3. Act as an electronic mail system to control the printing of system bulletins, procedure status information and user reports and advise the user of all reports waiting his attention. These reports may be viewed immediately on his VDU or directed to a remote batch facility.
4. Provide interlock facilities to control the type of access, i.e. interactive/batch, available at the time of data base updates. Access to TADMAR may also be suspended whilst any recovery operations are required as a result of any system failures.
5. Attach object and data files required for the execution of selected procedures.
6. Create a status file for use by subsequent programs containing user names, job origin, access permission, etc.

7. When required, inform the user of options available at each stage of processing parameters.
8. Provide edit checks on supplied parameters and report the results of the edit checks.
9. Access the required control statement procedure file, substitute parameters and control to the procedure file.

OPERATIONAL DESCRIPTION

Network data to create, modify, or remove information in the NRA is first prepared off-line on a VDU floppy disk using specially developed, forms mode, data entry software, and then down-loaded to TADMAR to create an input transaction file. **Fig. 6** shows the VDU screen layout for the preparation of information about the storing of Switching Stage information in the NRA. Provided the user is an authorised user of procedures to update the NRA (authority checking is carried out by the CDB) the user runs the input validation procedures which will report any errors of a syntactic nature on the input transaction file. Where errors occur corrections are made and the transaction file rerun until the errors are removed.

After the successful validation on the input transaction file, an entry is made on a WORKLIST indicating this transaction file is to be loaded into the NRA when the next BULKUPDATE run is carried out. Any number of input transaction files from any number of users may be created, and each file has a corresponding entry made on the WORKLIST.

Transaction files are normally prepared and validated in timeshare mode through the working day and used to update the NRA data base through BULKUPDATE which is automatically run each night.

Two types of traffic data files are produced from TDAS. These are from the DTR systems CENTOC, 10CDTR and TRAXE and from the detailed traffic measurement systems TRA, DETRAM and TRAXE. DTR produces one input traffic tape per week per State in addition to approximately 50 tapes per State per year on an ad hoc basis. Approximately 50-100 tapes from the detailed measurement systems are produced per State per year with higher numbers being generated pre-Easter and pre-Christmas when peak traffics occur in the network.

As tapes from TDAS for each State are available to load into TADMAR the State user will initiate a traffic input validation run to validate the format and some of the data content of the input tape. TADMAR identifies what parts of the network are being measured, from information on the incoming measurement tape, and then extracts the relevant network trunking details from the NRA, and attempts to match this information to that on the incoming tape.

Fig. 7 illustrates a typical report of errors. In the example it would be necessary to create, in the NRA, any circuit groups not already existing in NRA, using procedures previously described.

Once input traffic data files are properly matched with the NRA a SDF will be produced. At this point information will be forwarded to the SIA indicating that this particular traffic study (i.e. input traffic tape) has now been REGISTERED by TADMAR.

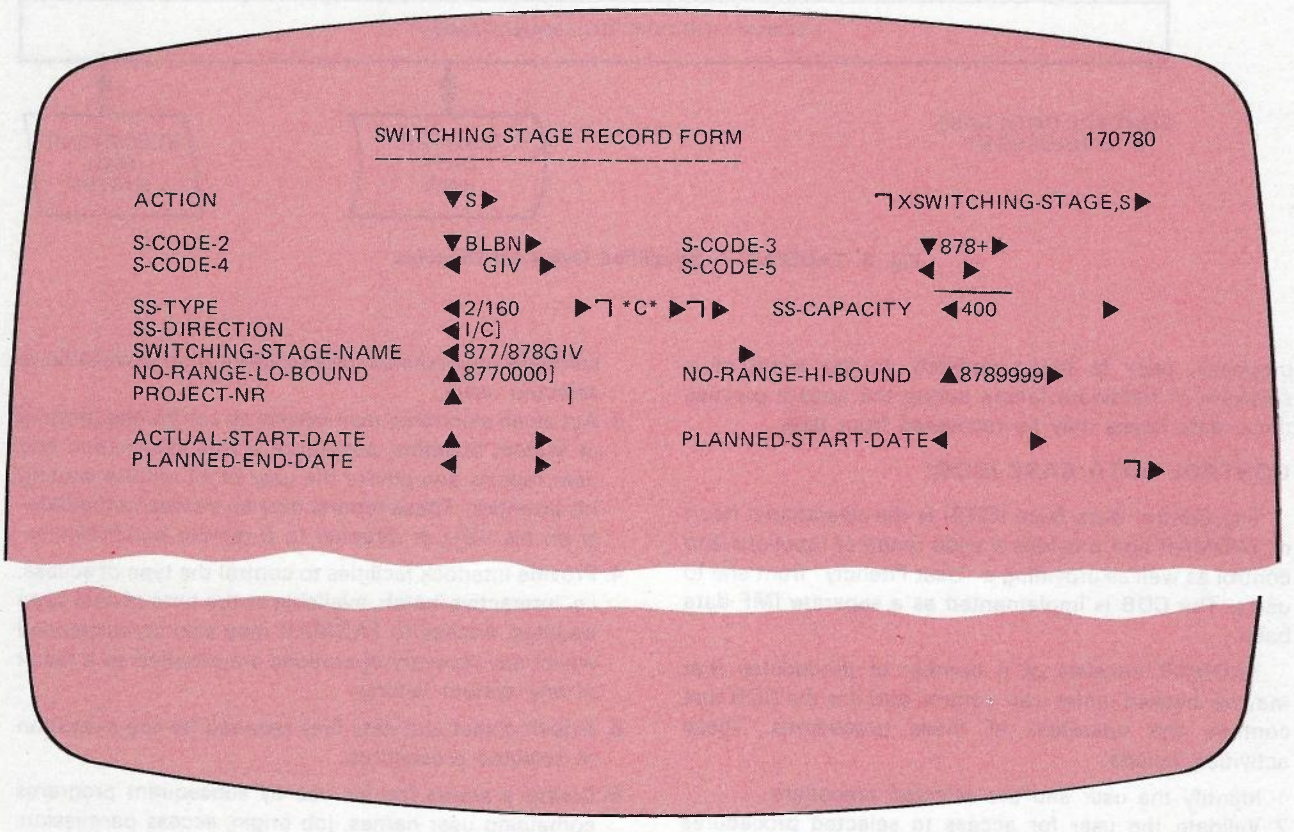


Fig. 6. Network Data Preparation — VDU Display.

```
                                   - - T A D M A R - -
REPORT  OD-00201          STRAPOC STATISTICS / ERROR REPORT               TDE
------                    ---------------------------------               ---
   STUDY ID: 3C840409095220     TITLE
                                -----
                      ERRORS DETECTED WHILE SCANNING THE STRAP FILE
                      ---------------------------------------------

EXCHANGE ZMEL NOT ON NRA - UNABLE TO INSERT REFERENCE INFO


                  MISMATCHES BETWEEN NRA AND STRAP      REPTERR: ALL
NRA GROUP         SDF GROUP                PORT/MON/GRP       COMMENTS
---------         ---------                ------------       --------

                  R:T CROX CROX E2          0541002  *M* MISSING ON NRA
R:T FOSC TOOR V1                            0402016  *M* MISSING ON STRAP
                  R:T FOSC YRAC V1          0402016  *M* MISSING ON NRA
R:T FTGC FTGY X1  NRA=00000/MEAS=00010      0501006      *W* CCTS MISMATCH
R:T HAMS HAMS Y1                            0661037  *M* MISSING ON STRAP
R:T KYAC SHPC X1                            0206015  *M* MISSING ON STRAP
R:T LONS LONS C1 A  NRA=00100/MEAS=00000    0731017      *W* CCTS MISMATCH
R:T LONS LONS C1 B  NRA=00100/MEAS=00000    0731018      *W* CCTS MISMATCH
R:T LONS LONS C1 C  NRA=00100/MEAS=00000    0731025      *W* CCTS MISMATCH
                  R:T MELA ADEA C1          0731045  *E* GROUP OCCURS TWICE
                  R:T MELA ADEA C1          0731045  *M* MISSING ON NRA
R:T MELA ADEA C2                            0731110  *M* MISSING ON STRAP
```

Fig. 7. Network Data Validation — Error Report.

Following the creation of a SDF, procedures are invoked to report and/or analysis measured traffics contained on the SDF either at the summary level (i.e. the TCBH traffic for each group for each session) or at the detailed level i.e. at the basic half hour level. **Fig. 8** illustrates examples of these reports.

Where adjustments to traffics have to be made due to a variety of fault conditions that may have occurred during the measurement period, e.g. circuits being blocked out of service or faulty TDAS equipment, it may be necessary to recalculate the TCBH traffic values and TADMAR provides facilities to automatically carry out these recalculations.

In the case of DTR studies, tests are carried out and exception reports produced where traffic values on the SDF exceed certain preset Erlangs/Trunk values or are outside limits based on traffic trends derived from the last 8 weeks of measurements as contained in the HDA.

Once data on the SDF is adequately validated and any necessary adjustments made, a study complete (STUDCOMP) procedure is run. This has the effect of automatically archiving the SDF to tape and generating up to two transaction files of selected traffic statistics to load into the NRA and HDA depending on the setting of special processing flags set in the NRA and which are carried forward through the SDF at the time the SDF is created. The creation of these transaction files places further entries onto the BULKUPDATE work list which controls the running of the BULKUPDATE run described in the next section.

Information is also written into the SIA to indicate the traffic study has been completed and onto what magnetic tape reels the SDF has been written.

Each night a BULKUPDATE run is initiated to update the NRA, HDA and SIA data bases with the transaction files created from both validated SDF's and network validation runs. Each transaction file input to bulk update is entered on a WORKLIST file, the contents of which can be examined and individual entries cancelled if required. This facility gives users the opportunity to delete particular transaction files from the update process if they subsequently discover some errors have been made on a particular transaction file. In this case a new transaction file can be created and included in the same bulk update run.

```
                                          - - T A D M A R - -
REPORT OD-0902                        TITLE - CENTOC STANDARD STUDY 02/04/84-08/02/84

OCCUPANCY STUDY SUMMARY OF RESULTS                                    ADJUSTED DATA
----------------------------------

GROUP NAME       WARN. CCT   TCBH  TRAFFIC TRAFFIC BUSY HOUR TFC   AVER   REF.
                 FLAG  QTY   START UNCORR  SCF     UNCORR    SCF   CCT    NUM.
                             TIME          CORR              CORR  OCCY

T ADEA MELA M2         00004 2130    2.69   0.00     2.81    0.00  0.00 0731065
T ADEA MELB M1         00132 1000   75.57   0.00    76.80    0.00  0.00 0731081
T ADEB MELA M1         00004 1900    1.67   0.00     2.01    0.00  0.00 0731066
T ADEB MELB M1         00010 1030    5.00   0.00     5.65    0.00  0.00 0731080
T ADEH MELA M1         00012 1930    8.11   0.00     8.27    0.00  0.00 0731067
T ALBA MELA M1         00020 2030   18.47   0.00    18.65    0.00  0.00 0731061
T ALBA MELB M1         00008 0900    6.12   0.00     6.40    0.00  0.00 0731068
T ALBC MELB M1         00026 0930   19.84   0.00    20.56    0.00  0.00 0731069
T AONA SHPC X1       * 00013 1900    6.11   0.00     7.33    0.00  0.00 0210053
T ARCI SHPC X1       * 00005 2100    2.08   0.00     2.19    0.00  0.00 0210054
T AVOA MARX X1         00017 1900    6.99   0.00     7.82    0.00  0.00 0208015
T AXDC AXDC E1         00013 0900    4.29   0.00     4.29    0.00  0.00 0301005
T AXDC AXDC RA         00100 0900    1.42   0.00     1.62    0.00  0.00 0301019
T AXDC AXDC RC         00100 1530    0.02   0.00     0.02    0.00  0.00 0301024
T AXDC AXDC RF         00100 0930    0.88   0.00     1.24    0.00  0.00 0301020
```

Fig. 8A. Route Traffic Summary Report.

```
                        - - T A D M A R - -                  RUN DATE 11/04/84.  PAGE NO. 001

REPORT OD-0903                    TITLE -
DETAILS OF TRAFFIC - TM50 :       GROUP -    T ADEA MELB M1                  EXCHANGE       -
ADJUSTED   DATA             DESCRIPTION -    ADELAIDE 1 10C -MELB 2 (R1678)  CONTROL END - S ADEA    OVN
GROUP-NO.   731081                           ------------------------------  NON CONTROL - S MELB 03  GI2
AVAILABILITY - FULL                                                          CIRCUIT QTY -    132
                                BH
DAY   DATE   MAX MIN UNAV  TRAFF                      HALF HOUR COMMENCEMENT TIMES


SESSION1                       :   0300
---------------
MON 02/04/84   0   0   0   0.00 :   0.00
TUE 03/04/84   1   0   0   0.10 :   0.10
WED 04/04/84   1   0   0   0.80 :   0.80
THU 05/04/84   2   0   0   1.00 :   1.00
FRI 06/04/84   1   0   0   0.60 :   0.60
                           -----------------
    AVERAGE TRAFFICS       0.50       0.50
    TCBH-START : 0300  TCBH TRAFFIC:  0.50

SESSION2                       :  0900   0930   1000   1030   1100
---------------
MON 02/04/84  86  26   0  71.70 : 31.70  63.10  75.00  68.40  67.50
TUE 03/04/84 108  25   0  81.90 : 40.40  65.90  88.20  75.60  72.90
WED 04/04/84  89  30   0  76.60 : 50.90  74.20  76.10  77.10  75.30
THU 05/04/84  97  23   0  77.65 : 36.00  85.00  70.00  73.00  82.30
FRI 06/04/84  94  22   0  76.15 : 34.00  68.70  72.90  79.40  72.70
                          ------------------------------------------
    AVERAGE TRAFFICS      76.80         54.99  73.91  75.57  74.42
    TCBH-START : 1000  TCBH TRAFFIC:  75.57

SESSION3                       :  1400   1430   1500   1530   1600
---------------
MON 02/04/84  82  37   0  65.35 : 47.20  60.90  65.20  65.50  65.00
TUE 03/04/84  87  39   0  71.45 : 53.00  68.00  74.90  68.00  71.10
WED 04/04/84  89  58   0  75.40 :  0.00* 71.40  77.40  73.40  65.20
THU 05/04/84  89  39   0  70.75 : 47.90  61.30  73.50  68.00  72.56
FRI 06/04/84  96  35   0  75.20 : 43.40   0.00* 69.70  77.00  73.40
                          ------------------------------------------
    AVERAGE TRAFFICS      71.63         56.64* 69.14* 71.26  69.92
    TCBH-START : 1500  TCBH TRAFFIC:  71.26

SESSION4                       :  1830   1900   1930   2000   2030   2100   2130   2200
---------------
MON 02/04/84  65  16   0  45.10 : 25.70  27.00  37.90  31.10  27.40  32.50  54.60  35.60
TUE 03/04/84  53  14   0  38.35 : 31.00  27.50  32.80  30.60  30.80  32.60  44.10  28.30
WED 04/04/84  55  20   0  40.40 : 30.20  30.20  26.60  35.90  25.40  25.60  44.90  35.90
THU 05/04/84  47  10   0  35.65 : 19.40  25.40  26.90  29.20  28.40  33.50  37.80  26.10
FRI 06/04/84  31   4   0  24.60 : 18.10  23.60  25.60  21.70  18.00  16.90  22.30  11.00
                          ---------------------------------------------------------------
    AVERAGE TRAFFICS      36.82         25.81  28.35  29.83  27.85  27.11  34.48  34.06
    TCBH-START : 2100  TCBH TRAFFIC:  34.48

    BUSIEST HOUR TRAFFIC:     76.80
    MAXIMUM TCBH START TIME: 1000    MAXIMUM TCBH TRAFFIC:   75.57
```

Fig. 8B. Detailed Route Traffic Report.

For security purposes, prior to the actual update of the data bases, their contents are automatically copied to tape under control of the CDB. In the event of hardware or software failures during the actual update process the databases may be recovered from tape.

Although the BULKUPDATE processes are mostly carried out at night, where there is an urgent operational need, selected users may elect to run the update during the working day. However, in this case users will not be able to access the data bases during the update process.

Processing carried out during the bulk update run ensures that the logical integrity of the data base models remain consistent. For example, any attempt to store a new switching stage for an exchange that does not exist in the data base will be rejected. Following the running of bulk update procedures each user will automatically receive reports indicating any errors for the set of transaction files.

NRA STRUCTURE

To enable a proper analysis of the traffic flowing in the network it is necessary to have a comprehensive model of the trunking of the network through which this traffic flows. The NRA database represents this model and is based on that information generally contained on exchange trunking diagrams. The development of this model, or conceptual schema, has involved a selection, naming and classification process resulting in the need to unambigiously define name and code the components that make up the network i.e. exchanges, switching stages, circuit groups, etc.

These definitions and associated network identification coding methods are now fully described in a series of Telecom Technical Publications Ref. (8) and an outline of the principles involved are contained in Ref. (9) titled, "A Standard identification Scheme for Transmission Paths."

Fig. 9 describes the model of the network in the NRA database. Each box represents a component of the

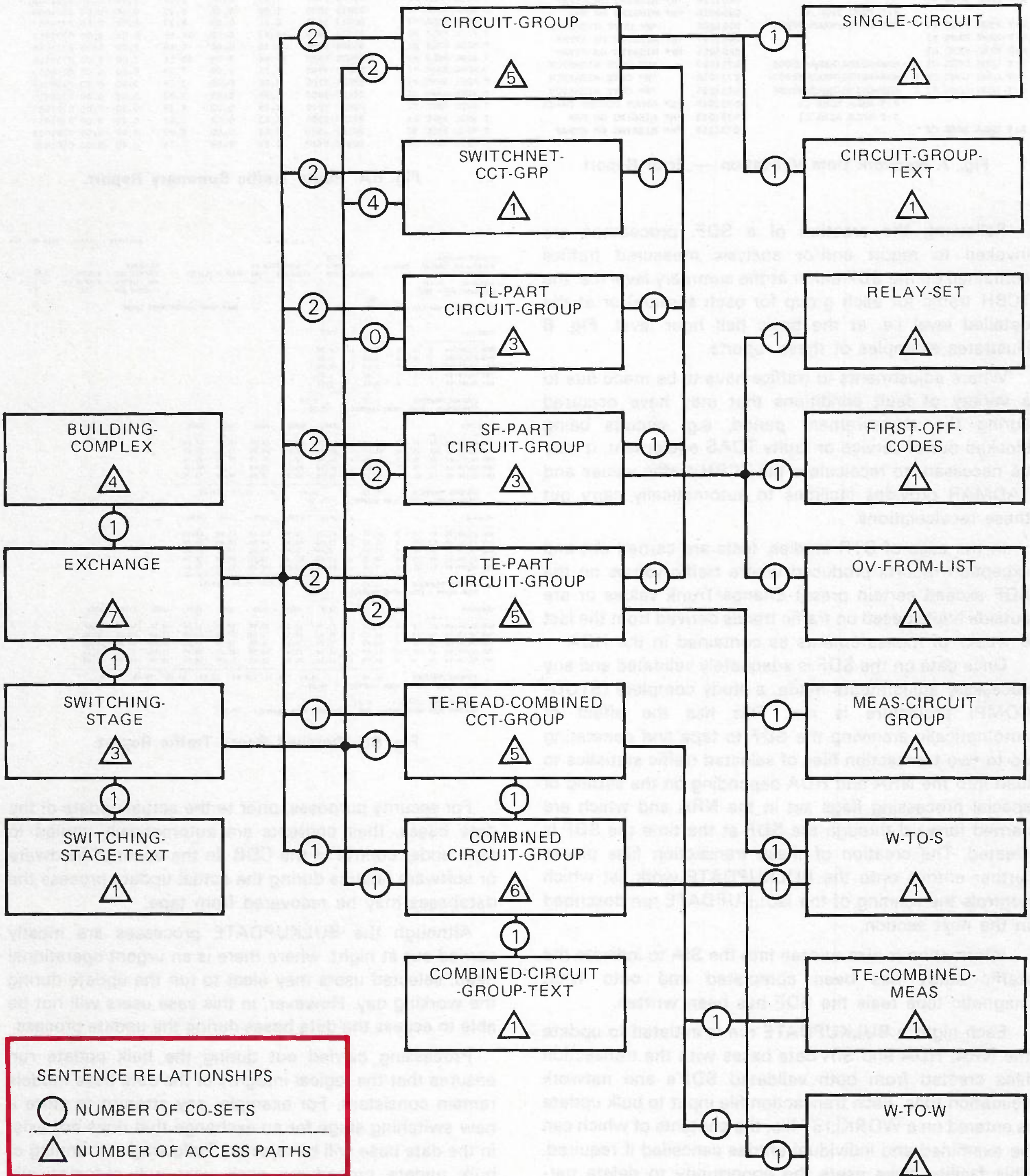


Fig. 9. Model of Network Trunking — NRA.

network or a description about a component of the network and represents a record, or a sentence in IMF terminology.

For purposes of updating or retrieving from the database one or more access paths are established into each sentence type as part of the external schema. In addition COSET relationships are established between various pairs of sentence types. The function of a COSET is to provide a means of navigation, for retrieval purposes between an owner sentence and the many occurrences of a member sentence in a two level hierarchy of sentence types.

Fig. 9 shows the various access paths and cosets between sentences in the NRA. This figure shows the default external schema. Other external schema may be established for particular application programs or users which consist of only a subset of these access paths and cosets.

Fig. 10 shows a typical switching stage sentence and its associated roles. One occurrence of the sentence is used to uniquely describe each of the many thousands of Switching Stages in the network with the roles S-CODE1 to S-CODE5 being the standard identification code used to uniquely identify each switching stage.

```
01  SWITCHING-STAGE
                   OBTAIN     IS PERMITTED
                   FIND       IS PERMITTED
    02  S-CODE-1                        PIC X(001)
    02  S-CODE-2                        PIC X(004)
    02  S-CODE-3                        PIC X(004)
    02  S-CODE-4                        PIC X(005)
    02  S-CODE-5                        PIC X(002)
    02  SWITCHING-STAGE-NAME            PIC X(030)
    02  SS-TYPE                         PIC X(010)
    02  SS-INLETS-CAPACITY              PIC 9(005)
    02  SS-OUTLETS-CAPACITY             PIC 9(005)
    02  SS-SUBS-CAPACITY                PIC 9(007)
    02  SS-ORIG-RATE                    PIC 9(001)V9(003)
    02  SS-TERM-RATE                    PIC 9(001)V9(003)
    02  SS-NO-RANGE1-LO-BOUND           PIC X(007)
    02  SS-NO-RANGE1-HI-BOUND           PIC X(007)
    02  SS-NO-RANGE2-LO-BOUND           PIC X(007)
    02  SS-NO-RANGE2-HI-BOUND           PIC X(007)
    02  SS-SWNET-RESPONSE-CODE          PIC X(001)
    02  SS-CONTROL-STATE                PIC X(003)
    02  SS-ACTUAL-START-DATE            PIC X(006)
    02  SS-ACTUAL-END-DATE              PIC X(006)
    02  SS-UPDATE-DATE                  PIC X(006)

ACCESS PATH NAME IS       A2004
  SEARCH KEY IS           S-CODE-2
                          S-CODE-3
                          S-CODE-4
                          S-CODE-5

  ORDER IS ASCENDING

ACCESS PATH NAME IS       C0011
  SEARCH KEY IS           S-CODE-2
  ORDER IS ASCENDING
  SYNONYMS ORDERED BY     S-CODE-3
                          S-CODE-4
                          S-CODE-5

ACCESS PATH NAME IS       I2004A
  SEARCH KEY IS          SS-SWNET-RESPONSE-CODE
  ORDER IS ASCENDING
  SYNONYMS ORDERED BY    S-CODE-2
                         S-CODE-3
                         S-CODE-4
```

Fig. 10. Switching Stage Sentence.

SYSTEM OUTPUTS AND APPLICATION PROGRAMMES

As a subject data base of traffic and trunking information TADMAR has a capability of producing output reports directly either on a VDU or hardcopy, or providing interfaces into specifically developed application programs.

Currently a number of application programs have been developed to meet specific needs, however, it is expected as this new generation of traffic systems are more fully implemented into the network and a larger base of traffic information is established in TADMAR, new reports and application programs will be developed, particularly to support the emerging network management functions as well as the traditional needs of the network planners.

The following are two examples of application programs currently developed.

i. Network Congestion Monitoring

One of the early applications of DTR has been in the monitoring of the performance of the trunk network against the Maximum Allowable Grade of Service (MAGOS) standards.

This application consists of extracting the past four weeks TCBH traffics on backbone and fully dimensioned trunk routes from the HDA together with the number of circuits on the route, mean to variance ratio of traffic and design grade of service for each route. The actual grade of service of each route is then calculated based on the average of the TCBH traffics for the past four weeks. **Fig. 11** shows a typical output report from this process. The results from these calculations are finally returned to the HDA for use in other reporting processes.

This particular procedure is generally run at the end of each Engineering Period, however, users may elect to run the procedure more frequently if required.

To support quarterly reporting procedures from States, to the Headquarters Operation Sub-Committee, graphical output may be produced showing the number of trunk routes exceeding design limits over each engineering period for up to two years. **Fig. 12** shows a typical output.

- - T A D M A R - -

TRUNK NETWORK CONGESTION REPORT SUMMARY - NON-CONCESSIONAL TRAFFIC

REPORT OD-06302 TITLE - CONGESTION REPORT

PERIOD ENDING 25/02/84 FOR STATE OF VICTORIA

	ORIGINATING EXCHANGE	TERMINATING EXCHANGE	ORDER LAST PERIOD	NO OF CCTS	CONGESTION EST AVG % TCBH
1	WONTHAGGI	MELBOURNE 4	0	04	15-20
2	WINDSOR	NORTH MELBOURNE	0	50	5-7
3	MELBOURNE 4	PAKENHAM	0	33	5-7
4	MELBOURNE 4	WINDSOR	0	30	5-7
5	MELBOURNE 4	NORTHCOTE	0	16	5-7
6	NORTHCOTE	CITY WEST	0	20	3-5
7	WINDSOR	WINDSOR	0	180	2-3
8	WINDSOR	CITY WEST	0	32	2-3
9	MORWELL	YARRAM	0	22	2-3
10	MELBOURNE 3	NORTH MELBOURNE	0	11	2-3
11	SHEPPARTON	DENILIQUIN	0	05	2-3
12	WANGARATTA	BENALLA	0	53	1-2
13	HAMILTON	HAMILTON	0	45	1-2
14	BENDIGO	COBRAM	0	21	1-2
15	HEALESVILLE	MELBOURNE 4	0	06	1-2
16	WANGARATTA	WANGARATTA	0	88	.2-1
20	SHEPPARTON	SHEPPARTON	0	60	.2-1
21	HAWTHORN	HAWTHORN	0	40	.2-1
24	FRANKSTON	FRANKSTON	0	28	.2-1
26	CITY WEST	MELBOURNE 1	0	24	.2-1
31	NORTH MELBOURNE	CITY WEST	0	18	.2-1
32	NORTHCOTE	NORTH MELB L11	0	13	.2-1
33	NORTH MELBOURNE	NORTH MELBOURNE	0	10	.2-1

THERE ARE 23 ROUTES WITH CONGESTION ABOVE THE NON-CONCESSIONAL DESIGN GRADE OF SERVICE.

THE NUMBER OF CONGESTED GROUPS REQUESTED WAS 283

THE TOTAL NUMBER OF ROUTES CHECKED WAS 283

Fig. 11A. Route Congestion Report.

-- T A D M A R --

RUN DATE 16/03/84. PAGE NO. 002

REPORT OD-06301 TITLE - CONGESTION EXCEPTION REPORT PERIOD 094 END 25/02/84 LAST UPDATE 16/03/84

ORDERED ON EXCHANGE CUTOFF CONGESTION LEVEL = DESIGN GOS

EXCHANGES ORIG-TERM	DIM CAT	TELEPHONE CIRCUIT GROUP	RTE NO.	COM'D CCTS	WKG CCTS	WEEK	MEAS ERLANGS TCBH	TCBH	V/M USED	GOS DESIGN D	GOS DESIGN N	ESTIM AV D N	OVERLOAD (GOS) CURRENT PERIOD D	OVERLOAD (GOS) CURRENT PERIOD N	RANK AV. PREVIOUS PERIOD D	RANK AV. PREVIOUS PERIOD N
	F	T BGNA BENB Y2		0040	0040	1 D	17.11	0930	2.000	0.5	0.5	0-.2	180	20	0	0
BENDIGO-BENDIGO						2	20.77	0930								
						3	19.83	0930								
						4	21.72	1000								
						1 N	30.64	2100				7-10				
						2	31.90	2100								
						3	30.71	2100								
						4	31.50	2100								
	F	T BGNA COBC C1		0021	0021	1 D	8.80	1000	2.000	1.0	5.0	1-2	14	23	0	0
BENDIGO-COBRAM						2	9.83	0900								
						3	10.60	0900								
						4	10.80	0930								
						1 N	13.30	2100				7-10				

Fig. 11B. Route Congestion — Detailed Exception Report.

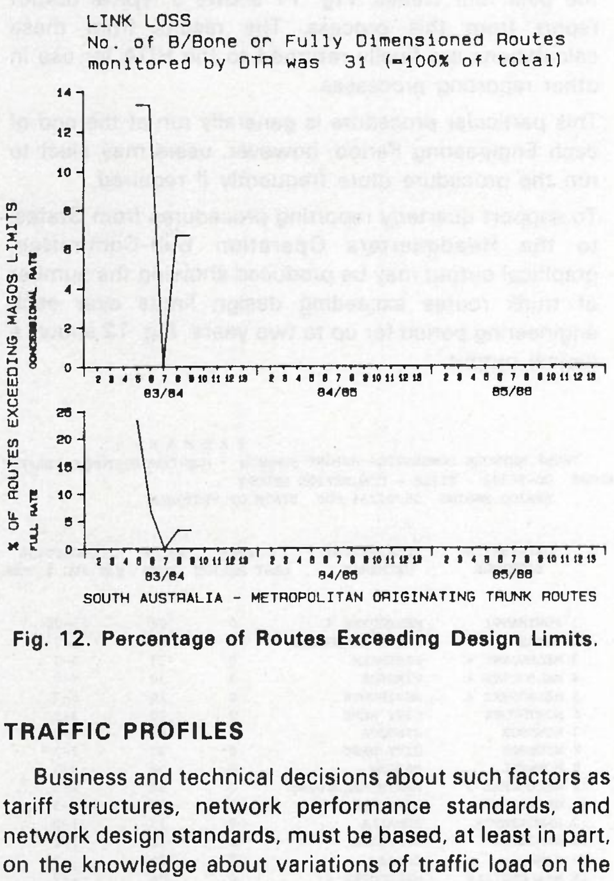


Fig. 12. Percentage of Routes Exceeding Design Limits.

TRAFFIC PROFILES

Business and technical decisions about such factors as tariff structures, network performance standards, and network design standards, must be based, at least in part, on the knowledge about variations of traffic load on the network throughout the day, week and year. TADMAR provides a number of outputs in graphical form, that indicate these variations in load, which may be used as part of the various decision making processes.

Fig. 13 shows a typical graph of the hour to hour traffic (over a week) on the incoming high usage routes to the Sale Minor Switching Area.

This graph is produced by selecting from the relevant SDF, the circuit group for which a traffic profile is required and down loading this information onto a VDU floppy disc file. Graph plotting software also contained on the floppy disc is then used to plot the required graphs in an off line mode using a graph plotter connected to the VDU.

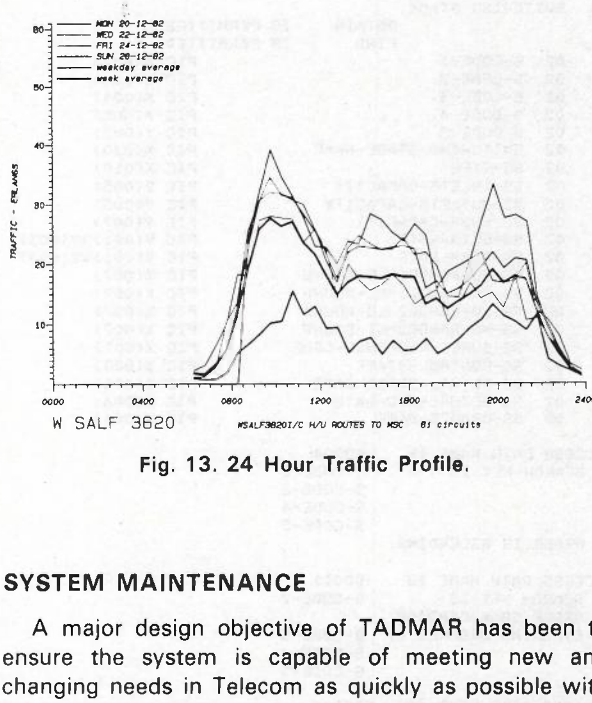


Fig. 13. 24 Hour Traffic Profile.

SYSTEM MAINTENANCE

A major design objective of TADMAR has been to ensure the system is capable of meeting new and changing needs in Telecom as quickly as possible with minimal disruption to the operational system and a number of features have been included facilitate meeting this objective.

Development, test and production versions of TADMAR software exist concurrently in the overall TADMAR system and access to the various versions of software is controlled by the Control Data Base (CDB). This allows a relatively simple process to develop, test and incorporate new or amended procedures or reports into the production system. In many cases this new or amended software will be developed directly by users. In addition, any new or amended software put into the production system can then be made available to other users under control of the CDB.

In a data base environment this general maintenance of the data base is carried out as part of what is called data base administration function. Other functions included in these activities provide for such things as system tuning, user education, etc. Currently this function is split between the HQ development team and staff in each State Traffic Engineering group and is designed to support a wide base of users.

ACKNOWLEDGEMENTS

The author wishes to acknowledge the significant contribution to the development of the TADMAR project by the consultant team from the Consulting Services Division of Control Data Australia Pty. Ltd., and to Mr H. O. Chamberlain, Senior Technical Officer, Grade 3, of the Headquarters Traffic Engineering Application Section.

CONCLUSION

Data base management techniques have been applied to the development of TADMAR as an integral part of a new generation of traffic data gathering and analysis systems to service Telecom through the 1980s.

TADMAR provides ready access to significantly more comprehensive traffic information, on a timely basis, than previous systems, and considering the relatively high cost in the collecting and analysis of this data, the challenge is now to exploit to a maximum the use of these new traffic systems in such areas as network management, traffic forecasting, tariff setting and network design and thus assist Telecom in meeting its corporate objectives.

REFERENCES

1. G. A. BENJAMIN — Telephone Traffic Measurements in the 1980s, The Telecommunications Journal of Australia, Volume 33, No. 3 1983.
2. R. O. G. JACOBS — The CENTOC Daily Traffic Recording System, The Telecommunications Journal of Australia, Volume 33, No. 3 1983.
3. C. W. PRATT — Development and Application of Telephone Traffic Measuring Equipment Part I, The Telecommunications Journal of Australia, Volume 23, No. 3.
4. L. TYRELL — Development and Application of Telephone Traffic Measuring Equipment Part II, The Telecommunications Journal of Australia, Volume 24, No. 1.
5. J. BRIDGFORD, G. MONSBOURGH, K. RAY, J. SERVILL — A Summary of Computer Applications in Telecommunications Planning.
6. R. G. ROSS — Data Base Systems — Design Implementation and Management.
7. Modelling in Database Management — Edited by G. M. NIJSSEN — Proceedings of the IFIP Working Conference on Modelling in Data Base Management Systems.
8. Standard Identification Schema for Transmission Paths Telecom Technical Publications TPH 0027.
9. Hart and Hayes, A Standard Identification Schema for Transmission Paths, The Telecommunication Journal of Australia, Volume 33, No. 3, 1983.

Caution in rapid charging of nickel-cadmium sealed batteries

K. G. MOTTRAM
Telecom Australia Research Laboratories

Small Nickel-Cadmium sealed batteries are frequently used in industry and at home. When the cells are discharged, they can be recharged at moderate currents and usually over an extended period, say overnight. However, sometimes there is a temptation to recharge the batteries rapidly and at conditions which can be hazardous. The purpose of this article is to briefly discuss electrochemical batteries in general, and describe the particular problems met when charging sealed nickel-cadmium batteries.

Primary cells can only be discharged once, and are discarded when their charge is exhausted. The electrochemical reactions are not reversible. The most popular types are carbon/zinc and 'alkaline' cells, and these are used for low to medium current drain applications. Typical uses are for powering torches, portable electric instruments, portable radios and small toys.

In secondary cells the electrochemical reactions are reversible and consequently they can be recharged after discharge. The most widely used types are lead-acid and nickel-cadmium. Common uses are for electric power storage in motor vehicles, telephone exchanges, solar-powered microwave repeaters, portable power tools and portable measuring instruments. In contrast to primary cells, these are used where relatively higher currents are required, or for economy, a rechargeable battery is justified.

The nickel-cadmium cell comes in two configurations, vented or sealed. The vented cells work only in an upright position and at a low internal pressure of 0-70 kPa (0-10 psi). During charging the vent will open and close as gas pressure, resulting from the generation of hydrogen and oxygen, increases and is relieved. Water must be added regularly to maintain the electrolyte volume. Vented cells are used for starting engines, powering switching in electric power generation, where mass precludes the use of lead-acid cells or where an almost constant potential discharge characteristic is desirable.

Sealed cells can work in any orientation and are generally smaller than the vented cells. Maximum approximate capacities are: button cells 1 Ah, cylindrical cells 7 Ah and rectangular cells 50 Ah. The pressures that can be generated in sealed cells can reach very high values. Typical mIximum values to be expected are: button cells 7.5 MPa (1100 psi), cylindrical cells 2 MPa (290 psi), and rectangular cells 600 kPa (90 psi); **Fig. 1** shows a button cell, tested in the Telecom Research Laboratories, which exploded at 2.5 MPa (370 psi). For safety purposes some manufacturers provide an emergency vent in sealed cells, but during normal operation a sealed cell does not permit venting of gas to the atmosphere. If the vent in a sealed cell does operate, permanent damage will frequently result.

During charging, energy conversion at the negative electrode is almost 100% efficient. As a result, hydrogen is only evolved when the negative electrode is fully recharged. In the design of sealed cells, it is common for the negative electrode capacity to be about 1.4 times that of the positive electrode, so that during normal operation hydrogen is never evolved as the negative electrode is never fully charged, even though the cell itself may be fully charged. In contrast, energy conversion at the positive electrode is far less efficient and oxygen is evolved long before the positive electrode is fully charged. The oxygen diffuses to the negative electrode where electrochemical recombination with water takes place to form hydroxyl ions, and this reaction generates heat. When the cell is fully charged, further charging will result in a rapid rise of temperature. The faster a cell is recharged, the faster it generates oxygen. Very high internal pressures will result if the rate of oxygen generation exceeds the rate of oxygen recombination.

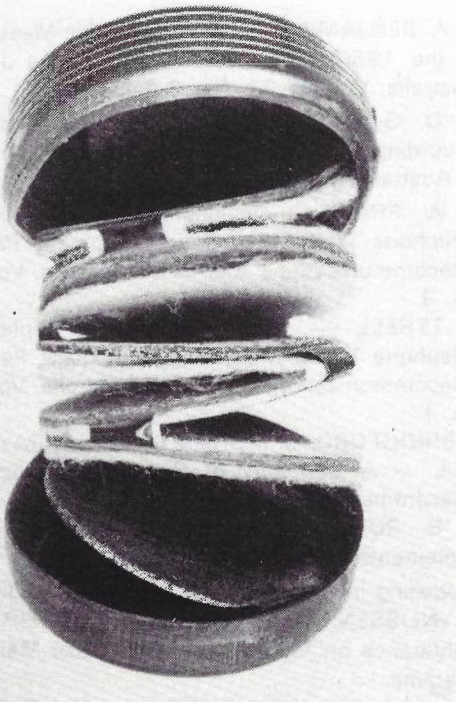


Fig. 1 Button Cell Which Exploded at 2.5 MPa (370 psi)

With sealed nickel-cadmium cells it is possible to modify the performance by altering the internal construction. For example the electrodes may be solid or sintered. Hence a cell manufacturer can design for vastly different charging rates or oxygen recombination rates depending on what specific properties are sought.

Thus a particular manufacturer may produce one size of cell, e.g. D size, with a number of different internal configurations, and consequently these cells are capable of being recharged at quite different rates. One manufacturer produces cells, with different internal structures, which can be recharged in 10-14 hours, 3-5 hours and 15-30 minutes respectively.

Cells requiring recharging times of 10-14 hours and 3-5 hours can be charged at the manufacturer's recommended current magnitude, through simple circuits preferably incorporating a timer. Once these cells are fully charged, their temperature and internal pressure will start to rise, but their construction is such that they can sustain a period of overcharge at the recommended current without damage.

Cells for fast recharging rates are designed for enhanced rapid oxygen recombination, which in turn leads to rapid temperature rise once the cell is fully charged. Circuits for rapid charging of this type of cell should include both potential sensing and temperature sensing facilities, charging being automatically terminated once either limit is reached. Both parameters need to be monitored for safety, because of the complex interdependency of charge rate, cell temperature, cell design, degree of cell matching, peak cell voltage and cell voltage characteristic, as well as cell ageing characteristic. **Fig. 2** illustrates the behaviour of three of these parameters during fast charging.

For safety reasons the cell manufacturer's recommendations for maximum charging currents and times for sealed nickel-cadmium cells must be strictly observed. Circuits for rapid charging of special fast charge cells must include potential and temperature safety sensors. Rapid charging of cells which are not designed for this purpose is dangerous as the risk of exploding a cell and the consequent hazard from spattering of caustic electrolytes is very real.

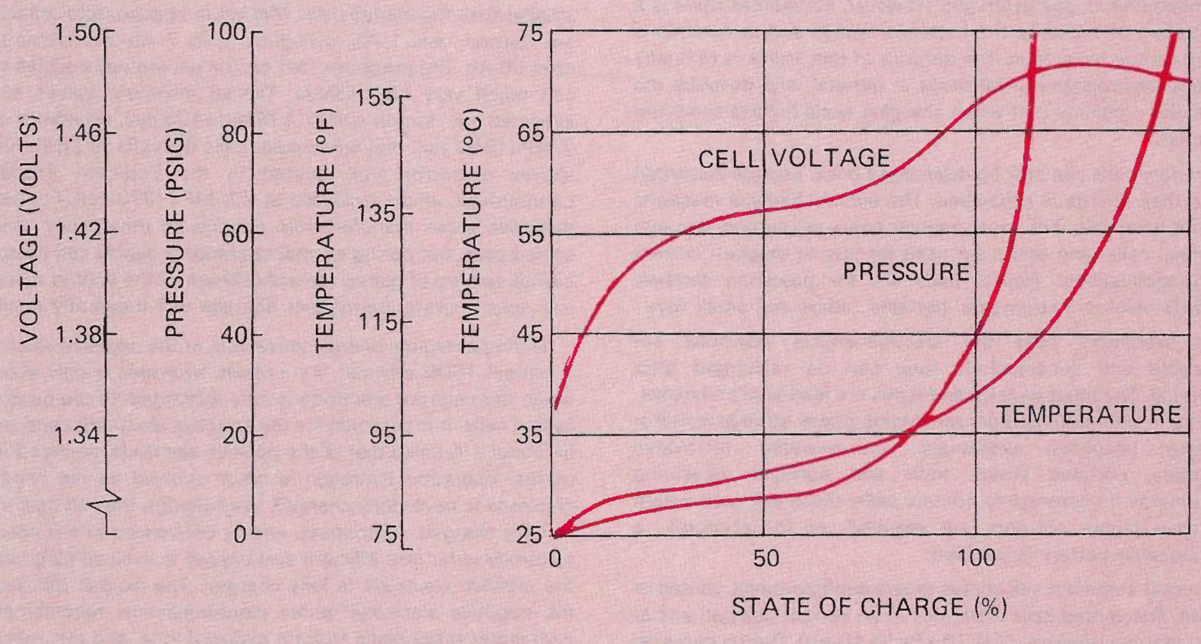


Fig. 2 Sealed Cell Parameters during Fast Charging

(Reproduced with the kind permission of GEC Australia Ltd.)

Individual Circuit Monitoring

B.F. GRIMSHAW

Individual Circuit Monitoring (ICM) is a technique for obtaining accurate information on the performance of telephone exchange traffic circuits and common control equipment under live traffic conditions.

It provides a cost effective means of maintaining a higher proportion of workable equipment in service than would otherwise be the case. This article describes the basic principle of ICM and details he application of the technique in the Australian telephone network.

INTRODUCTION

Telephone exchange traffic circuits or common control equipment which develop faults that remain undetected for lengthy periods, can have a significant impact on the performance of the telephone network. This overall performance can be influenced by some equipment failures causing traffic circuits to have low customer holding times and thereby attract more traffic than would normally be expected. Within this concept equipment performing in this manner is classed as being a "KILLER" while other equipment failures which totally prevent or limit customer usage are categorised as being "ALWAYS IDLE", "ALWAYS BUSY" or "SLOW RELEASE". **Fig. 1** shows typical examples of these various conditions which are generally termed "EXCEPTIONS" to the normal.

The early identification of malfunctioning equipment is a desirable and prime objective of any telephone exchange maintenance program. ICM provides a means of achieving this maintenance objective by enhancing the existing service indicators and supplying accurate information on the performance of the equipment being monitored. The information supplied by ICM allows the available staff resources at any one time to be directed to the malfunctioning equipment which is having the most adverse effect on service. This results in a cost effective means of maintaining a higher proportion of workable equipment in service than would otherwise be the case.

APPLICATION OF ICM IN THE AUSTRALIAN NETWORK

The ICM technique was first developed in the USA during 1972 and following the encouraging results obtained, Telecom Australia decided in 1975 to field trial two different ICM systems in New South Wales and Victoria. Evaluation of the field trial results indicated that there had been a significant improvement in the availability of traffic circuits connected to exchanges equipped with ICM.

Subsequently in 1983 Telecom approved the installation of permanent ICM equipment in their major SPC and electromechanical Trunk Switching Exchanges (Comprising Metaconta 10C and L.M. Ericsson ARM 20 Equipment), plus Minor switching centres (generally ARF/ARM 50 Equipment) with greater than 500 trunk and junction circuits. The Telesciences AUTRAX ICM system was selected for use in New South Wales, Victoria and Queensland, while the ALMGREN ICM system was selected for development and installation in the remaining states. In addition approval was given for the provision of a portable ICM Unit — ALSTON Model 615 (500 inlets) on the basis of one unit per Telecommunications District. Telecom has approximately 80 such Districts, with typically the larger metropolitan districts consisting of 15 to 20 terminal telephone exchanges with a total of 120,000 customers per district.

Telecom has established maintenance guidelines for the most efficient use of ICM equipment in the Australian telephone network. This policy specifies that for every exchange using ICM the following equipment should be monitored:

- **All Emergency traffic circuits;**
- **All Outgoing traffic circuits;**
- **All Traffic Setting ("Z" point) traffic circuits;**
- **All Common Control Equipment.**

The exact exchange monitoring points, together with the recommended maintenance procedures are detailed in the Telecom Technical Publications relating to the Operation and Maintenance of telephone exchanges. (Refer — Publications listed under "Further Reading").

BASIC PRINCIPLE

The basic principle of ICM when applied to telephone exchange equipment maintenance is that similar items of equipment should over a sufficiently large time period, exhibit similar call holding times. Items of equipment which are never seized, permanently seized or having holding times significantly at variance with the normal are presumed to be worthy of investigation, possibly faulty. The data collected to determine the holding time calculations is usually derived from a single wire input per device and is generally either a seizure, busy/free test point, statistical meter or equipment timeout lead. The normal busy/idle or statistical meter pulse conditions occurring on each input are recorded in an associated buffer storage area.

Each storage area consists of FOUR memory buffers for each input. Two of these buffers are used for storing the EVENT and USAGE data during the current study period and are termed the ACTIVE buffers. The other two

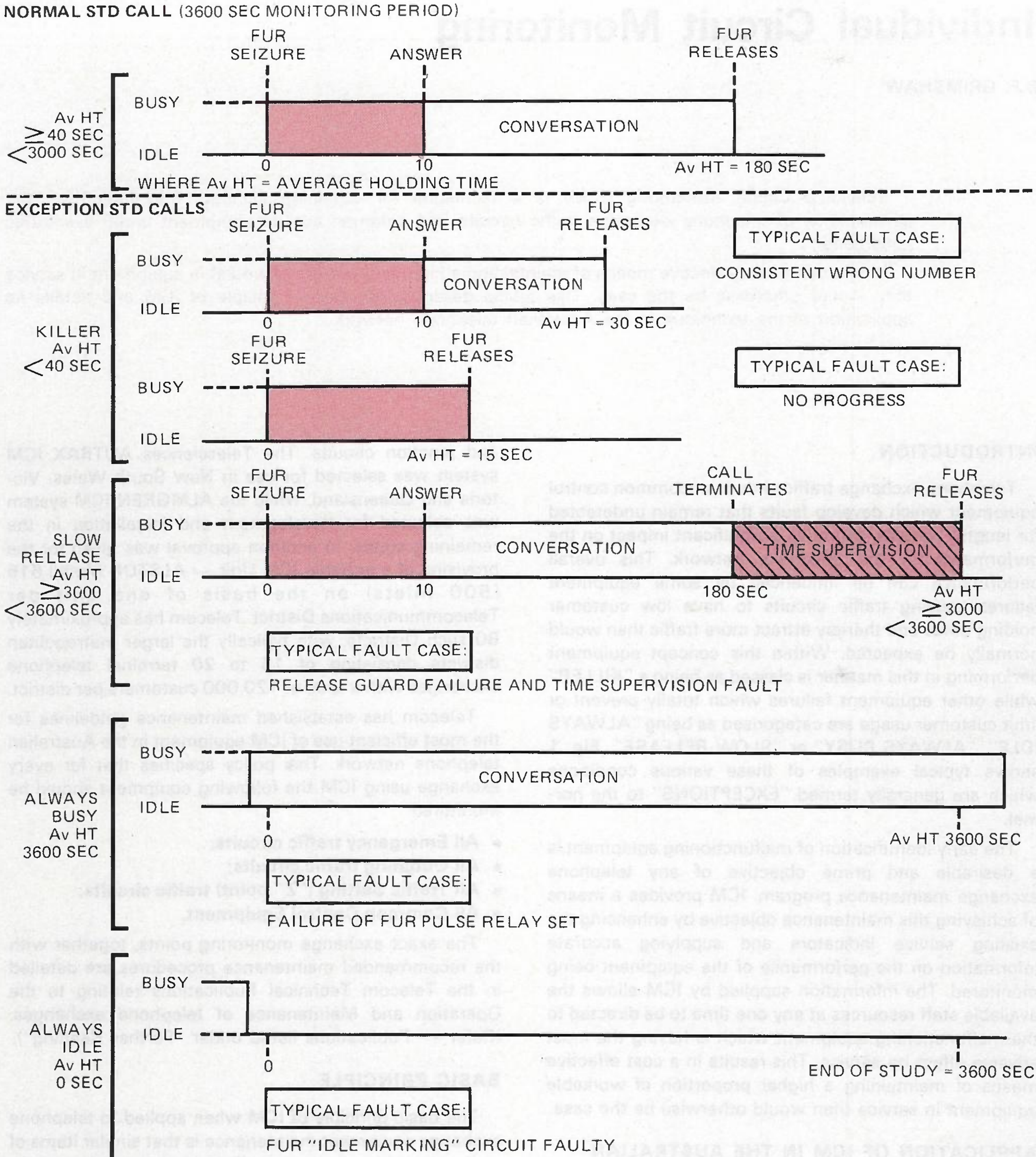
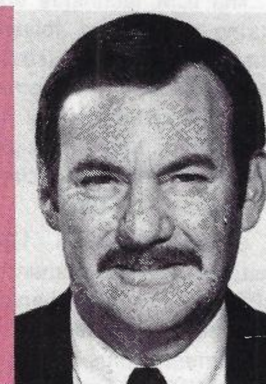


Fig. 1 — Typical Examples of ICM Exceptions.

B. F. GRIMSHAW is a Senior Technical Officer Grade 2 in the Network Operations Branch, Telecom Australia, Headquarters. He joined the PMG Department as a Technician in Training in 1963 and was attached to the Victorian Country Branch. Between 1963 and 1981 he was involved in the maintenance of LOCAL and TRUNK SWITCHING exchanges and spent 6 years with the Network Performance Group (Victoria), before joining the Trunk Service Section in that state in 1977. He gained experience with ICM equipment while a Senior Technical Officer Grade 1 at the Melbourne ARM Trunk Exchange. He joined the Exchange Switching Service Section at Headquarters in 1982 and currently specialises in all Trunk Switching aspects within that group.



buffers are used for storing the data collected from the previous study period and are termed the PASSIVE buffers.

Fig. 2 shows the basic network connection and data flow areas used in the Telesciences AUTRAX system. In this system when the Central Data Control (CDC) centre is scheduled to interrogate a remote site the relevant exchange ICM terminal is POLLED. As the terminal data is received it is first validated then sent to both the NEW DATA and ACCUMULATED DATA Areas on disc. From these areas the data can be transferred to the DATA QUEUE and subsequently sent to the magnetic tape for later downstream processing.

Alternatively the data can be immediately processed to determine if any "Exception or Performance" reports are required to be formatted and sent to the relevant

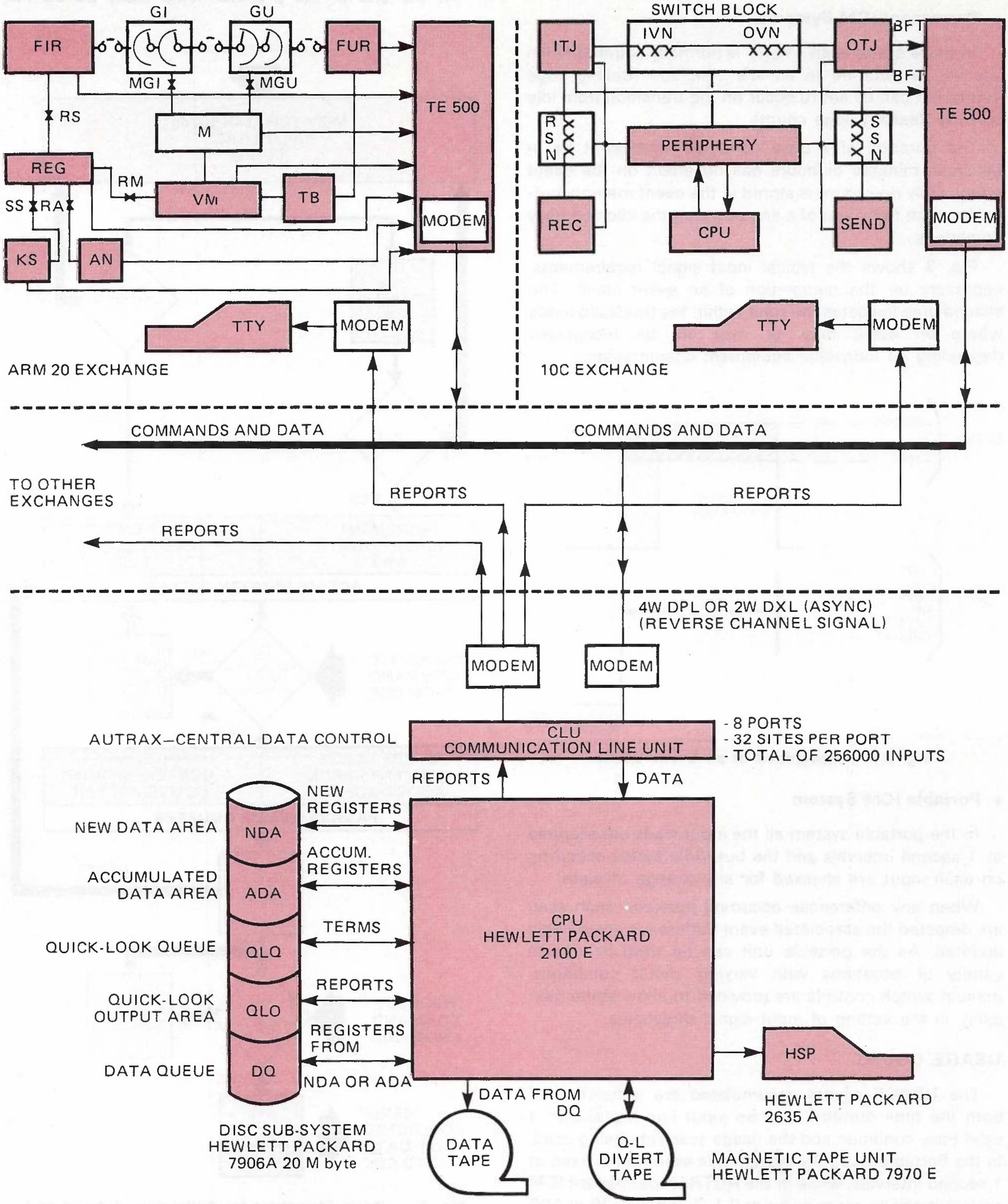


Fig. 2 — AUTRAX ICM System.

maintenance control centre for attention. This reporting technique is referred to as the QUICK LOOK function of the AUTRAX system.

EVENT MONITORING

In all the ICM systems an EVENT is a condition whereby a line goes busy for a duration of time, then returns to an idle condition. The methods used to gather this information differ depending on the ICM system used.

• Permanent ICM Systems

In these systems an EVENT is normally counted when the line is returned to an idle condition (trailing edge count) but can be set to occur on the transition from idle to busy (leading edge count).

The duration of a busy condition whether it be in seconds, minutes or hours has no effect on the event count. Only one count is stored in the event memory buffer for each transition of a line between the idle and busy conditions.

Fig. 3 shows the typical input signal requirements, necessary for the recognition of an event count. The shaded area indicates the zone within the threshold limits where an event may, or may not be recognised depending on individual equipment characteristics.

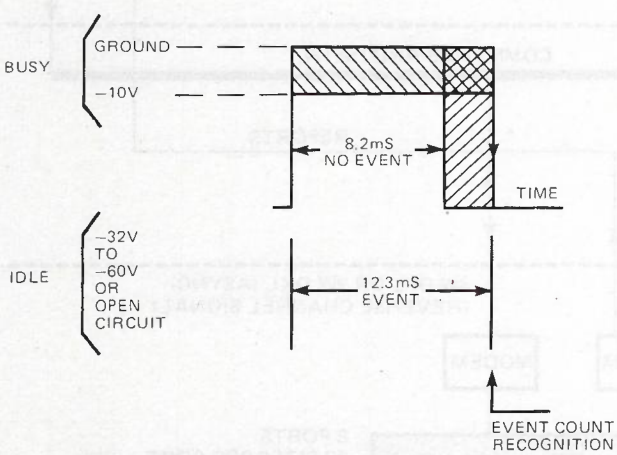


Fig. 3 — Recognition of an Event Count.

• Portable ICM System

In the portable system all the input leads are scanned at 1 second intervals and the busy/idle states occurring on each input are checked for any change of state.

When any differences occurring between each scan are detected the associated event buffers are accordingly updated. As the portable unit can be used in a wide variety of situations with varying circuit conditions, manual switch controls are provided to allow some flexibility in the setting of input signal thresholds.

USAGE COUNT

The USAGE counts accumulated are a function of both the time duration that an input line has shown a valid busy condition and the usage scan rate being used. In the Portable ALSTON system this scan rate is fixed at 1 second intervals, while in the AUTRAX permanent ICM system it can be set to occur at 0.1, 1, 3.6, 10, 36 or 100 seconds, depending on the type of equipment being monitored. (Traffic circuits would normally be set at a 10 second scan rate). The accumulated counts stored in each register buffer represent the period of time that the associated input lead was busy during a specific time interval. A count is inserted in the associated usage buffer each time a scan cycle is activated and an input is in a busy condition. The number of counts recorded for an input represents the total number of busy conditions encountered during the specific study period.

At the end of the predetermined study period the

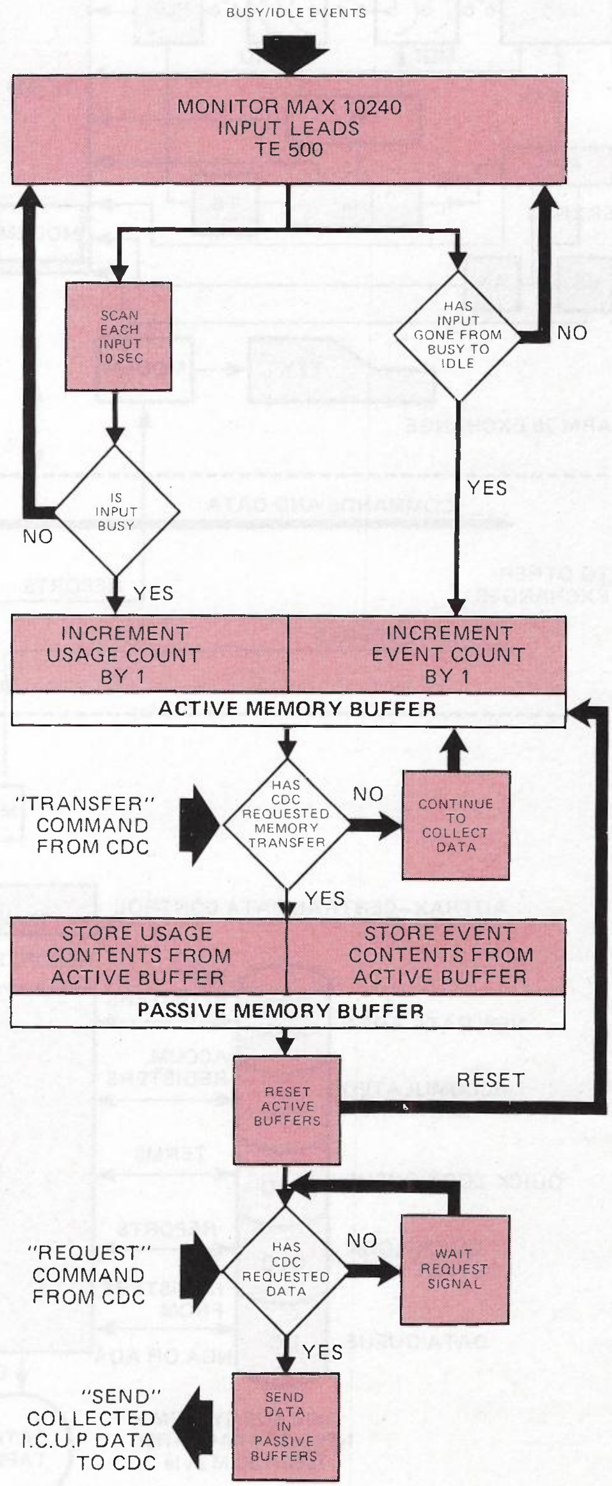


Fig. 4 — Basic Flowchart for Collection of Event and Usage data.

EVENT and USAGE data will be transferred to the Central Data Control (CDC) centre of the permanent system or the processor section of the portable unit, where the calculation process will be applied. **Fig. 4** shows a basic flowchart for the collection of EVENT and USAGE data as used in the AUTRAX system TE500 exchange terminals. These ICM terminal inputs are continually monitored for EVENT counts and scanned every 10 seconds for USAGE counts. All valid conditions are stored in the associated Active memory buffer.

When the CDC polls the terminal it will send a "Memory Transfer" command which causes the terminal "Active" memory data to transfer into the "Passive" memory buffers. The Active buffers are then "Reset" and the input monitoring process continued. When the CDC is ready to receive the data it will send a "Data Request" command which causes the "Passive" memory data to be transmitted at a speed of 1200 Baud to the CDC for analysis.

ICM CALCULATIONS

Typical processing which can be carried out by the ICM equipment may consist of one or more of the following calculations.

- **Individual Circuit or Device Occupancy**
  This calculation uses the EVENT counts and typically is applicable for the collection of individual statistical meter registrations.

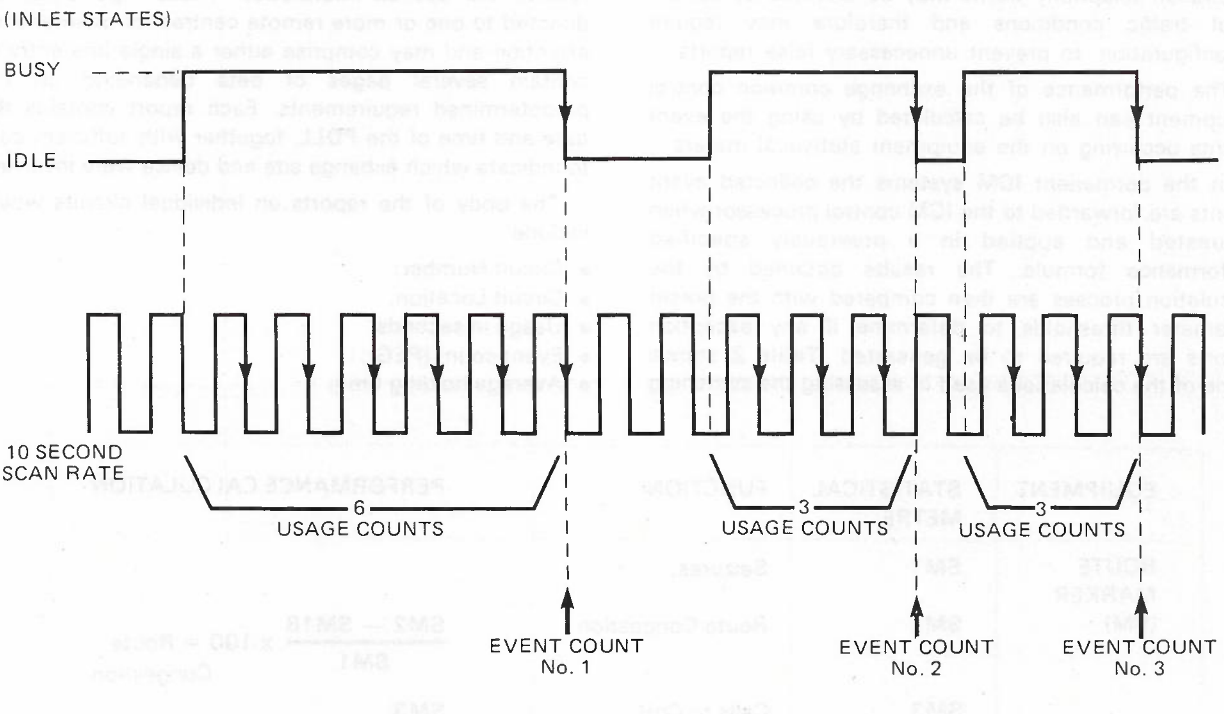
- **Individual Circuit or Device Holding Time**
  This calculation uses the USAGE counts and typically is applicable for individual circuit or device traffic studies. The information calculated can be presented in Minutes, Seconds or Erlangs as required.

- **Group Occupancy**
  This calculation provides the EVENT count information on a Group basis and typically is used to obtain statistical information such as the "Total Number of Calls" switched by a particular exchange, or the calculation of "Route Time Congestion" on specific routes.

- **Group Holding Time**
  This calculation provides the USAGE count information on a Group basis and typically is used for the accurate dimensioning of traffic routes.

- **Crossed Leads**
  This calculation checks each input against all others for the same EVENT and USAGE count, which could indicate a crossed connection between two or more exchange devices.

- **Circuit or Device Exceptions**
  In this calculation both the EVENT and USAGE counts are processed to determine the AVERAGE HOLDING TIME of each individual circuit and device. This facility has proven to be extremely valuable for maintenance use and **Fig. 5** shows the principle used for the calculation of average holding times by the AUTRAX system. Once the average holding times have been calculated the results



$$\text{AVERAGE HOLDING TIME} = \frac{\text{USAGE COUNTS X SCAN RATE}}{\text{EVENT COUNTS}}$$

$$\text{Av HT} = \frac{12 \times 10}{3}$$

$$\text{Av HT} = 40 \text{ SECONDS}$$

Fig. 5 — Calculation of Average Holding Time.

TYPE OF CIRCUIT	NORMAL AVERAGE HOLDING TIME	ICUP THRESHOLDS			
		LOW HT	HIGH HT	MINIMUM PEG COUNT	NUMBER OF EXCEPTIONS
STD	180 sec	40	3000	10	1
ISD	360 sec	40	3000	10	1
MOPAX	120 sec	30	3000	10	1
OPERATOR INQ	90 sec	20	3000	10	1
TEST	45 sec	10	3000	10	1

TABLE 1 — Typical ICM Threshold Parameters.

are then compared to a list of predetermined parameter values for each device. If any individual calculated average holding time exceeds the threshold limits then an exception report will be created. This overall calculation process is commonly referred to as ICUP (Individual Circuit Usage and Peg Count).

Table shows the typical threshold parameters which have been determined from experience gained in the New South Wales and Victorian trials. These parameters, although considered as being suitable for the average Australian telephony traffic may be affected by certain local traffic conditions and therefore may require reconfiguration, to prevent unnecessary false reports.

The performance of the exchange common control equipment can also be calculated by using the event counts occurring on the equipment statistical meters.

In the permanent ICM systems the collected event counts are forwarded to the ICM control processor when requested and applied in a previously specified performance formula. The results obtained by the calculation process are then compared with the preset parameter thresholds to determine if any exception reports are required to be generated. **Table 2** shows some of the calculations used in assessing the switching performance of an ARM 20 Trunk exchange. At predetermined times summary reports can be generated detailing the performance of both the traffic circuits or the exchange common control equipment for a previously specified study period.

OUTPUT REPORTS

The production of teletype output reports is the final result of all the activity occurring in the ICM equipment and it is the medium with which the technical staff receive the desired information. These reports can be directed to one or more remote centres for maintenance attention and may comprise either a single line entry or contain several pages of data depending on the predetermined requirements. Each report contains the date and time of the POLL, together with sufficient data to indicate which exhange site and device were involved.

The body of the reports on individual circuits would include:

- Circuit Number;
- Circuit Location;
- Usage in seconds;
- Event count (PEG);
- Average holding time;

EQUIPMENT	STATISTICAL METRE	FUNCTION	PERFORMANCE CALCULATION
ROUTE MARKER (VM)	SM1	Seizures	
	SM2	Route Congestion	$\frac{SM2 - SM18}{SM1} \times 100 =$ Route Congestion
	SM3	Calls to CpH	$\frac{SM3}{SM1} \times 100 =$ CpH Loss
	SM8	Congestions	$\frac{SM8 - SM2}{SM1} \times 100 =$ Internal Loss
	SM18	"U" Turn Control Attempts	

TABLE 2 — Typical Exchange Performance Calculations.

- Remarks (Busy, Idle etc.);
- Group name for first circuit in group.

Performance type reports contain PEG and USAGE data but the actual format of each report would vary depending on the requirements for a particular state maintenance group.

A list of the types of reports which can be produced by the ALSTON and AUTRAX ICM systems is shown in **Table 3.**

Fig. 6 shows a sample "Common Equipment Exception" report which could be produced for the MARKERS of an ARM 20 Trunk Exchange.

The information presented in this sample provides the following details:

- Date and Time of POLL;
- Exchange Identity;
- Marker Identity;
- Interval in Hours;
- Performance Calculation being Monitored;
- Threshold Exception limits;
- Total Calls;
- Number of times thresholds previously exceeded (eg., EXCPT *3);
- Overall Performance.

Fig. 7 shows a sample "Traffic Circuit Exception" report which could be produced for the traffic circuits of an SPC Metaconta 10C Trunk Exchange.

The information presented in this example provides the following details:

- Date and Time of POLL;
- Exchange Identity;
- Exchange Unit Number (EU);
- Interval in Hours;
- ICM Inlet Number (CCT);
- Traffic Circuit Number (TCCT);
- Junctor Identity (JUNCTOR);
- Erlangs in Hours (ERL);
- Peg Count (PC);
- Holding Time (HT);
- Remarks

  ie: IDLE = ALWAYS IDLE
  BUSY = ALWAYS BUSY
  EXCPT = Outside Thresholds *n*times
  SPARE = Inlets which have experienced activity and are dedicated spare.
- Group Name

ALSTON REPORTS	POLL	REPORT DESTINATION
TRAFFIC REPORT	¼, ½ 1 or 24HR	LOCAL OR REMOTE
DIVISION OF REVENUE REPORT	¼, ½ 1 or 24HR	LOCAL OR REMOTE
MAINTENANCE REPORT *ALWAYS BUSY *ALWAYS IDLE *KILLER *SLOW RELEASE *CROSSED LEADS	¼, ½ 1 or 24 HR	LOCAL OR REMOTE
AUTRAX REPORTS	**POLL ***	**REPORT DESTINATION**
EXCEPTION REPORT *EXCEPT — HIGH/LOW HT + MIN PEG *ALWAYS BUSY *ALWAYS IDLE *SPARE	P	REMOTE
TOTAL DAY EXCEPTION REPORT	T	REMOTE
DETAIL REPORT	P	HSP (High Speed Printer)
TOTAL DAY DETAIL REPORT	T	HSP
CIRCUITS WITH SAME USAGE + PEG	T	HSP + REMOTE
GROUP SUMMARY REPORT	T	HSP + REMOTE

* NOTE 1:

POLL = AUTRAX Polls can be set for any length but are usually 1HR
P = "P" Poll using only New Data
T = Poll using Data Accumulated over several Polls

TABLE 3 — Types of Output Reports.

AUTRAX QUICK LOOK REPORT 01/07/84 11.00 POLL INTERVAL: 1.00 HRS
EXCHANGE SITE: (EXAMPLE ARM)

EQUIPMENT: MARKERS

EXCEPTION LEVELS		LINK LOSS	CPH CALLS	TOO LONG WAIT GD	
		0.2%	0.5%	0.2%	
MARKER	SEIZURES				REMARKS
1	3901	0.54%	0.00%	0.12%	*EXCPT *1*
3	3269	0.55%	0.22%	0.01%	*EXCPT *1*
4	3515	0.51%	0.06%	0.18%	*EXCPT *1*
TOTAL STAGE 1	21650	0.42%	0.07%	0.10%	
11	3929	1.09%	0.00%	0.14%	*EXCPT *1*
12	3888	1.16%	0.08%	0.16%	*EXCPT *1*
13	3889	0.98%	0.00%	0.17%	*EXCPT *1*
14	3769	1.19%	0.03%	0.18%	*EXCPT *1*
TOTAL STAGE 2	23237	1.10%	0.03%	0.13%	
TOTAL EXCHANGE	44887	0.77%	0.05%	0.11%	

Fig. 6 — Example "Common Equipment" Exception Report.

CONCLUSION

The results being obtained from the use of ICM as a maintenance aid indicate significant benefits for Telecom. Malfunctioning traffic circuits are being identified more quickly and subsequently repaired in a shorter time, resulting in the improved availability of workable circuits. In some cases elimination of these ineffective circuits has provided sufficient relief and avoided the costly provision of extra circuits. In one trial Trunk Exchange the total number of traffic circuits "Out of Service" at any one time was reduced from 5% to 2% after several months of using ICM. The "Always Busy" detection feature of ICM has provided an automatic means of locating Long Held calls which have failed to release and this is an important improvement in the supervision of the metering facility. Therefore as ICM becomes more widely used throughout Australia further direct improvements can be expected to be seen in the overall performance of Telecom telephone network.

REFERENCES

1. Telesciences Computer Systems, Inc. New Jersey, USA — AUTRAX ICM equipment specification.
2. Alston Division, CONRAC Corporation, California, USA — ALSTON 615 ICM equipment specification.
3. J. N. Almgren, Pty. Ltd., Sydney, Australia, — ALMGREN ICM equipment specification.

FURTHER READING

1. Telecom Technical Publications.

TPH 0178 "ALSTON — Portable ICM User Guide" (Issue 1 — 1982).

TPH 0476 "AUTRAX — Permanent ICM Description and Exchange Operating Procedures. (Issue 1 — 1983)

TPH 0957 "ALMGREN — Permanent ICM Description and Exchange Operating Procedures. (Issue 1 — 1984).

AUTRAX QUICK LOOK REPORT 01/07/84 00.00 POLL INTERVAL: 24.00 HRS.
EXCHANGE SITE: (EXAMPLE 10 C — XXXX)
TOTAL DAY EXCEPTION — OUTGOING CIRCUITS EU1

TE500

CCT		TCCT	JUNCTOR	ERL	PC	HT	REMARKS	GROUP IDENTITY
1	788	001	0174 0	0.00	0		IDLE	T XXXX BATM C1 033 0
1	274	031	0512 0	0.54	120	16	EXCPT *3	T XXXX DANC 082 0
1	29	011	041D 0	1.18	280	15	EXCPT *3	T XXXX DAND 081 0
1	565	009	0635 0	24.00	0		BUSY 1	T XXXX DROF Q1 088 0
1	133	005	0485 0	1.24	272	16	EXCPT *3	T XXXX FRTD 142 0
1	43	024	042B 0	0.49	88	20	EXCPT *3	T XXXX FTGC 106 0
1	483	006	01E3 0	1.47	310	17	EXCPT *3	T XXXX HGTT 130 0
1	434	003	05B2 0	0.74	271	10	EXCPT *3	T XXXX MELE 269 0
1	931	003	03A3 0	24.00	0		BUSY 1	T XXXX WIRF AY 178 0
	242	SPARE	00F2 0	0.01	3	10	SPARE INLET ACTIVITY	
	309	SPARE	0135 0	0.02	2	45		
	445	SPARE	01BD 0	1.20	20	216		

Fig. 7 — Example "Traffic Circuit" Exception Report.

Future Development of the Melbourne-Sydney Telecommunications Route

J. M. BURTON B.E. (Hons), BA, Litt.B.
D. J. PILTZ B.E. (Hons)

The provision of a 30 fibre single mode optical fibre cable is to take place between Melbourne and Sydney as the next phase of development of that transmission route. The cable is to be equipped with high capacity digital systems operating at 140 Mbit/s and 565 Mbit/s. This paper examines the planning aspects and technical issues, which lead to this significant application of new technology to a strategic part of the Australian long distance transmission network.

INTRODUCTION

In the past five years, important changes have occurred in the application of optical fibres to the provision of long distance telecommunication transmission systems. Great improvements have been made in this technology and the point has now been reached where the cost effectiveness of optical fibres is growing in a number of telecommunication applications compared to traditional transmission techniques such as copper pair cable, coaxial cable and radio systems.

These technological changes have been addressed by a Planning Committee in Telecom who formally took up the question of the appropriate technology for the next phase of development for the Melbourne-Sydney route. This strategically important route needs special consideration to enable opportunities to be met in a competitive environment.

FORECAST OF BEARER REQUIREMENTS

The forecast of bearer requirements for the Melbourne-Sydney route was the basis for development plans. The provision of Melbourne-Sydney transmission links was examined in the light of a timely, orderly and economic development of the national transmission network.

Growth of the Melbourne-Sydney telecommunication route is such that forecasts indicate that the existing radio route would require relief by 1987. This is necessary to ensure that capacity is available to provide for leased 2 Mbit/s services, as well as normal telephony network growth. Capacity has also been allowed for the eventual replacement of the coaxial cable systems. The cable would be equipped initially to meet requirements for two years ahead, with additional systems installed in 1989 and in 1990. It has been estimated that more than 20 additional 140 Mbit/s bearers will be required by the end of 1990.

If 565 Mbit/s equipment were available the requirements could be met with a combination of this equipment and 140 Mbit/s equipment. However, the exact mix of equipment depends upon the level of supply of 565 Mbit/s equipment in 1985/86.

A practical mix of systems was assumed in formulating the fibre count and also two fibres are required for inter-access between wayside terminal stations, accessible at intermediate repeaters and terminal sites only. This brought the total fibre count to 30.

ALTERNATIVES FOR DEVELOPMENT OF THE MELBOURNE - SYDNEY ROUTE

A number of alternatives were considered to meet the forecast development to 1990. The present 6 tube coaxial cable is currently equipped with one 18 MHz system and two 12 MHz systems. There is doubt over the long term performance of the coaxial cable due to oxidation of insulating spacers. For this reason, any new development of the route should take account of the existing and possible future coaxial cable deterioration and the provision of wayside services.

New Coaxial Cable

If a new coaxial cable were to be provided to meet the 1990 requirements with 140 Mbit/s systems a 50 tube cable would be needed. The material cost for such a cable is estimated to be in excess of $100m for the 1000 km route. If a mix of 140 Mbit/s and 565 Mbit/s systems were used a 24 tube cable would be required. This cable would need to be ditched and could not be directly ploughed into the ground. Line equipment for such a project would be of the order of 36 terminals and 5000 regenerators (some spaced at 1.5 km) and the total cost of this alternative is of the order of $80m. A new coaxial cable is economically unattractive based on these first order estimates.

Radio Relay Route

The current radio route Melbourne to Sydney is expected to be fully equipped in 1987 with 3 radio bands and no further tower space is available. To expand with 11 GHz radio would require a re-engineering of the route. Technical difficulties arise in using the 6.7 GHz radio band for a new route out of Melbourne as it is planned to use this band in five directions ie Adelaide (2), Sydney, Morwell and perhaps Melbourne to Geelong. Although the Morwell radio route could be expanded further and extended to Sydney via Bega and Woollongong, circuits to intermediate centres on the existing coaxial cable route would not be provided on this radio system. Three radio bands would need to be placed into service to provide the 1990 forecast bearer demand. Cost estimates for a new radio route equipped with (1+5) x 140 Mbit/s 3.8 GHz, (1+7) x 140 Mbit/s 6.7 GHz and (1+11) x 140 Mbit/s 11 GHz have been prepared. The total installed capital cost is estimated as $65m.

This estimate does not include an allowance to meet wayside service requirements and this aspect would add further costs to a radio alterntive. A new radio route to provide a large number of bearers is an economically unattractive alternative to meet the development.

Optical Fibre Cable

Initial estimates were made to test the economic application of this technology. The estimates were based on a 30 fibre cable using a mixture of 140 Mbit/s and 565 Mbit/s line equipment to meet wayside services and intercapital requirements. The total installed capital cost is estimated as $44m.

The above estimated cost alternatives to provide the next development phase of the Melbourne-Sydney route indicate that optical fibre cable and systems are the cost effective alternative.

In addition, the optical fibre cable alternative will provide the appropriate strategic solution to meet future marketing initiatives. At this stage of technological development, optical fibre offers the economic implementation of 565 Mbit/s digital streams with the future possibility of higher bit rates. By the early 1990's, it is expected that the initial optical fibre cable will be capable of carrying about 1000 2 Mbit/s digital streams between Melbourne and Sydney.

THE CHOICE OF OPTICAL FIBRE TECHNOLOGY

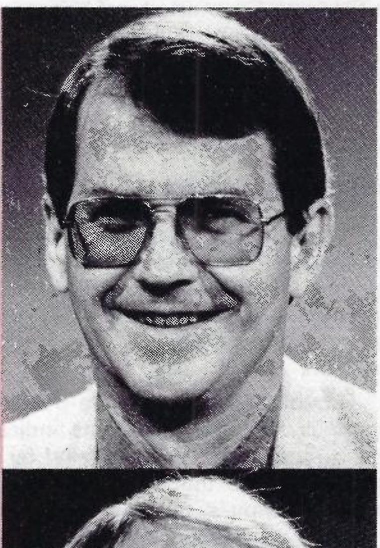
A field trial associated with single mode optical fibre (SMOF) is currently in progress which aims to install cable and equipment between Melton and Ballarat. To date the field trial has shown that ploughing optical fibres over long distances is a practical proposition and Figure 1 shows Australian developed machinery successfully ploughing in a section of cable during the field trial. The hauling of optical fibres into ducts has already been undertaken in other field trials. In addition suitable high capacity optical fibre equipment is available from reputable suppliers for the Melbourne-Sydney route. Assessment of the performance of the SMOF line equipment is yet to commence.

TECHNICAL PARAMETERS

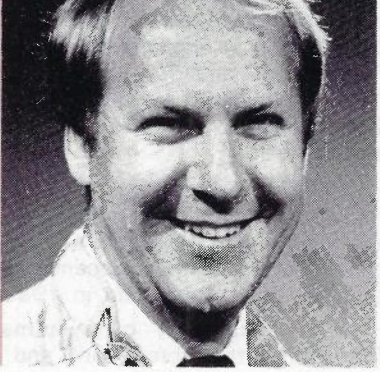
The following proposals for technical parameters have been made by expert groups between meetings of the Planning Committee. During the study an examination of economic and strategic factors associated with the project was carried out in addition to the technical considerations.

Route Choice

The cable is to be installed on the direct route from Melbourne to Sydney via Albury and Canberra as indicated in Figure 2, in principle following the existing coaxial cable route but in some instances deviating from the original alignment due to changes caused by road construction or environmental considerations. A preliminary survey was undertaken by NSW and Victorian Administrations to confirm the practicability of this proposal. In the course of this work analysis



JOHN BURTON is with the Planning Division in Telecom Australia Headquarters. After a period as a technician in far northern Queensland and the north west of New South Wales, he joined the Telecom Research Laboratories in 1974 as an Engineer working on microwave radio and on the early development of the Digital Radio Concentrator System. In 1979, he moved to Headquarters Planning Division and has since been involved with planning studies associated with the introduction of new technology into transmission networks. He is currently the Superintending Engineer of Transmission Planning Branch.



DAVID PILTZ joined the PMG in South Australia as a Cadet Engineer in 1973. After graduating in 1975, he was involved in a variety of engineering tasks in Metropolitan Districts Works and then Country Installation. In 1977, he transferred to Country Branch, Southern Section, where he had an involvement in the rural automation programme. Since April 1981, David has been working in the Inter-exchange Networks Section of Transmission Planning Branch Headquarters where he has been directly involved with preparation of policies and guidelines for transmission networks. He is currently acting Principal Engineer in Inter-change Networks Section.

indicated that the optical fibre cable could be installed close to the coaxial cable on most of the route and access to existing above ground repeater sites would be readily available. In the light of the extremely low fault incidence on the coaxial cable in ducts conduit routes through towns are to be used.

These proposals mean the shortest known practical route and existing above ground repeater sites can be used at an estimated saving of $1m (for housings and power). The provision of services to wayside centres by systems on the fibre cable was also considered and the choice of the existing route allowed this to be achieved as many repeater sites are located in existing exchange buildings.

Number of Fibres

The fibre count was based on the forecasts as previously indicated. Initially 24 fibres with 140 Mbit/s systems was proposed based on the replacement of the coaxial systems post 1990. An examination of the latest forecasts showed that to meet the 1990 demand more than 24 fibres would be required. The availability of 565 Mbit/s equipment was investigated in more detail as a number of manufacturers had tendered this equipment recently and it is likely that deliveries could be expected in 1988/89. Based on this information a 36 fibre cable was proposed equipped with (1+13+1) x 140 Mbit/s and (1+2) x 565 Mbit/s by 1990.*

The cost of the increase in the size of the cable from 24 to 36 fibres was considered to be a significant penalty. In addition the Planning Committee considered that allowance should be made to provide for the possible degradation of coaxial circuits and to provide Service Protection Bearers as required. On current costs electrical multiplexing was less costly than Wave Length Division Multiplexing. To reduce the fibre count and have a cost effective proposal manufacturers were approached on earlier deliveries of 565 Mbit/s equipment. Following satisfactory responses it was decided that 565 Mbit/s systems be installed on the route at the outset. This allows a 30 fibre cable to provide sufficient bearers to meet the 1990 forecast requirements if it were equipped with (1+7) x 140 Mbit/s systems and (1+4+1) x 565 Mbit/s systems.*

*(protection + working + service protection)

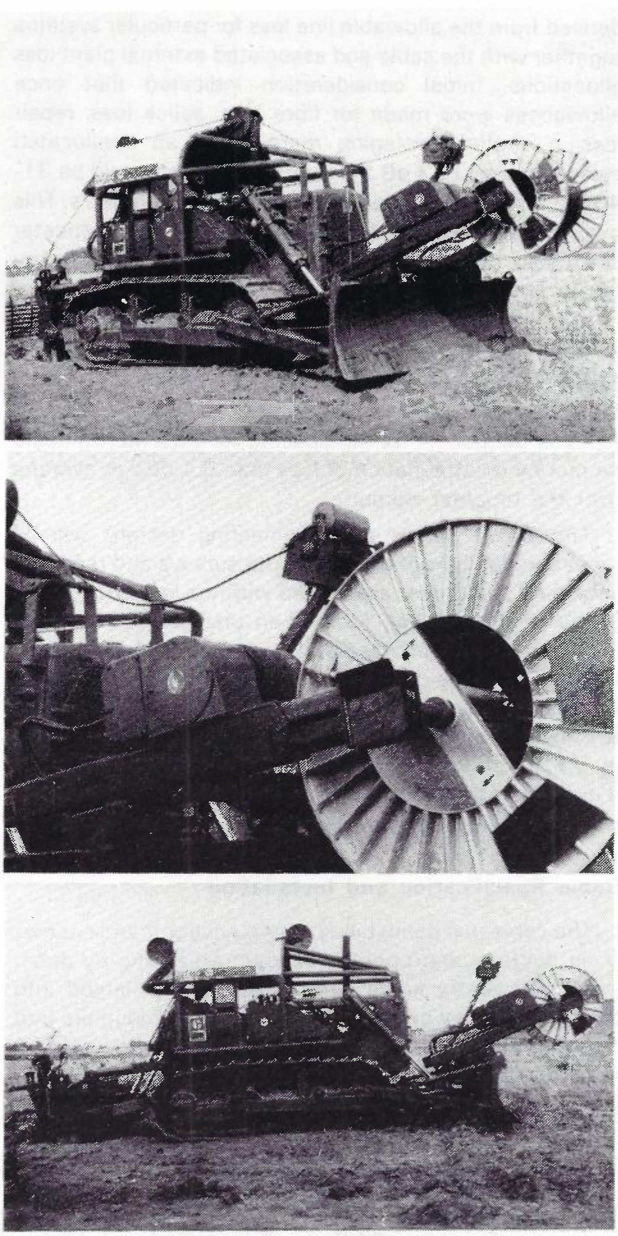


Fig. 1 — Optical Fibre Cable Ploughing Tractor

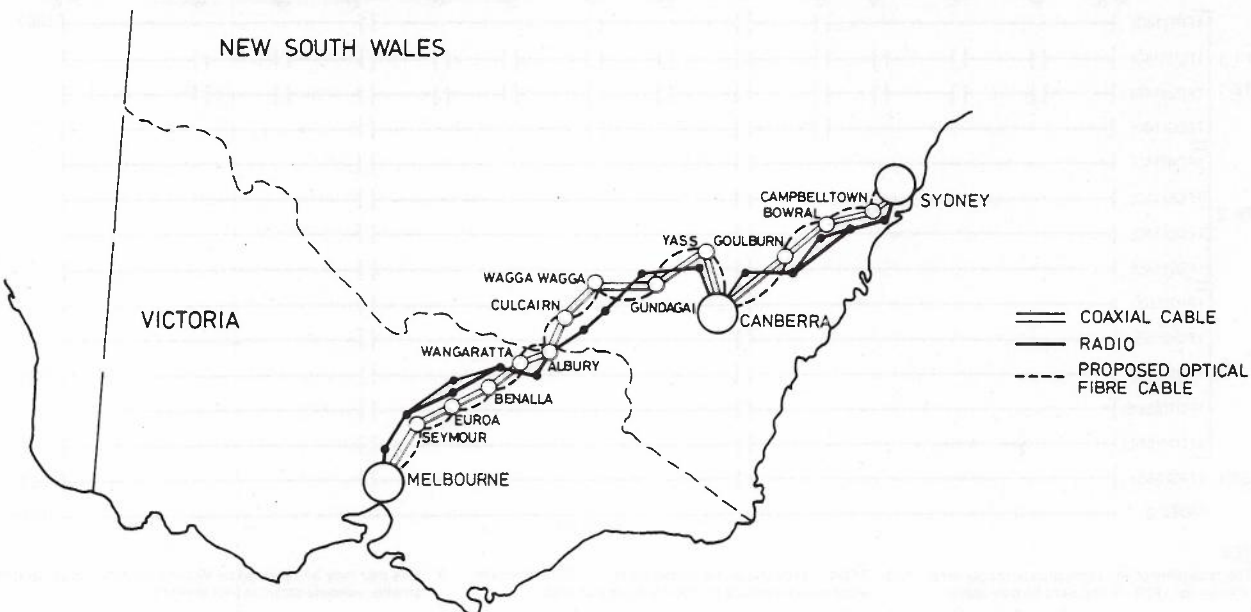


Fig. 2 — Melbourne-Sydney Telecommunications Route

System Capacity, Availability and Allocation

The consideration of systems to be used is associated with the route choice and fibre count and both 140 Mbit/s and 565 Mbit/s systems will be installed on the cable. The 140 Mbit/s systems will service both wayside centres and provide intercapital requirements. In the absence of an international standard the 565 Mbit/s equipment will have 4 x 140 Mbit/s standard CCITT G703 interfaces.

Uncertainty was expressed as to the reliability of in-service optical line systems based on the wide range of figures quoted by manufacturers and to achieve availability objectives the systems will be protected in a 1+N mode. It is recognized that the greatest risk of route failure is still mechanical damage to the cable.

Once further experience has been gained with laser diode reliability the protection constraint can be releaxed if system availability objectives are achieved. Almost all modern optical fibre systems for long haul application are capable of in-service performance monitoring and have an inbuilt supervisory system with a fault location facility. Order wire systems, both express and omnibus, can be provided as part of the line equipment. Systems provided on this route should be capable of the above features for maintenance action in the detection and repair of faults. For maintenance reasons the route will be subdivided into three main sections to allow monitoring, fault finding and patching. These sections are Melbourne-Albury, Albury-Canberra and Canberra-Sydney.

The "layout of line systems" in Figure 3 indicates how the wayside and inter-capital systems are allocated. The inter-capital systems would have terminals at Melbourne (Exhibition), Albury, Canberra (Deakin) and Sydney (Newtown). The wayside systems would be accessible to all centres indicated.

Repeater Layout.

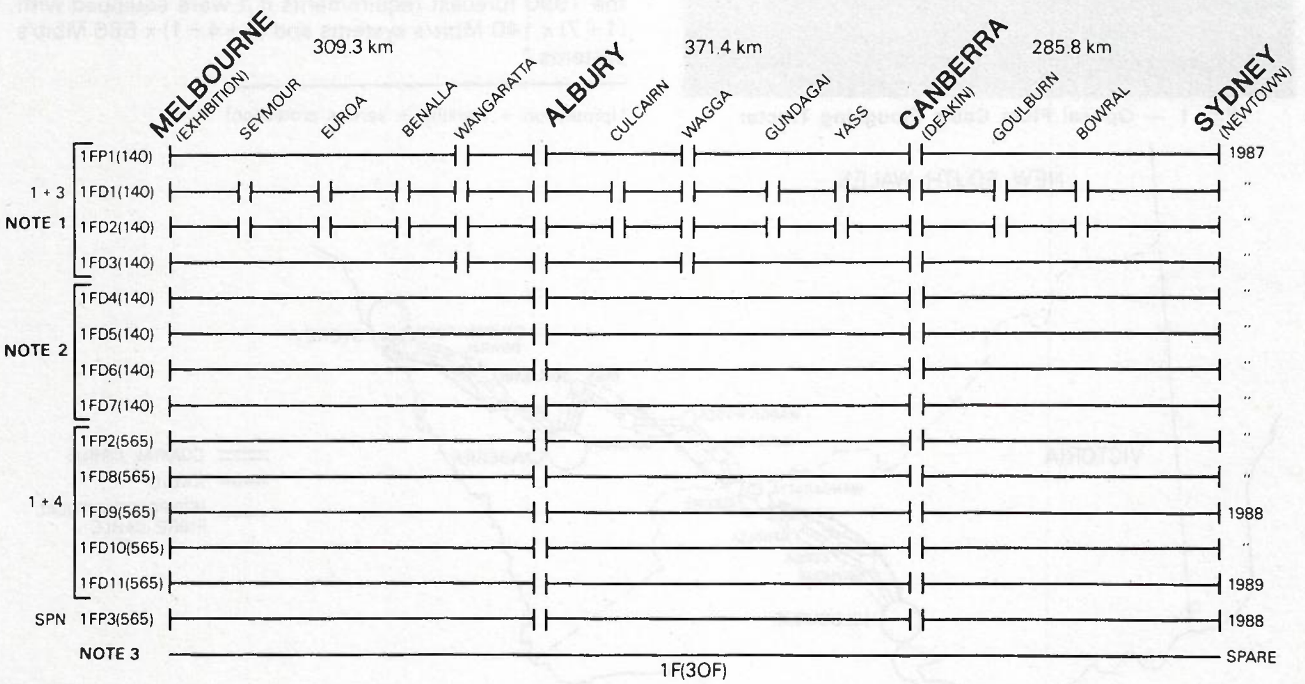
The repeater layout is based on the optical power budget and the physical constraints of existing repeater sites and intermediate stations. The power budget is derived from the allowable line loss for particular systems together with the cable and associated external plant loss allocations. Initial consideration indicated that once allowances were made for fibre loss, splice loss, repair loss, a degradation/aging margin and an unallocated system margin of 3 dB the repeater layouts would be 31-40 km for 140 Mbit/s and 23-30 km for 565 Mbit/s. This meant that every third existing above ground repeater site could be used for 565 Mbit/s systems and every fourth site for 140 Mbit/s.

For direct buried (ploughed) and duct cable a 36.4 km repeater spacing for 140 Mbit/s or a 27.3 km spacing for 565 Mbit/s can be realised by specifying an initial cabled fibre attenuation of less than 0.5 dB/km average over the repeater section. A 32 km spacing for 565 Mbit/s could be met by an attenuation of less than 0.4 dB/km average over the repeater section.

The above details and engineering designs will be refined in the light of detailed route surveys and tendered cable and equipment associated with the implementation phase of this project. More than one fibre attenuation quality may be purchased for the route irrespective of transmission rate depending on the influence of price for various qualities of fibre and variations in repeater spacings. However the repeater spacing being planned, ie, 27.3 km for both 140 Mbit/s and 565 Mbit/s is realisable with current fibre technology; with 0.5 dB/km fibre attenuation being generally adequate.

Cable Specification and Installation

The cable will be installed in two environments, namely: in ducts in metropolitan or town areas and by direct burial in country areas. The cable will be hauled into ducts where they are available and directly ploughed into the ground on the remainder of the route. As no 1500 nm equipment has been offered on current tenders, the cable will be optimised for 1300 nm operation and



NOTES

1. The feasibility of the protection arrangements shown for 1FD1 - 3 requires further study.
2. 1FD4-7(140) should be protected by 1FP2(565) (Avoids additional terminals at intermediate stations).
3. This pair may be required by Victoria for systems serving the smaller wayside stations (not shown).

Fig. 3 — Melbourne-Sydney Optical Fibre Cable No. 1 — Layout of Line Systems

manufacturers asked to provide information about the expected performance at 1500 nm.

Regarding optical fibre cables which are directly buried, various papers have been produced recommending filled designs. One of the major factors to be considered is an aging problem generally attibuted to "hydrogen diffusion". Experiments have shown that fibre attenuation can increase as a result of hydrogen diffusion. The attenuation increases observed (up to 0.3 dB/km) are most marked in cables containing metals where water has ingressed and having fibres with high phosphorous doping levels. Pressurising cables in the long distance network would require metallic moisture barriers and the development of new techniques for pressurising small diameter cables at distances considerably less than proposed repeater section lengths. This proposal is economically unattractive.

In view of the above factors it is essential that the buried cable should be non metallic and filled and it is expected that the duct cable will be the same.

Sites and Powering

The use of existing above ground repeaters subject to space limitations has been advocated as these sites are readily accessible and have commercial power connected. These sites will be upgraded with appropriate battery/rectifier installations to provide sufficient back-up in the event of commercial power failure. The approximate requirement is 12-18 W for 140 Mbit/s repeaters and 20-25 W for 565 Mbit/s repeaters.

CONCLUSION

A single mode optical fibre cable consisting of 30 fibres has been chosen the most economic and strategic alternative to further develop the Melbourne-Sydney telecommunications route. The new cable will follow generally the route of the existing coaxial cable, although deviations are proposed in some instances. A route distance of about 970 km is involved and the optical cable will be ploughed in for about 78% of the distance, while for the remainder it will be hauled into ducts.

Line transmission equipment consisting of 140 and 565 Mbit/s systems will be installed in existing repeater and communications buildings. Existing repeater buildings used originally for valve operated coaxial cable systems are spaced about 9 km apart and generally every third building will be used for the optical fibre repeater equipment (ie 27 km spacing).

This first Melbourne-Sydney system provides a major starting point for an overall national plan for the introduction of optical fibre systems into the Telecom Australia long distance trunk network. The cable systems will complement digital radio systems already planned for introduction in the national network.

The cable and systems are expected to be ready to carry traffic by November 1987 and the total estimated cost of the project including essential conduit work is $44m.

REFERENCES

1. Melbourne-Sydney Optical Fibre Working Group "Future Development of the Melbourne-Sydney Telecommunications Route Report No 1" March 1984.
2. Line Transmission Equipment Construction Branch "Industry Briefing Melbourne - Sydney Optical Fibre Project."
3. InterCapital Trunk Planning Newsletter No 7 1982-3.

NATIONAL DIGITAL BROADBAND BEARER PLAN

A strategic plan for the development of the Australian Intercapital Trunk Network has been produced by the Planning Division, Telecom Headquarters covering the period 1988 to 2000.

The development plan addresses the challenge of meeting the demand for digital telecommunication bearers on the intercapital transmission routes. The telecommunition demand under consideration arises from the growth of leased services, the Digital Data Network, Special Services Network and telephony networks. It is possible to provide economically routes which will satisfy total network demand which may vary over a wide range and provide service protection by the introduction of Single Mode Optical Fibre (SMOF) cables and systems. I would appear that the investment required for the SMOF equipment in the late 1980s will tend to match that invested in digital radio systems in the mid-1980s.

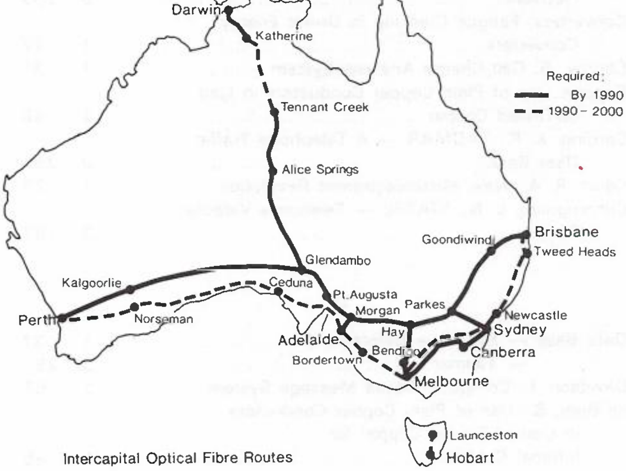
The Melbourne-Sydney route has been identified as having a high priority. Other intercapital SMOF routes are indicated on the accompanying map. It can be seen that diverse optical fibre routes are proposed between Perth, Adelaide, Melbourne, Sydney and Brisbane. The currently proposed cable sizes are as follows:

Perth — Adelaide 18 fibres
Adelaide — Melbourne 24 fibres
Melbourne — Sydney 30 fibres
Sydney — Brisbane 24 fibres

The cable sizes have been selected to meet the demand using 565 Mbit/s systems with repeaters spaced at 30 km. The annual intercapital requirement from 1986/87 to 1991/92 is expected to be 1900 route km of SMOF cable requiring about 40,000 fibre km equipped with about 70 terminals and 330 repeaters, (ie per-annum).

Repeaters will be sited in existing accomodation where possible. Where commercial power is not available, optical fibre repeaters will be solar powered and accommodated in underground shelters similar to those used in solar powered microwave radio systems.

To maintain an orderly SMOF installation programme it is necessary to continue to instal digital radio on certain routes where radio equipment can be added to the existing infrastructure prior to the availability of an alternative optical fibre route.



Intercapital Optical Fibre Routes

INDEX — Volume 34, 1984

No.	Pages
1	1-96
2	97-184
3	185-280

The Telecommunication Journal of Australia

ABSTRACTS: Vol. 34, No. 3

VIATEL — TELECOM'S PUBLIC VIDEOTEX SERVICE: L. N. Cunningham, Telecom Journal of Aust. Vol. 34, No. 3, 1984, Page 187.

Videotex is one of a number of new products that Telecom Australia is offering to its customers.

This paper discusses briefly the development of videotex, its features, and some typical applications for the service.

It also outlines the charges which will apply for the Telecom service, and discusses possible future developments of videotex.

VIATEL — A VALUE ADDED SERVICE: D. J. King, Telecom Journal of Aust. Vol. 34, No. 3, 1984, Page 191.

VIATEL is Telecom Australia's first truly value added network service, where the service offered goes beyond that of networking to information management.

This paper describes VIATEL from both a service and networking point of view. It outlines the network that has been set up to give user access into VIATEL, as well as the network options available to Service Providers who may base their operation either entirely on VIATEL or partly on VIATEL and partly on their own external computer.

The paper also covers aspects such as user numbering, security and messaging.

SULTAN — A COMPUTERISED TEST NETWORK FOR TELEPHONE LINES — FACILITIES AND OPERATION: K. L. Hicken, R. W. Ditton and J. R. McIntyre, Telecom Journal of Aust. Vol. 34, No. 3, 1984, Page 201.

Telecom Australia has developed and is progressively implementing a major computer based system to replace the existing customer line testing facilities. This system, called SULTAN (Subscribers Line Test Access Network), incorporates central minicomputers, and outposted microprocessor driven test robots in terminal exchanges. This article introduces SULTAN and describes, in general terms, the system and its application.

TELECOMMUNICATIONS TECHNOLOGY IN THE OUTBACK: J. M. Burton, Telecom Journal of Aust. Vol. 34, No. 3, 1984, Page 213.

This paper describes a development strategy for the telecommunications network in rural and remote areas and outlines the technologies which are available for use in these areas. Telecom is confident that the technologies described and the plans outlined for rural and remote areas will provide our customers with world standard services at affordable prices.

INTERWORKING OF LOCAL AREA NETWORKS AND PUBLIC NETWORKS: E. K. Chew, Telecom Journal of Aust. Vol. 34, No. 3, 1984, Page 221.

This paper reviews the methods for network interworking between Local Area Networks (LANs) and public telecommunications networks. The networking properties of LANs and their characteristic differences from public networks are explained. Basic principles of internetworking are then discussed and used to analyse the key issues associated with LAN — public network interworking. Existing solutions are contrasted. The preferred approach and its current state of development are described. Finally, current research on the interconnection of LANs with the future Integrated Services Digital Network (ISDN) is also briefly mentioned.

TACONET: TELECOM AUSTRALIA'S COMPUTER NETWORK: P. Flanagan, Telecom Journal of Aust. Vol. 34, No. 3, 1984, Page 233.

Telecom Australia's computer network, TACONET, is facing a number of challenges due to the need for the network to enable connection to Honeywell largescale mainframes and minicomputers, its rapid growth and newly introduced IBMC (FACOM) facilities. A Network Plan has been prepared, focussing upon the issues and defining projects required for achievement of an integrated network.

Major activities include connection of low speed lines and connection to both FACOM and Honeywell host computers. A brief history of the network as well as its future development are included.

NEW STANDARD TELEPHONE: F. M. Doyle, Telecom Journal of Aust. Vol. 34, No. 3, 1984, Page 243.

Telecom Australia is introducing a new range of standard telephones to replace the existing dial telephone instruments. This article discusses the background to the introduction, the design of the instruments, the launch strategy and future trends in telephone instrument design.

The new standard telephone incorporates a transmitter of novel design, the 20E electronic transmitter, and this is also described.

TADMAR — A TELEPHONE TRAFFIC DATA BASE: K. P. Cording, Telecom Journal of Aust. Vol. 34, No. 3, 1984, Page 251.

This article describes the traffic data base application TADMAR which has been developed as an integral part of a new generation of traffic data acquisition processing and analysis system to meet Telecom needs during the 1980s. Some of the concepts and application of data base management techniques which have been applied to TADMAR are also described.

INDIVIDUAL CIRCUIT MONITORING: B. F. Grimshaw, Telecom Journal of Aust. Vol. 34, No. 3, 1984, Page 263.

Individual Circuit Monitoring (ICM) is a technique for obtaining accurate information on the performance of telephone exchange traffic circuits and common control equipment under live traffic conditions.

It provides a cost effective means of maintaining a higher proportion of workable equipment in service than would otherwise be the case. This article describes the basic principle of ICM and details the application of the technique in the Australian telephone network.

FUTURE DEVELOPMENT OF THE MELBOURNE-SYDNEY TELECOMMUNICATIONS ROUTE: J. M. Burton and D. J. Piltz, Telecom Journal of Aust. Vol. 34, No. 3, 1984, Page 271.

The provision of a 30 fibre single mode optical fibre cable is to take place between Melbourne and Sydney as the next phase of development of that transmission route. The cable is to be equipped with high capacity digital systems operating at 140 Mbit/s and 565 Mbit/s. This paper examines the planning aspects and technical issues, which lead to this significant application of new technology to a strategic part of the Australian long distance transmission network.

TELECOMMUNICATION SOCIETY OF AUSTRALIA
ADDRESS CHANGE AND APPLICATION FORM

TO STATE SECRETARY *(For local subscribers) (Mark the appropriate box)*

☐ Box 6826 GPO Sydney, NSW 2001 ☐ Box 1183 GPO Adelaide, SA 5001
☐ Box 1802Q GPO Melbourne, Vic. 3001 ☐ Box T1804, GPO Perth, WA 6001
☐ Box 1489 GPO Brisbane, Qld. 4001 ☐ C/- Telecom Australia, Engineering Branch, Hobart Tas. 7000

OR GENERAL SECRETARY *(For Overseas Subscribers)*
Telecommunication Society of Australia,
Box 4050, GPO Melbourne, Vic. 3001. Australia.

I WISH TO ADVISE:

☐ CHANGE OF ADDRESS ☐ MEMBERSHIP APPLICATION ☐ SUBSCRIPTION APPLICATION

PLEASE SEND JOURNALS TO:
(Work address for Telecom employees) *Previous Journals were sent to:*

NAME .... ADDRESS ....
(BLOCK LETTERS)

ADDRESS ....

.... POST CODE ....

POST CODE ....

REMITTANCE $ .... ENCLOSED PHONE .... Signature .... Date ....
(Rates are as shown on page 280.)

(THIS FORM FOR USE BY TELECOM AUSTRALIA EMPLOYEES ONLY)

TELECOMMUNICATION SOCIETY OF AUSTRALIA

Authority — Deduction From Salary

(TO BE FORWARDED THROUGH SOCIETY STATE SECRETARY)

TELECOM AUSTRALIA

I hereby authorise the Australian Telecommunication Commission, its duly authorised servants and agents to deduct .... each fortnight from my salary/way, to be paid to the Telecommunication Society of Australia.
The amount to be deducted may be varied from time to time by the Society in accordance with revised rates of contribution.
All payments made on my behalf in accordance with this Authority shall be deemed to be payments by me personally.
This Authority shall remain in force until revoked by the Telecommunication Society of Australia or cancelled by myself in writing.
In consideration of this deduction being made, I indemnify the abovementioned employer and employees thereof against any failure to make deductions and remittances as authorised herein.

Dated this .... day of 19

☐ Permanent Signature ....

☐ Temporary Designation ....

Branch

Commission Address

Pay sheet Number or Staff Clerk Code .... Work Telephone ....

PLEASE USE BLOCK LETTERS

A.G.S. No.	Surname	Given Name	Commission Code
			TSOA 685

This Portion Must be Completed By The Society	Old Basic Rate	New Basic Rate	Certified by Society
	$	$	

DETAILS BELOW FOR INSERTION BY TELECOM AUSTRALIA

Permanent Variation		Remarks	Team No.	Paysheet No.
Increase	Decrease			

Computed by .... Processed for

Checked by .... period ending ..../......../........

THE TELECOMMUNICATION JOURNAL OF AUSTRALIA

POLICY. The Journal is issued three times a year (March, July and November) by the Telecommunication Society of Australia. The object of the Society is to promote the diffusion of knowledge of the telecommunications, information transfer, broadcasting and television services of Australia by means of lectures, discussions, publication of the Telecommunication Journal of Australia and Australian Telecommunication Research, and by any other means.

The Journal reports on the latest developments, both technical and commercial, in telephony, radio and TV and is distributed to professional engineers, executives and technical staff engaged in the planning, marketing, installation and operation of telecommunication services in Australia and overseas, also to manufacturers in this field, government departments, universities and consultants.

The Journal is not an official journal of the Australian Telecommunications Commission. The Commission and the Board of Editors are not responsible for statements made or opinions expressed by authors.

Editors of other publications are welcome to use not more than one-third of any article, providing credit is given at the beginning or end, thus, "Reprinted from the Telecommunication Journal of Australia". Permission to reprint larger extracts or complete articles will normally be granted on application to the General Secretary.

Contribution of papers are encouraged. Information on how to prepare contributions for the Journal is available from members of the Board of Editors. Communication to the Editors should be addressed to Editor-in-Chief, TJA, Box 4050 GPO Melbourne, Victoria, Australia 3001. (Phone (03) 67 5622).

SUBSCRIPTION AND MEMBERSHIP RATES.

ENQUIRIES

Any enquiries, changes or applications may be directed to the State or General Secretaries on the Address Change and Application form overleaf.

MEMBERSHIP RATES — $9.00 p.a.

Residents of Australia may join as members using the Application Form directed to their State Secretary. Others should apply to the General Secretary. Cheques should be made payable to the "Telecommunication Society of Australia".

SUBSCRIPTION RATES — $15.00 p.a. Australia, $22.00 Overseas

These rates apply to organisation and overseas applications. A subscriber is a non-member who is entitled to secure copies of the Journal. Cheques should be made payable to the "Telecommunication Society of Australia".

POSTAL CHARGES

Journals are sent post free by surface mail to members and subscribers in Australia.

ADDITIONAL COPIES

These may be purchased by members for $6.00 per copy. non-members for $8.00 per copy and overseas applicants for $12.00 per copy.

Addresses of The General Secretary or Editor-in-Chief,
Telecommunication Society of Australia,
Box 4050, G.P.O., Melbourne, Victoria, Australia 3001.

ADVERTISING: The total net advertising revenue is paid to the Telecommunication Society of Australia, whose policy is to use such funds in the dispersion of knowledge within the telecommunication industry.

Advertising Manager: Mr M. Chin, Tel. (03) 606 7644.

Advertising Contractor: ADTEL — Contact B.H. Worrell. Tel. (03) 772 9398. Address: 81 Lochiel Avenue, Edithvale, Victoria 3196.
Rate Cards giving full details of specifications and charges are available from ADTEL.

CIRCULATION. Average circulation during year ending December 1982:

Within Australia:	6462
To Overseas Countries:	461 (60 Countries)
Total Readership (estimated by survey)	10,548

Printed by Standard Commercial Printers, 2 Railway Rd., Cheltenham, 3'