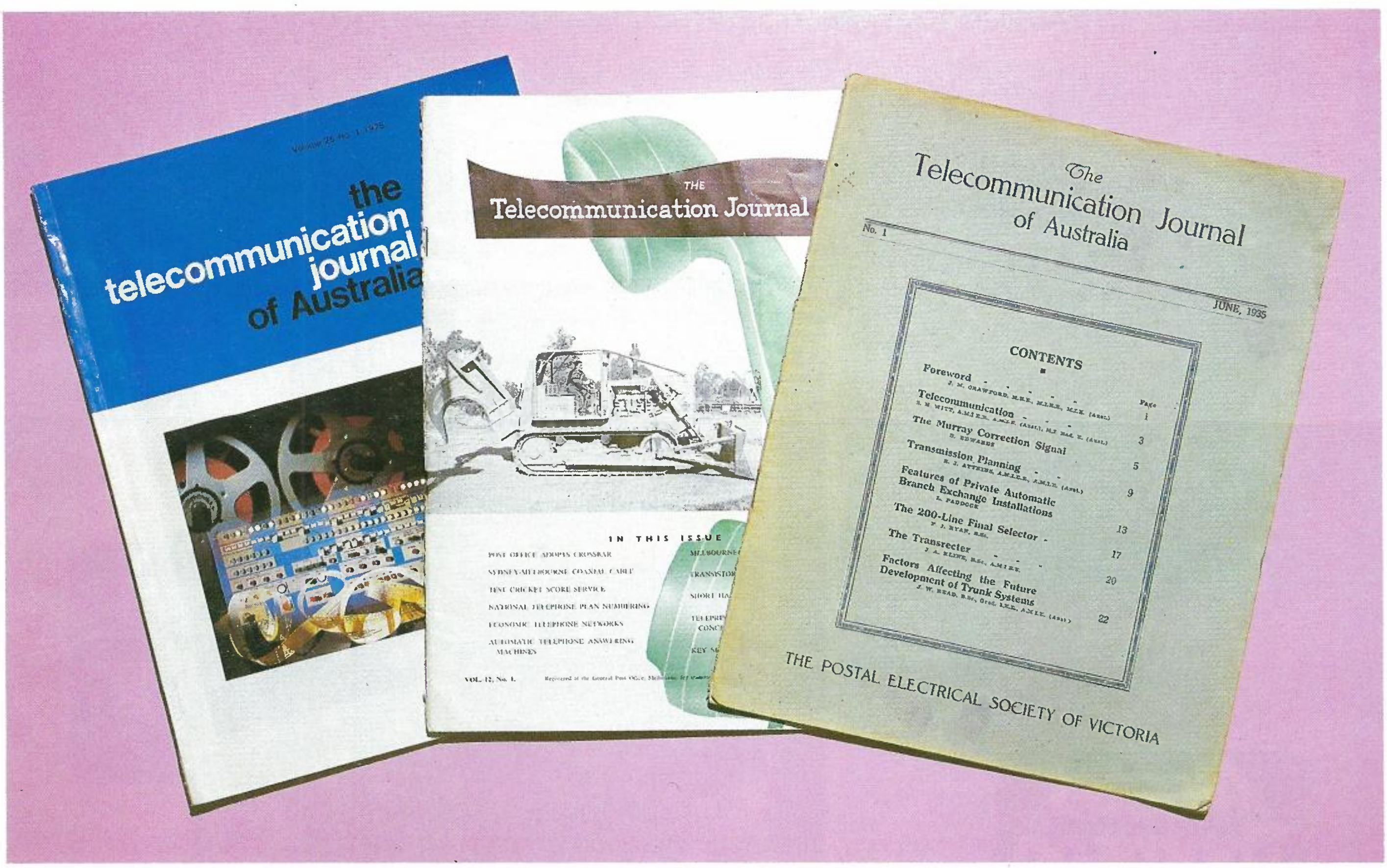
Volume 35 No. 1, 1985

the telecommunication journal of Australia

50th Year Golden Jubilee 1935-1985



FEATURED IN THIS ISSUE

- SULTAN Network
- TELETEX
- Decorator Telephones
- SWITCHNET
- SULTAN Tester
- AUSTPAC
- Traffic Forecasting
- Speaking Clock

THE TELECOMMUNICATION JOURNAL OF AUSTRALIA

ISN 0040 2486

Volume 35 No. 1, 1985

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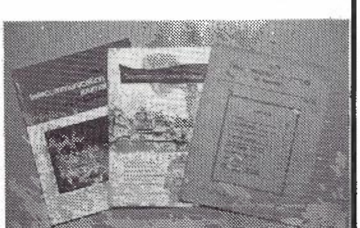

Cover featuring the changing face of the Journal over 50 years.

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OTHER ITEMS

FOREWORD

THE purpose of a foreword in a venture of this kind is, I suppose, to send it forth with every initial good wish—a sort of literary breaking of a champagne bottle on the prow of this our Victorian Technical Argosy as she takes the water for her maiden voyage. If that be so, then very sincerely do I contribute my word of Good Luck and Bon Voyage.

I well remember, as Secretary of the Institution of Post Office Electrical Engineers, helping to launch a Journal which, at its inception, was equally modest, and which we sent forth with equal trepidation. Its first issue was on All Fools' Day, 1908, and there were some who facetiously connected the date with the venture; but to-day the Journal is probably the premier Telecommunication Journal of the World—"The Post Office Electrical Engineers' Journal." It also started from small beginnings and from a sense of the need which British Post Office Engineers were then feeling of some vehicle by which they could pool and share their engineering knowledge and experience. For the true Scientist and Engineer is never selfish or exclusive. He is glad to bring his contribution into the common hive of knowledge and place his observed data at the disposal of his fellow-workers, whether they be workers in the realm of inductive thought, research or practical engineering. The value of a Journal of this kind to our Engineers is emphasised in another article in these pages, but may I stress one vital truth—it is only possible to achieve success in a Journal of this kind by widespread and consistent support!

So, just as 64 years ago the Society of Telegraph Engineers in London founded the great Institution of Electrical Engineers with its world-wide membership and authoritative Journal, and 27 years ago the Engineers of the British Post Office founded the Post Office Electrical Engineers' Journal, which to-day has also a world-wide circulation, so may our Victorian venture be a prelude to an All-Australian Communication Journal, which in due time will increase in value and become the authoritative record of the steady progress of Communication Engineering in Australia.

J. M. Crawford

Above is the Foreword which appeared in the first issue of this Journal in June 1935.

The Golden Jubilee of The Journal

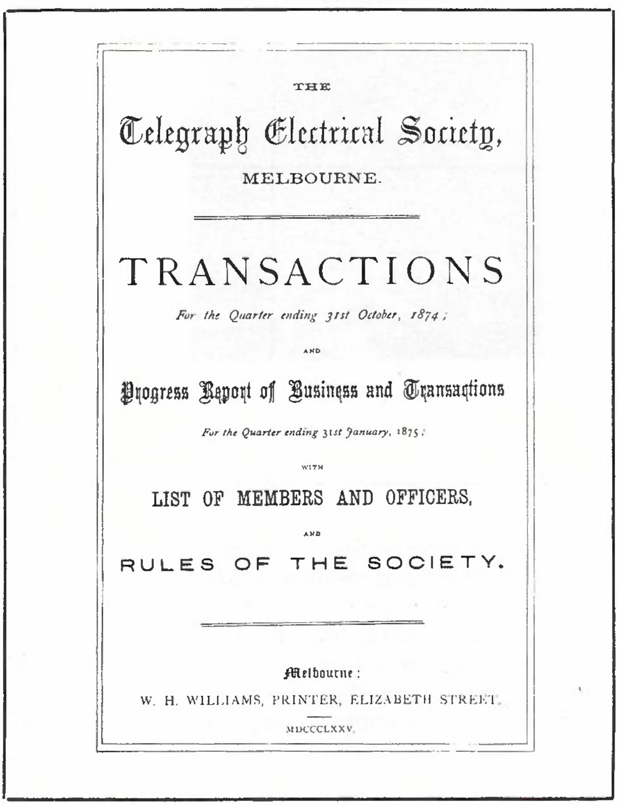
MUN CHIN B.Sc.Hon., M.Sc., MIEE
Editor-in-Chief

INTRODUCTION

In August 1874, a group of officers of the Post and Telegraph Department, Melbourne, founded The Telegraph Electrical Society. As far as we are aware, this is the first known Australian society formed specifically to cater for telecommunications interests. The stated purpose of the Society was to be ". . . the promotion of the knowledge of electricity, especially as connected with telegraphs".

The Society was energetic in its early days and regularly published a little booklet called "Transactions" to record its activities. The name of this booklet was changed to the "Journal" of the Society and, in many ways, was similar to the present Telecommunication Journal of Australia.

The Society went through periods of change and it was variously restructured in 1908, 1923 and 1932. In 1959, a further reorganisation of the Society took place to make it truly representative nationally with a change of name to the "Telecommunication Society of Australia". The objective of the Society is to promote the diffusion of knowledge of the telecommunications, broadcasting and television services of Australia by means of lectures, discussions, publication of the Telecommunication Journal of Australia and Australian Telecommunication Research. Recognising the advent of the Information Age, the Society in 1983 amended its constitution to include "information transfer" as another area of interest to the Society. This then is the current position of the Society.



THE

Telegraph Electrical Society,

MELBOURNE.

TRANSACTIONS

For the Quarter ending 31st October, 1874;

AND

Progress Report of Business and Transactions

For the Quarter ending 31st January, 1875;

WITH

LIST OF MEMBERS AND OFFICERS,

AND

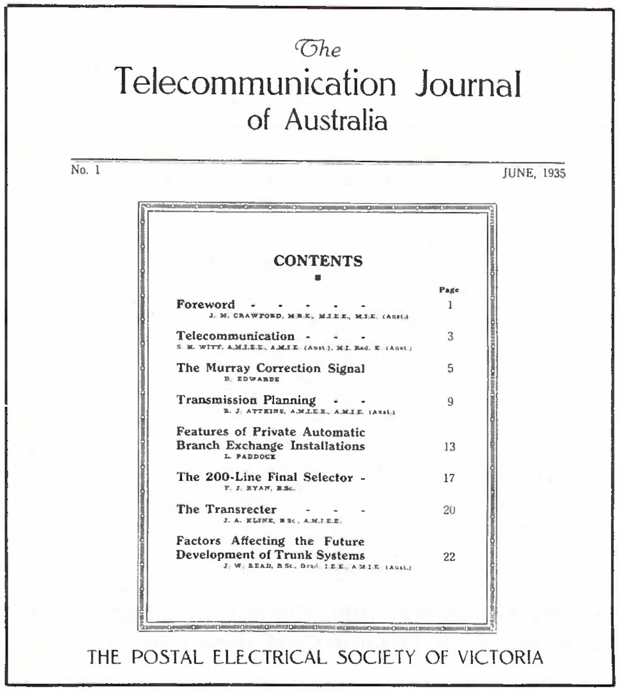
RULES OF THE SOCIETY.

Melbourne:

W. H. WILLIAMS, PRINTER, ELIZABETH STREET,

MDCCCLXXV.

To its readers this Journal is often referred to as the TJA, The Journal or Telecom Journal. Under whatever title, the TJA is an important link between the Society and its members. In a country as big as ours it is not always possible for the members to attend the informative lectures organised by the State Divisions of the Society. Thus, the only practical means of keeping members of the Society informed is through the Journal. Now in its 50th year of publication it is appropriate that we reflect for a while, examine our history and move forward purposefully.



The Telecommunication Journal of Australia

No. 1 JUNE, 1935

CONTENTS

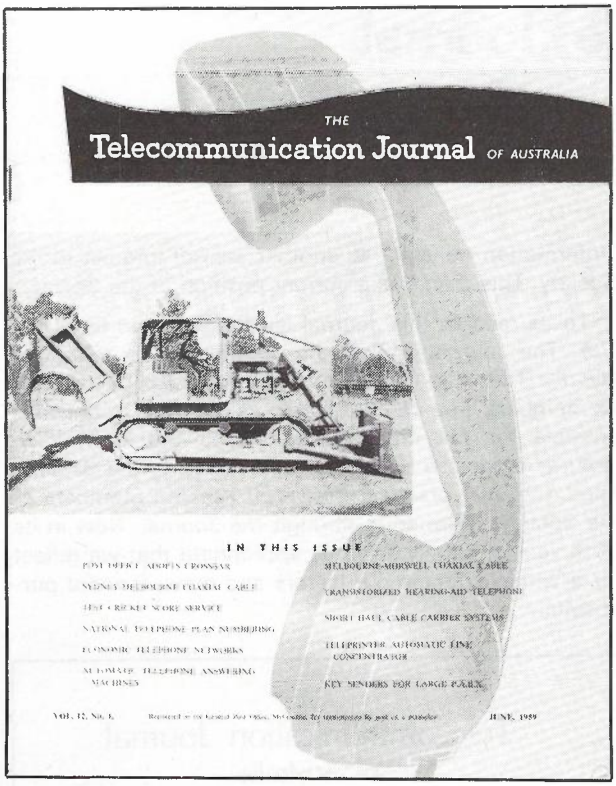
THE POSTAL ELECTRICAL SOCIETY OF VICTORIA

HISTORY OF THE JOURNAL

The Society is over 100 years old and yet the Journal is only 50 years old. Why?

In its early days (1874 to circa 1881) Transactions of the Society was published but not widely distributed. Few copies of the Transactions survived the passage of time. In 1932, following a major reconstruction of the Society, the new committee embarked on the publication of a Journal for national distribution — and the first Telecommunication Journal of Australia, as we know it, was issued in June 1935. Since that date the production of the Journal had never been interrupted. Thus, although the Journal should celebrate its 111th Birthday, it is however more appropriate to celebrate the Birthday of the Journal which we can readily recognise and identify.

In the Foreword to the first issue of the Journal, the vision was that this new venture would be ". . . a prelude



to an All-Australian Communication Journal, which in due time will increase in value and become the authoritative record of the steady progress of Communication Engineering in Australia." The Society has indeed achieved this vision. The Journal now enjoys a wide readership both in Australia and in some 60 countries overseas and it is considered to be the only journal which records the development of the Australian Telecommunications network.

When the Journal was first published in 1935, the Board of Editors comprised of Messrs A. R. Gourley, J. A. Kline and R. M. Osborne. They were sub-editors of the Journal and it was not until 1960 that the concept of an Editor-in-Chief emerged. N. M. Macdonald who had been a member of the Board of Editors since 1949 become the first Editor-in-Chief in 1960. The following table records the names of the Editor-in-Chief since 1960.

Editors-in-Chief

N. M. Macdonald	1960-1964
V. J. White	1964-1971
G. Moot	1972-1977
L. M. Mitton	1977-1981
R. Keighley	1981-1983
Y. M. Chin	1983-

The Journal commenced with two issues each year of some 25 pages but, by 1940, there were three issues each year of some 60 pages. In June 1959, the standard "blue-grey" cover which had served for nearly 25 years, was replaced with a more modern cover which features a coloured symbol of a hand-conversor of the telephone and manufacturers were invited to advertise in the Journal. In June 1973 a further improvement to the printing style and format was introduced, together with two-colour reproduction of articles. In 1975 the format of the Journal was modernised and this format has been retained to this day.

CONTROL AND PRODUCTION OF THE JOURNAL

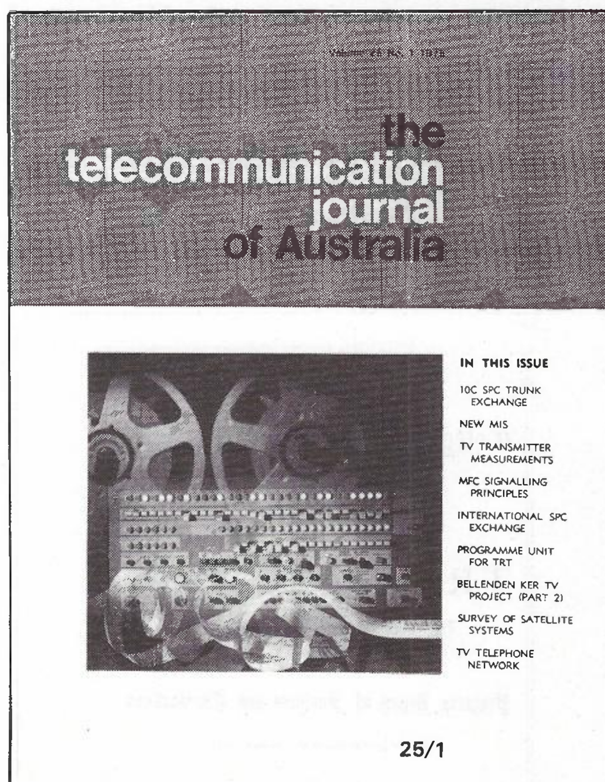
To the readers it must be a mystery as to the functioning of the Journal. For most, the Journal appears periodically on their table at work or in their post box at home.

The Journal is the official organ of the Telecommunication Society of Australia. The Society encourages Australian authors to share their knowledge through discussions and articles published in the Journal.

The Council of Control, the controlling body of the Society appoints a Board of Editors to manage the production of the Journal. Members of the Board are editors who work on a voluntary basis and they are usually experts in their field. Thus, the Editors can guide authors not only in the method of technical writing, but also the professional content.

The Board is also assisted by State Representatives who are responsible for the promotion of the Journal at State level, securing quality papers from State authors for possible inclusion in the Journal.

The Editor-in-Chief is selected by the Council of Control and is responsible for the publication of the Journal. He is assisted by the Production Manager who looks after the day to day business.

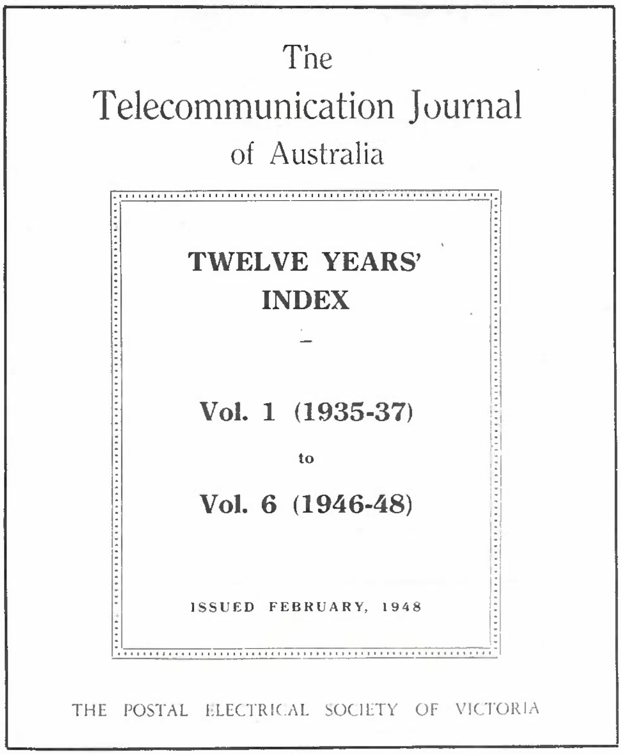


The Journal is financed by two sources: the Council of Control and advertising revenue. Although it is the aim of the Journal to break even financially, in fact it has to rely on a substantial subsidy from the Council of Control to achieve our end objective. By the nature of the Journal, it enjoys a long shelf life. Thus, advertisers find it attractive to place corporate promotion matters in the Journal. This revenue helps the Board in containing the cost of production.

THE JOURNAL — PAST AND PRESENT

Without doubt the Journal has been a valuable reference source for many readers. In the early years the Journal was the only source of information about telecommunications in Australia. Many readers found the "Answers to Examinations" feature of the Journal useful to their private studies.

In recent years, although there is an abundance of printed material about telecommunications in general the Journal is still the only authoritative publication dealing specifically with the Australian communications network and systems.



The Journal has served its readers well, and it is with readers' support that we achieve our ideals as readers sometimes become authors. In so doing other readers benefit.

For a young nation such as ours 50 years is a significant period. It is undeniable that telecommunications play a major part in the building of Australia as a nation. Without doubt the Society and the Journal played an important role in this construction.

I am certain that the Society and the Journal will continue in this role for the next 50 years and more.

REFERENCE

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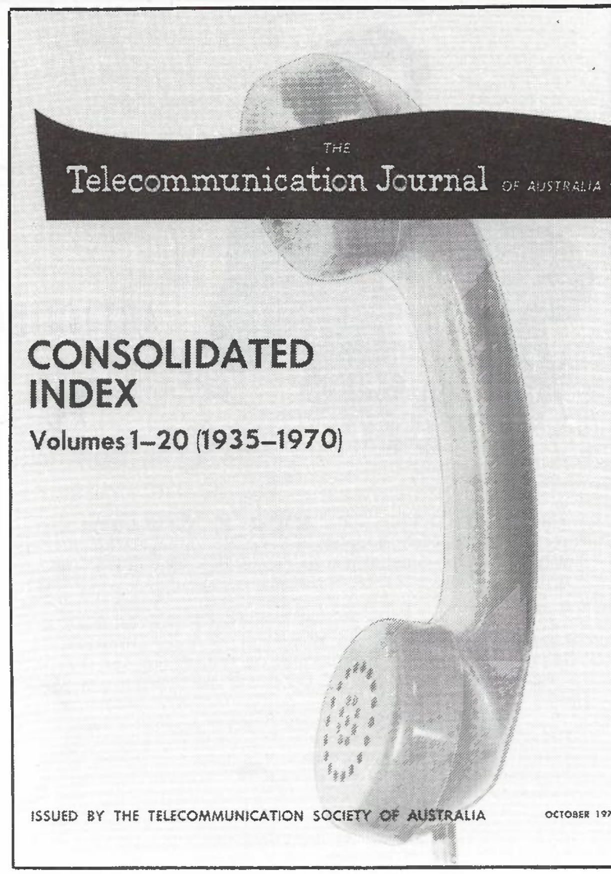
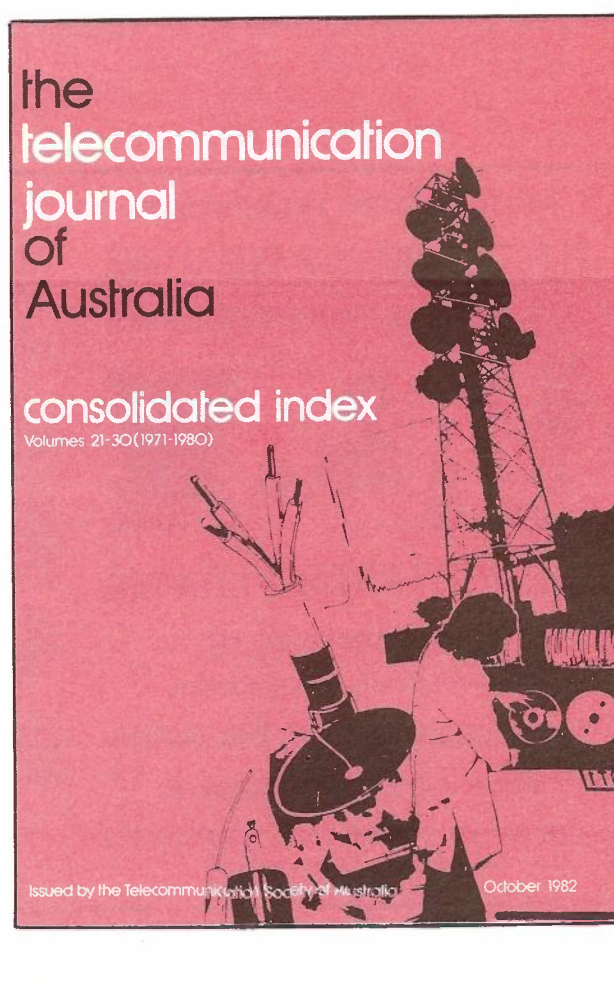


The changing face of the Journal Index



THE ARTICULATING OR SPEAKING TELEPHONE.

DURING the past few months **MR. J. E. EDWARDS** has made a great variety of experiments to test the powers of the Telephone. It is found possible to speak with facility through a hundred miles of wire, and persons using them on lines of a few miles long can converse with ease in the same manner as though they were in the same room; even the voice of the person speaking can be recognised at the other end of the line.

In the early part of February a pair of these Instruments was fixed on Messrs. M'LEAN BROS. AND RIGG'S line, which communicates between their Warehouse, 69 Elizabeth street, and their Store, 190 Bourke street west, near Spencer street, about one mile by wire, by which all their business is transmitted, the Telephone having superseded the Wheatstone instruments previously used. The Telephone can be seen in use, and also on sale, there at any time during business hours.

These Instruments are of great practical value. They can be used for any purpose, and in any position, without technical training, wherever communication or conversation is required from a distance, as between the principals and employes in commercial houses—between central and branch banks—in mining operations, between the manager's office and the employes in the mine—in large hotels or mansions—in factories of every description between the manufacturer and his factory, and between the superintendent and his leading men; and, in fact, it may be considered as an ordinary speaking tube, with all the advantages of Telegraphic communication.

The above arrangement needs but a wire between the points of communication, a pair or two pair of Telephones, and two alarm-bells to call attention to either end of the line, though a hundred yards or miles apart.

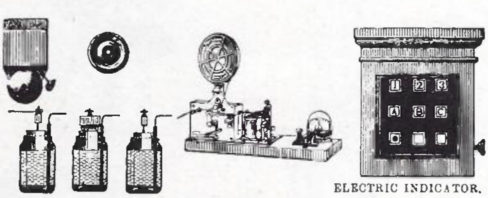
Further particulars and estimates may be obtained on application to M'LEAN BROS. & RIGG, 69 ELIZABETH ST.; or

J. E. EDWARDS, the Manufacturer, 37 Erskine st., Hotham Hill, Melbourne.

ARTICULATING TELEPHONES,

ELECTRIC BELLS & INDICATORS,

FOR PUBLIC AND PRIVATE BUILDINGS.



ELECTRIC INDICATOR.

J. E. EDWARDS, PATENTEE,

MANUFACTURER OF

ARTICULATING TELEPHONES,

Telegraph Instruments, Electric Bells, Indicators

Galvanic Batteries, Galvanometers, &c.

35 & 37 ERSKINE STREET,

HOTHAM HILL, MELBOURNE.

J. E. EDWARDS' NEW PATENT INDICATOR is very simple and reliable, which enables him to supply a first-class Indicator at a lower price than any other of even inferior workmanship. Estimates for fitting Telephones or a series of bells in hotels, mansions, etc., will be furnished on application.

All orders, accompanied with cash remittance, will receive immediate and careful attention.

It is now conceded that the ringing of house bells by means of **Cranks**, moveable **Wires**, and **Oscillating Pendulums**, which are uncertain of action, confusing to the persons attending them, and, in short, clumsy contrivances, are altogether things of the past. On the **Electric Bell System**, all pulling, tugging, and the grating noises occasioned by the cranks, and consequent breaking of the wires, are done away with; for, however distant **The Electric Bell** may be, or however tortuous its course, it can be rung by the slightest pressure of the finger on a little ivory button; and, as the electric wires do not move, the wear and tear, as on the old system, is entirely avoided. In order to secure an entirely satisfactory result three things are necessary, viz., the exclusive use of first-class and highly finished materials—the employment of skilled workmen—and the superintendence of a person of long practical experienee.

With these at command J. E. EDWARDS (who was connected with the Melbourne Post and Telegraph Department for upwards of Ten years) is able to execute in a first-class manner any orders entrusted to him. He has had the honor to execute work on a large scale, and attained results highly satisfactory at the following public and private buildings:—

The Treasury	General Post Office	The London Chartered Bank
Parliament Houses	Crown Law Offices	Registrar-General's Buildings
Beechworth Asylum	Melbourne Town Hall	New Government Offices
Ararat Asylum	Crown Law Offices	W. J. Clarke's, Esq.
Royal Mint	Messrs. Sands & McDougall	And many others, including

THE NEW GOVERNMENT OFFICES.

The Bells and Indicators may be seen in operation in Melbourne.

The Telecommunication Journal of Australia

No. 1. JUNE, 1935.

TELECOMMUNICATION.

S. H. Witt, A.M.I.E.E., A.M.I.E. (Aust.) M.I. Rad.E. (Aust.)

In days gone by it was the custom to speak of "Telegraphy," "Telephony," "Radio" as though they were separate arts, doubtless having mutual points of contact, but generally not a great deal in common; indeed, public utilities and commercial organisations were built up on one or the other of those apparently distinct divisions. Yet underlying the development and utilisation in such specialised spheres there always has been a common theory, the basic science, namely, that of the Transmission of Electric Currents of Varying Frequency.

It is not disparaging to say that a great deal of earlier development—and it has been enormous—occurred empirically, that is, by trial and error and painstaking visual observation of mechanisms. That is not at all an unusual phenomenon in human progress; other useful arts have progressed in the same way and there is much that excites our admiration in the tale of ingenuity and perseverance thereby told. But it is always interesting to try to find the reasons why an art should develop empirically rather than by scientific, and therefore logical, progression from fundamentals. Such reasons are generally obscure, often lost in the mists of antiquity, usually quite complex. To say that real knowledge accrues only when precise measurement can be made is a truism. Lord Kelvin made a statement to this effect which has now become famous, and the longer we live the more apt does his dictum prove to be.

In the case of the arts of which we are writing, it would not be far wrong to say that the main reason was the extreme difficulty of measuring the minute and rapidly varying electrical quantities that are involved. It was a difficult matter to obtain even an indirect indication of the magnitude of electric currents carrying, for example, speech impulses in a telephone circuit. A direct reading instrument was out of the question, for to give a readable indication more power was required by the instrument than the total amount available in the circuit. It is not surprising, therefore, that the earlier advances in the art of electrical communication were made on an empirical basis; rather, when we contemplate the difficulties, it is truly marvellous that so much has been accomplished.

During the last 20 years a profound change has been occurring: a change evolutionary in nature, but owing to the rapidity of its action, revolutionary when viewed in retrospect. It is due to the discovery and development of the electron tube, or thermionic valve, as it is sometimes called. In the short space of this article the genesis and development of the electron tube cannot be traversed; moreover, its history is so recent that it is common knowledge to present-day engineers, and there is also abundant literature to consult.

We are accustomed, however, to think of the electron tube in terms of the many valuable and ingenious devices that have been built upon it for its direct utilisation, as in amplifiers, telephone repeaters, radio receiving sets and the like. Some of these applications have been spectacular, having come directly under the notice of the public, even in the homes of the people, as, for example, radio receiving sets. One is inclined to believe, however, that the transcending importance of the electron tube and its derivatives lies in its application to the measurement of those electrical quantities that had hitherto been most elusive.

With the powerful tool so provided, it became practicable to verify by direct experiment the theorems in electrical transmission, so confirming and extending knowledge in the scientific side of the field and simultaneously enabling the engineer, who wished to make use of the knowledge for some practical end, to proceed to an application by methods that gave him confidence and satisfaction. These are basic matters, they lie at the foundations.

What have been the outstanding results of this buttressing of the foundations, so to speak? Without reference to chronological order, but rather taking a cursory glance over the superstructure that has become erected on those foundations, we see that there has been a great deal of stimulation of theoretical analysis into circuital arrangements of the elements of generalised networks, namely, the elements possessing the properties of resistance, leakance, inductance and capacitance. Combinations of these elements, both without a continued electro-motive force—*passive* networks—or with an internally associated source of energy—*active* networks—have been, and are being, the subject of intense investigation.

Many practical devices have been the direct outcome and there is space here to name but a few: The electric wave-filter, which is the key to the carrier-current system of telephony and telegraphy and certain of the more highly developed forms of long-distance point-to-point radio telephone systems; inductance *loading*, by which the properties of long telegraph and telephone lines may be modified in certain advantageous directions; equalisers, devices for making the response of lines and amplifiers independent of frequency over almost any desired range; phase correctors for making substantially equal the propagation time of different frequencies over long circuits. These devices are embodiments of the *passive* network.

Besides the more commonly known forms of amplifiers and repeaters, notable examples of derivations from the *active* network are: echo-suppressors for very long telephone circuits, to prevent confusion of the speaker by the return to his ear, after an appreciable interval of time, of his own voice electrically reflected from a distance point in the circuit; voice-operated switching systems, another key development which has made possible the operation of a radio-telephone circuit as a link between the trunk telephone systems of two countries. Some of the forms of the devices just named embody a third type of network which has been given much attention in recent years, the *non-linear* network. Such a network is characterised by a response having magnitude not directly proportional to the magnitude of the input to the network.

Not only has the study of transmission networks been prolific in their own development, but also the processes of their theoretical analysis have shed light in other directions. For example, it has been possible to apply them to the study of mechanical systems in their dynamic state. This has been done by making an electrical analogue of the mechanical system wherein the property of mechanical mass is represented by the property of electrical inductance, friction and viscosity by electrical resistance, the reciprocal of stiffness by electrical capacitance, and so forth. One of the outstanding results of study by this process has been the revolutionary change made a few years ago in the processes of phonograph recording and reproduction.

The advances in fundamental transmission knowledge, together with those in sister sciences, have been applied indiscriminately to the benefit of telegraphy, telephony, picture transmission and television, carried over wire systems and by radio. One result has been that whatever lines of demarcation may have existed between these fields of application have been made indistinct, and the terms have contracted upon a more specialised meaning, namely, that which connotes a particular use to which the ends of a transmission circuit may be put.

Thus it has become the habit, when speaking of the art as a whole, to use the term *electrical communication.* Now even that term has itself been the subject—or victim—of study. At the International Congress at Madrid in 1932 it was decided that the art warranted an all-embracing term and so the word *telecommunication* was evolved. Henceforth that Congress, which meets once in five years, will become known as the "International Telecommunication Congress." Since the new term has received general recognition because of its satisfactorily wide basis, it has been deemed a good one to apply to this new Journal.

Stress has been laid on the development of transmission theory for three reasons: firstly, because of its fundamental nature; secondly, because the intricacies of the transmission circuit, being electrical, are not directly visible; thirdly, because the manner of its development has been a powerful unifying influence in the telecommunication arts. There have yet to be mentioned the equally important developments in those devices of which the main purpose and functions can be appreciated by visual inspection, namely, the devices of utilisation applied to the ends of a transmission system; the units which furnish electrical power for operation; and the physical constructions that support, protect and insulate the electrical conductors of a complete telecommunication system.

But here, such things can be no more than just mentioned. The pages of this Journal will disclose the intricacies and almost uncanny accomplishments of automatic telephone switching mechanisms; the ingenuity of the mechanism of printing telegraph apparatus; the care which is taken both in the selection of material for, and in the development of novel methods of line construction, to meet economically the conditions of the Australian environment; the modern developments in power supply equipment; and interesting features of radio systems. Indeed, in the present issue of the Journal there are articles on some of these subjects. Finally, the functioning of telecommunication systems produces problems of finance, of traffic flow and adjustment of operating staff that call for specialised study by skilled people.

It is the hope of the sponsors of this Journal that it will provide a forum for those engaged in the art of Telecommunication in Australia to describe their works and express their views. Herein will be found, in convenient form, information upon the Telecommunication Services that are provided for the benefit of the people of Australia.

Decorator Telephones

S.J. SANDERS
C.S. WOOD, B.Sc.

In addition to the range of modern push button premium and standard telephones already offered to customers, Telecom Australia has introduced telephones with a variety of styles to appeal to many personal tastes in decor.

PHONES ARE LOOKING GOOD

Surveys in Australia confirm the experience of overseas telephone terminal markets that telephones which are essentially decorative appeal to customers, even though such telephones are usually offered without the technical sophistication available in modern push button telephones. They are attractive as finishing touches for domestic situations, whereas commercial users see appearance as secondary to facilities which enhance business efficiency.

Telecom decided to offer a range of telephones which would be purchased to reflect various personal tastes in decor. The first of Telecom's exclusive range of Decorator telephones have been on sale in a market trial in Western Australia since October 1984.

The telephones are for outright sale only under similar conditions to those applying to the Premium telephones available for sale since 1982. (See Refs. 1 and 2.) A warranty period of one year applies to the telephones described in this article.

DECORATOR PRODUCTS

The Decorator products chosen for initial market trial are decadic signalling rotary dial table telephones with no enhanced facilities. The range offers a variety of shapes and sizes, featuring antique-style handsets and casings. The telephones are hand crafted from natural materials with characteristic variations in grain, colour and texture, making many of the individual telephones unique. Genuine gold is used on trims, and on other parts such as the dials and handset cradles. Some carefully matched moulded plastic parts are used in the casings. Plaited handset and line cords are used on most of the telephones, to add to the antique effect.

There are seven distinct models, based on four fundamental shapes.

Minette telephones have small round bases, and are available in:

- Brown stitched leather covering **(Fig. 1)**
- Polished green variegated onyx marble **(Fig. 2)**
- White porcelain hand painted in a pink floral design **(Fig. 3)**

Fig. 2 Minette Green Marble

Fig. 1 Minette Brown Leather

Fig. 3 Minette Porcelain

Regale models have large square bases of:

- Polished green variegated onyx marble **(Fig. 4)**
- Inlaid rosewood veneer with a protective gloss finish **(Fig. 5)**

Diplomat is constructed from oiled beechwood in a shape resembling a desk with a sloping face. **(Fig. 6)**

Heritage is a rectangular ivory coloured wooden telephone, with a special surface treatment to simulate an aged appearance. The handset cradle is shaped differently from the cradle used on the other six models. **(Fig. 7)**

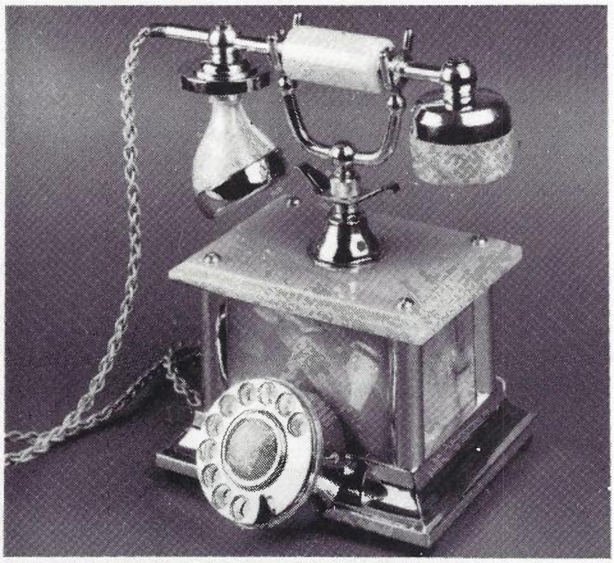


Fig. 4 Regale Green Marble

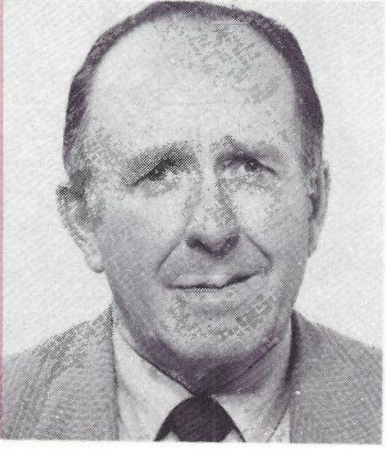
Fig. 5 Regale Wood

TECHNICAL DETAILS

Customers can buy Decorator telephones over the counter at Telecom Business Offices and may choose to self-install the telephones if the wiring and sockets are already in place. To facilitate this customer involvement in installation, Decorator telephones are required to have

CHRISTINE WOOD joined Telecom Australia as a graduate officer in 1976 and spent four years in market research activities. She has been involved with the introduction and marketing of telephone terminal equipment since 1981, and is currently responsible for the marketing of residential products in the Telephones Division of Commercial Services Department, Telecom Australia Headquarters.

STAN SANDERS joined the APO as a Junior Mechanic in 1944, and was appointed to the Telegraph Division in Victoria after completion of training. After appointments in the Northern Territory and South Australia as a Senior Technician, he transferred to Headquarters, and currently occupies the position of Manager — Test and Evaluation Centre in the Commercial Services Department, Telecom Australia Headquarters.



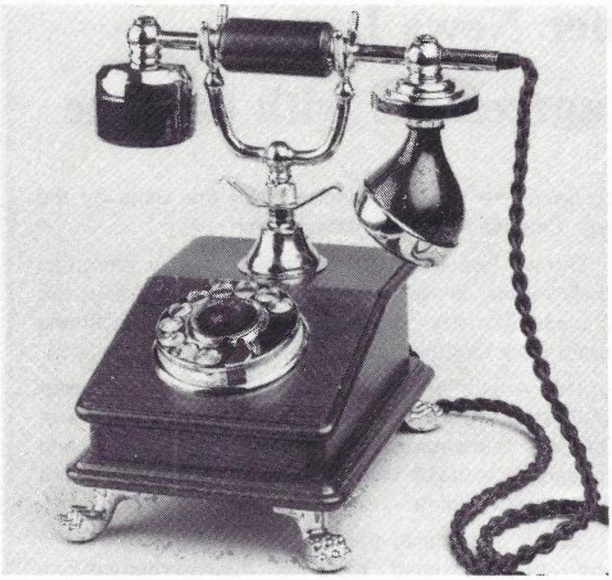


Fig. 6 Diplomat Wood

Fig. 7 Heritage Wood Craquelle

the following characteristics, the background to which has been described in detail in Ref. 2.

- Two-wire operation.
- Ringers that are compatible with the range of telephone exchanges and terminals in use by Telecom, and which offer no ring impairment or bell tinkle problems when in parallel with other telephones.
- Current sharing when in parallel with other telephones. Parallel telephones should have acceptable transmission and reception when in use simultaneously, to permit the effective conduct of calls between the telephones.
- Decadic signalling in either rotary dial or pushbutton form.
- Transmission performance to be satisfactory.
- Compliance with the functional surge test of 2 kV, 10/700 uS, the the insulation test of 3.5 kV rms.
- Freedom from Radio Frequency Interference.
- Operation over the temperature range of -10C to +55C.
- Reliability and maintainability.

As the Decorator telephones, generally, were designed to meet the specifications of other telephone administrations, the technical designs had to be modified and upgraded to meet Australian requirements. In particular, the use of decorative metal components and finishes in Decorator telephone cases, in close proximity to the telephone circuit components, needed very careful design to achieve the required high voltage isolation to protect the user.

SELLING STYLE

Decorator telephones sell themselves. There is no need to explain the benefits provided; they are obvious. The potential purchaser who wants to add prestige or a particular mood to a home needs to be encouraged to visualise the products enhancing familiar surroundings.

Advertisments and printed brochures were carefully produced to show the Decorator telephones at their best. High quality full colour photographs in furnished settings allow customers to match a telephone to specific rooms. The sturdy boxes which protect individual telephones have been exploited as colourful point of sale display items, showing accurate colour photographs and descriptions of the contents.

Decorator telephones are being promoted as part of Telecom's large range of quality products, and as being of particular interest to residential customers seeking telephones with decorative qualities.

FUTURE PRODUCTS

It seems only a matter of the designer's ingenuity to house a basic telephone in almost any shape and material. Hundreds of styles are in production around the world.

Apart from antique style telephones in natural materials, there is a wide selection of telephones with plastic moulded cases resembling historic telephones. Novelty shapes and electronic gadgetry are also used in products which have proved popular in overseas markets. Telephones crafted in wood and leather are now being produced in modern functional designs.

Products for the future will be selected to suit Australian market demand.

References

1. RENDLE, A.A., "Telecom Premium Telephones". Telecommunication Journal of Australia, Vol. 34, No. 2, 1984.

2. TREBILCO, W and LEW, W., "Technical Aspects of Premium Telephone Introduction". Telecommunication Journal of Australia, Vol. 34. No. 2, 1984.

Telecom signs co-operation agreement with Chinese

Telecom Australia has signed with Chinese telecommunications authorities a Memorandum of Understanding between the two countries.

This is seen as a significant step by Telecom, as the Memorandum covers not only technical co-operation, but also the important area of commercial co-operation in the field of telecommunications.

The signing last week formalises an existing agreement on reciprocal staff visits and confirms a close continuing relationship between Telecom Australia and the Chinese Ministry of Posts and Telecommunications.

A top level delegation from Telecom Australia visited China from 24 March - 1 April, 1985 for discussions with the Ministry of Posts and Telecommunications in Peking.

The delegation was led by Telecom's Managing Director, Mr Bill Pollock.

He was accompanied by the Director of Business Development, Mr Roger Banks, the General Manager Engineering, Mr Bob McKinnon, Assistant Director Business Development, Mr Ken Loughnan and an expert in switching and satellite engineering, Mr Boen Jong.

The team's visit to China followed visits to Australia of Chinese technical delegations in December 1984 and February 1985.

While in China the Telecom team discussed with the Chinese ways of advancing the cause of mutual co-operation and the outcomes of the visits by the two Chinese technical delegations.

During discussions, the parties broadly identified likely areas in which Telecom Australia and the Chinese Ministry of Posts and Telecommunications could work together in both the short and longer term.

The Australian delegation also gained a better understanding of the organisation and operations of Chinese telecommunications and the nature and scope of the major telecommunications development programs in China.

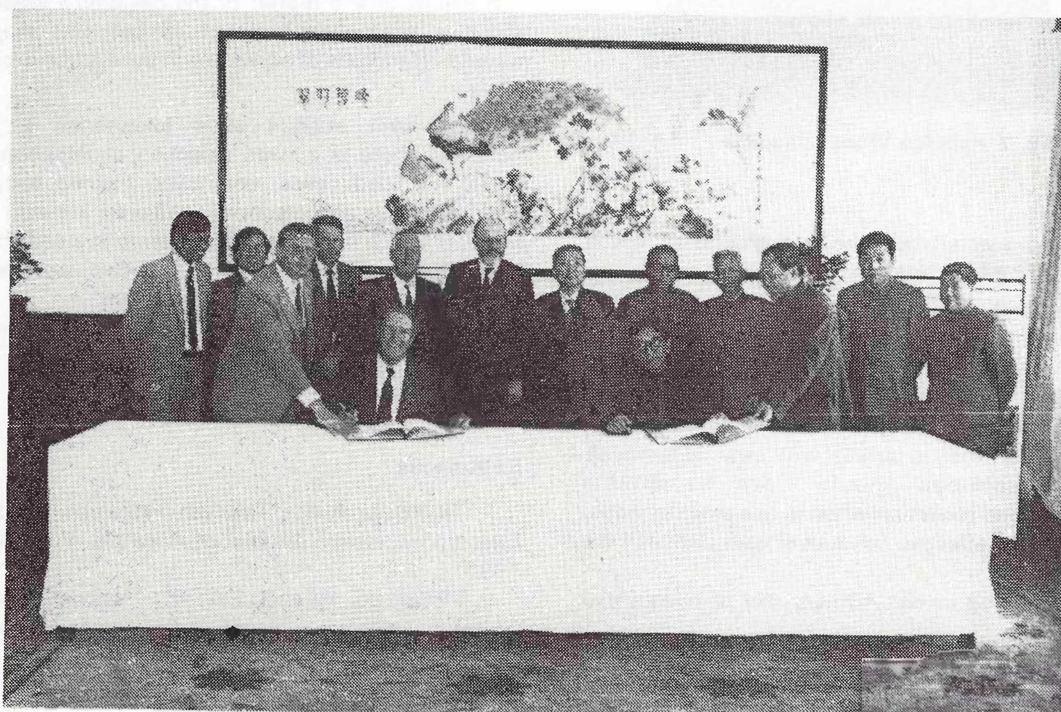
Senior officials in the Chinese Ministry recognise both the advanced state of telecommunications development in Australia, and the quality of our network.

The technical delegations from China had visited Australia to assess Telecom's unique solutions to providing long distance digital trunk systems and individual telephone services in rural and remote areas.

Australia is a world leader in the use of solar power for microwave radio routes and individual telephone services.

It has also designed a digital radio system to provide telephone services to places previously unattainable by ordinary terrestrial systems — at a cost much lower than satellite systems.

Also of interest to China are Australia's plans to link its capital cities by optical fibre cables within the next four years — this includes a Darwin-Adelaide cable.



The formal signing of a memorandum of understanding in respect of technical and commercial co-operation between Telecom and the Chinese telecommunications organisation.

New Data Communication Services & The Development of AUSTPAC
(The Australian Packet Switching Network)

M. JOHN HARRISON
Telecom Australia

A national packet switching service (AUSTPAC) was established in Australia in December 1982. This paper briefly reviews the present status of the network and describes a significant new electronic funds transfer application that has been implemented using AUSTPAC. A description is also given of the planned supporting role of the AUSTPAC network in the introduction of new public services such as Videotex, Teletex and Electronic Mail.

1. INTRODUCTION

AUSTPAC is a national packet switching network introduced by Telecom Australia in December 1982. Together with a new digital point to point transmission service (Digital Data Service — DDS), which was also introduced in December 1982, and the previously established analogue data transmission service (Datel), AUSTPAC forms part of a general plan which will provide public data communications networks and services to enable full development of the potential of computers and communications in Australia.

This paper briefly describes the present status of the network and its likely future development. A description is also given of the role of the AUSTPAC network in the support of a major electronic funds transfer user application, and planned public and private electronic mail, Videotex and Teletex services.

2. THE AUSTPAC NETWORK

2.1 Network Access

AUSTPAC currently supports two main categories of Data Terminal Equipment (DTE):

i. Synchronous DTEs operating in packet mode in accordance with CCITT Recommendation X.25 (eg. computers, front-end processors, cluster controllers, etc.) and at data rates of 2400, 4800, 9600 and 48000 bits/s.

ii. Asynchronous character mode terminals which interface to the network in accordance with CCITT Recommendation X.28 and communicate with X.25 DTEs via the network in accordance with CCITT Recommendations X.3 and X.29 and operating at data rates of 110 bits/s to 1200 bits/s.

Depending on the type and operating speed of the DTE, access to the network is provided via dedicated circuits using either analogue modems (ie. Datel Service) or digital transmission using the Digital Data Network. Access via the Public Switched Telephone Network (PSTN) is provided using national dial codes 01921, 01922 and 01923 for 110-300 bits/s, 1200 bits/s and 1200/75 bits/s full duplex service respectively. The 1200/75 service is a 75 bits/s forward, and 1200 bits/s backward transmission access for Videotex terminals.

2.2 Network Configuration

The initial (December 1982) network for AUSTPAC provided nationwide service through a node in each of the two largest capital cities (Melbourne and Sydney); with an installed capacity of 800 (approx.) asynchronous and synchronous ports. By October 1984, the network (Fig. 1) had been expanded with nodes in all the mainland capital cities and the installed capacity had been increased to some 2300 ports.

2.3 Network Expansion

Future expansions of the network are expected to more than double the present number of available

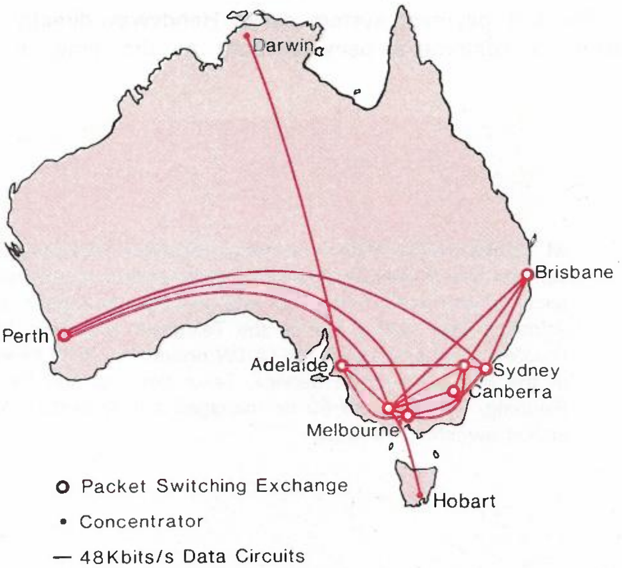


Fig. 1. Network Configuration

customer ports for each of the next 2 years, to provide in 1987 a total of 25 nodes with an available installed capacity of some 9600 ports.

Approximately 40% of these ports are asynchronous direct connections and public telephone network connections; 60% of the total ports are synchronous direct connections.

2.4 International Access

International access to packet networks in North America (eg. Tymnet, Telenet and Datapac) and Europe (eg. PSS, TRANSPAC and EURONET) has been available since July 1982. Initially a modified X.25 link was used for this access to the international gateway (provided by OTC), and then a full X.75 link was implemented in December 1983.

2.5 Tariffs

This service tariff structure currently consists of three separate components:

(i) Access — a charge for the type of transmission connection to the network. The charge is independent of distance between a terminal and the network (eg. $220/mth for 2400 bits/s dedicated synchronous link — including line and modem or DDS network terminating unit).

(ii) Usage — a charge for the volume of data transferred and the connect time. Usage charges are distance independent (eg. 88 cents / kilo-segment — 1 segment being 64 octets).

(iii) Facilities — a charge for subscription to a particular facility such as closed user group (eg. Permanent Virtual circuit — $80/mth).

3. ELECTRONIC FUNDS TRANSFER (EFT) AND AUSTPAC

3.1 EFT Application

A significant user application that has commenced operation on the AUSTPAC network is an EFT system developed by the Australian WESTPAC banking organisation in conjunction with a supermarket chain (Woolworths) and an oil company (British Petroleum).

The EFT payment system called Handyway directly debits a customer's bank account at the time of purchase, and at the same time automatically transfers the funds to the merchant's account.

Customers who have a WESTPAC debit card (Handyway card) are able to obtain services such as, goods only, goods and cash, or cash only from Handyway terminals located at 1000 retail outlets and 1500 branches and agencies operated by WESTPAC.

For the retailers this EFT point of sale (POS) technique provides significant marketing and financial management advantages, such as in providing faster customer checkout, cash dispensing at the point of purchase and elimination of bad debts.

3.2 System Components

The technical components of the EFT system (pictured in figure 2) are:

(i) A debit card (WESTPAC Handway card).

(ii) A point of sale terminal which includes a keyboard, line display, printer and manual swipe card reading device.

(iii) A terminal multiplexer/concentrator — which is able to handle 16 terminals and several virtual circuits.

(iv) A front end processor to perform initial debit card processing and protocol conversion between the AUSTPAC network and the host mainframe computer.

3.3 EFT Operation

The main steps in the operation of the POS terminal and interaction with the elements of the system are as follows:

(i) A customer debit card is wiped through the terminal reader — the amount is entered and appears on the customer verification unit (held for security by the customer) — the customer then enters his PIN (personal identification number).

(ii) In the case of a POS terminal which is directly connected to a multiplexer unit — this unit selects a VC (previously established across the AUSTPAC network) to the appropriate front end processor and then transmits a packet of data for verification.

(iii) In the case of a POS terminal which is directly connected to the AUSTPAC network — a direct call

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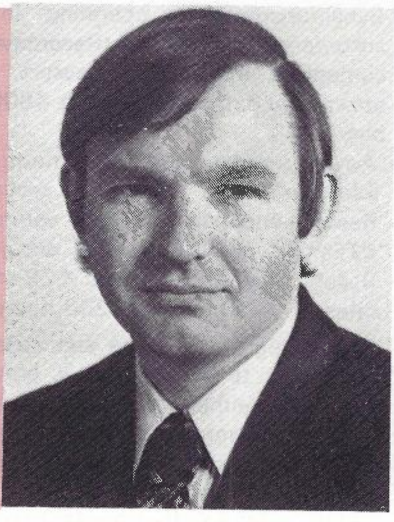


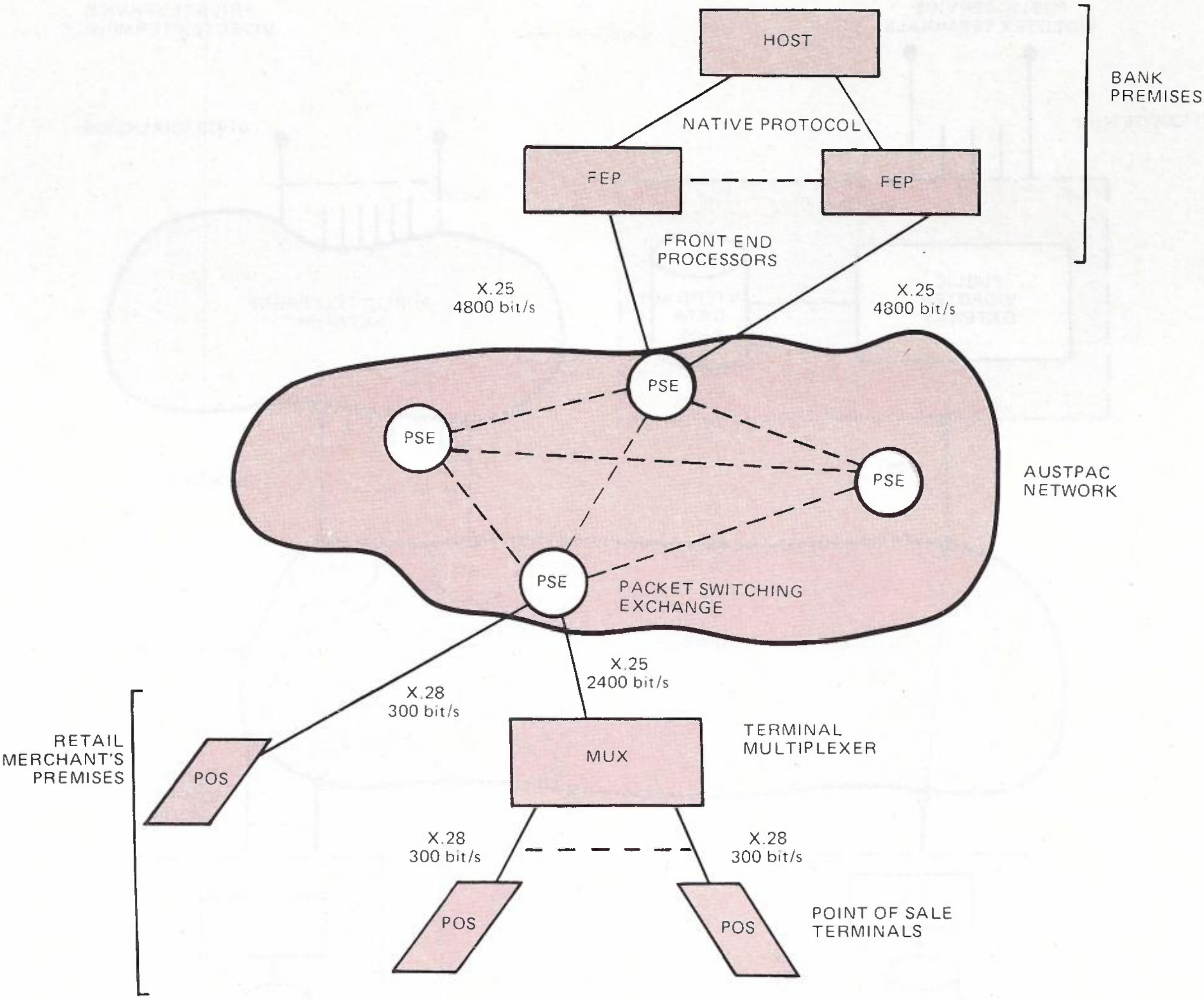


Fig. 2. Electronic Funds Transfer Network

is made across the AUSTPAC network to the appropriate front end processor, and a packet of data is transmitted for verification.

(iv) A verification packet of data is then transmitted from the front end processor to the originating POS terminal, displayed and the details printed on a customer receipt.

3.4 Network Aspects

For high concentrations of POS terminals, such as in a large retail store, access to the AUSTPAC network is obtained through a multiplexer **(Fig. 2)**. The multiplexer is directly connected to AUSTPAC using an X.25 synchronous 2400 bits/s link, configured with 2 VCs across the network to front end processors.

Less dense groups of terminals are handled by a direct 300 bits/s connection over an X.28 asynchronous link to the network, which is configured with a direct call facility.

Each terminal transaction consists of a 64 octet packet transmitted to the front end processor with a return 48 octet acknowledgement and verification packet. The overall terminal transaction response time is around 5 seconds.

At the front end processor access to AUSTPAC is provided over 4800 bits/s X.25 direct synchronous circuits with multiple logical channels, which terminate the VCs from multiplexers and direct calls established from single POS terminals.

4. VIDEOTEX SERVICES

4.1 National Videtex Service

Telecom Australia plans to establish a national Videotex service (VIATEL) by the end of this year (1984). This service will provide a range of financial, agricultural, travel, consumer and medical information and also contain information supplied by Telecom Australia, such as directory and telecommunication products details. It will also provide access to third party computers/databases through a gateway function. These specialised database services will further extend the range of information available to the user, and will also enable direct transactions with external computers for applications such as home banking, shopping from home, and direct travel and accommodation reservation and confirmation.

The AUSTPAC network's role in the provision of Telecom's public Videotex service is outlined in figure 3. Videotex terminals gain access to the public gateway via the telephone network and 1200/75 bits/s modem transmission. Access from the public gateway to remote third party data bases is provided via AUSTPAC using standard X.25 protocol.

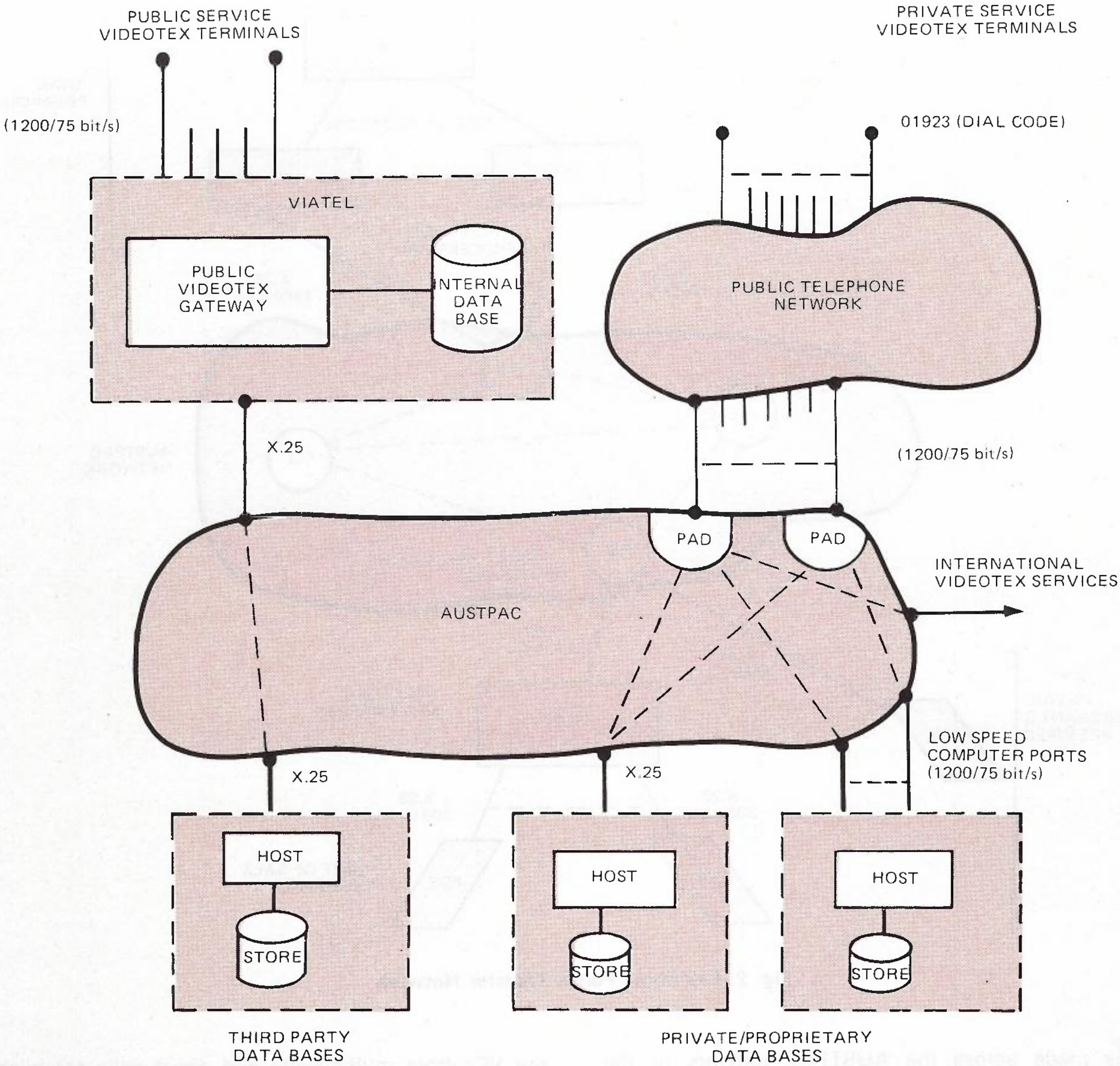


Fig. 3. Videotex Services and AUSTPAC

The national availability of AUSTPAC and its distance independent volume based tariffs, is expected to prove very attractive to entrepreneurs in establishing a large and varied range of third party provided information and services.

4.2 Proprietary Videotex Services

For private or proprietary Videotex services AUSTPAC provides public 1200/75 bits/s terminal access (**Fig. 3**); either through direct connections to the network, or via the public switched telephone network and national access code 01923.

At the 1200/75 bits/s network port AUSTPAC provides standard protocol interfaces for X.28 terminals and Videotex terminals (PRESTEL, TELETEL and NAPLPS). This interface provides special handling for * and # characters, and echo. To provide billing, automatic reverse charging is established for Videotex terminals; X.28 terminals may elect to use reverse charging or user charging (ie. NUI required).

A private data base service can be connected to the AUSTPAC network by standard synchronous X.25 circuits or by a dedicated 1200/75 bits/s low speed computer port facility. Services which have been established include those for the areas of Motel/Hotel and travel reservations, as well as agricultural (eg. livestock marketing) information.

Access to international Videotex databases (eg. British Telecom PRESTEL) is also available to 01923 and direct access users on the AUSTPAC network.

5. ELECTRONIC TEXT/MAIL SERVICES

5.1 Text Services

Business is making increasing use of electronic information and text communications. Indeed, the internal efficiency and external competitiveness of a modern company can be significantly effected by its ability to manage information transport within the organisation, and between the organisation and its suppliers and customers.

The only national public text communications facility that has been available for the past 20 years or so is the TELEX service. However, a new text communication service — Teletex — is to be introduced in 1985.

Teletex is a service developed to provide a better response than TELEX to modern office requirements for integration of local text processing (eg. typewriter functions), with capabilities for national and international standardised (CCITT) communication of formatted documents (eg. invoices) at high data transmission rates.

AUSTPAC's role in the provision of a national Australian Teletex[1] service is shown in **Fig. 4.** Teletex terminals operating at any synchronous speed (2.4, 4.8 or 9.6 Kbits/s) and directly connected to the AUSTPAC network will be able to communicate with the national and international TELEX user community via a Teletex-/TELEX conversion facility.

Direct communication between Teletex users on the main national Teletex Digital Network, and those on the AUSTPAC network is planned to be provided by a specific Teletex Interworking Unit.

Teletex users on AUSTPAC are expected to be those with high individual terminal traffic, or those concentrated groups of terminals connected to a local cluster controller, or host computer systems with an integrated Teletex interface capability.

A further possible mode of operation which is still under evaluation, is for Teletex terminals located on the general public switched telephone network to access the Teletex community via an X.25 (2400 bits/s) dial in facility to the AUSTPAC network.

5.2 Electronic Mail

While Teletex (and TELEX) are good examples of synchronised communicating systems (ie. sending and receiving entities are in direct contact) there is an important demand for person to person non synchronised information transfer; where communication takes place independently of the senders and receivers presence (or absence) and location. The storage, or electronic mailbox facility needed for this person to person service is now provided by a variety of computer based messaging systems (CBMS).

An example of a privately provided CBMS is ACIMAIL which is operated by Australian Consolidated Industries (ACI). ACIMAIL is based on Hewlett Packard mainframe equipment located in Melbourne, Victoria and is connected to AUSTPAC using 4.8 Kbits/s X.25 circuits. The AUSTPAC network acts as a nationwide collector of traffic for the service and through the public switched telephone network access (ie. 01921, 22, 23 for 300, 1200 and 1200/75 bits/s to AUSTPAC provides a travelling businessman with location and time independent access to his mail box. This access is not restricted to Australia, as international access for overseas travel or access by ACI European and Asian group member companies is also used.

While there are several privately operated electronic mail services available in Australia, widespread use of this kind of facility, especially by small to medium business organisations, generates a need for a standard national public electronic messaging service.

Telecom is planning to introduce such a service in mid 1985[1]. National access to this electronic mail service will be provided by the AUSTPAC network. Asynchronous terminals at any of the speeds 110, 150, 200, 300, 1200 or 1200/75 bits/s will be able to connect via the public telephone network, at a fee similar to a local call charge, to this new standard facility. Synchronous terminals directly connected to the AUSTPAC network will also be able to access the mail system, as will international traffic from packet networks in Europe, Asia and North America.

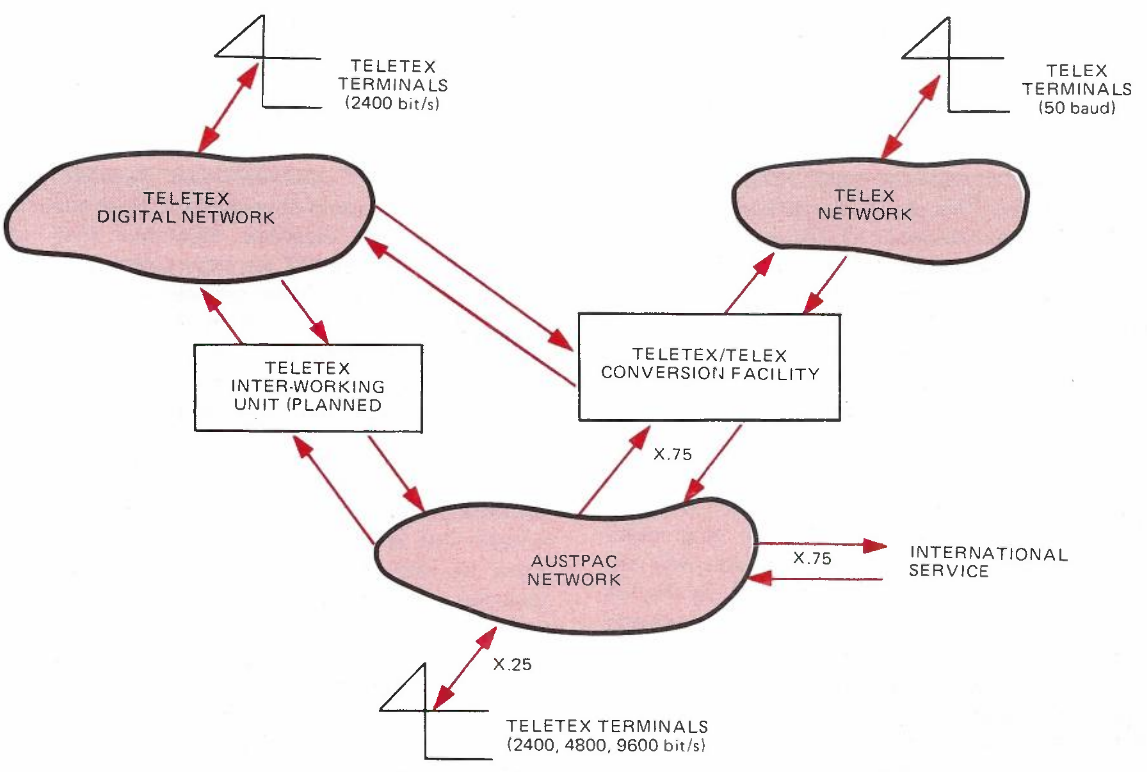


Fig. 4. Teletex Service Network

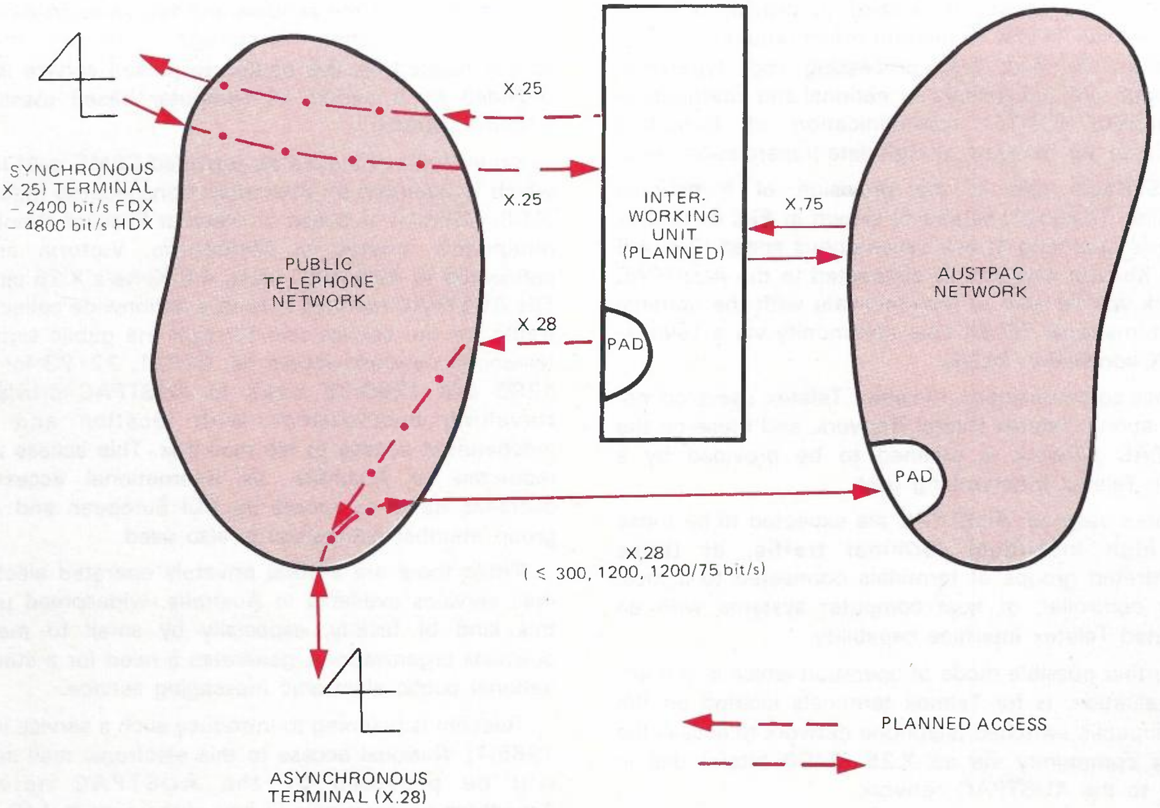


Fig. 5. Telephone/AUSTPAC Interworking Plan

6. FUTURE DEVELOPMENT OF AUSTPAC

6.1 Other Network Gateways.

Although AUSTPAC has some interfaces to existing networks, such as an asynchronous dial-in access from the public telephone network and an international interface to other countrys' packet networks, there are significant gaps yet to be bridged to achieve an objective of reasonable interconnectivity between terminal populations on the various public networks.

Perhaps the most important of these, because of the potentially large terminal population, is that of a full bothway interface between the public telephone and the AUSTPAC networks. This planned interface (see **Fig. 5**) will provide both asynchronous (X.28) and synchronous (X.25) terminals connected to the public telephone network with the ability to communicate with all services accessible via AUSTPAC such as national and international Videotex, Teletex, Electronic Mail and proprietary data bases.

Although the present planned telephone network interface is essentially oriented towards data transmission service derived from an analogue based network, a second phase of implementation will take account of the emerging all digital nature of a multi-services telephone network. This latter phase will see some integration of the networks to provide for the full X.1 range of data rates, which it is not possible to provide on an analogue based network.

The TELEX network, although under strong competition from Teletex and CBMS systems provides a national and international service to a large population of users. It is therefore planned to provide a real time (as compared to the store and forward Teletex/TELEX interface) interworking between the TELEX and AUSTPAC networks.

The introduction of this interworking unit is expected to substantially increase the utility of the TELEX terminal to a customer, by providing increased opportunities to access corporate or public data bases, or indeed any service available to a general data terminal. A further incentive is expected to be the low cost of this kind of communication, as it will be based on the much more cost effective (compared to TELEX) distance independent AUSTPAC service tariffs.

6.2 Transit Switching

The computer communication services market is characterised by rapid development. New public services such as Teletex, Videotex, Electronic Mail and user applications such as EFT are expected to grow at rates of 30-40% per annum. These services are in turn expected to generate demand for AUSTPAC network ports at similar growth rates.

By 1987 the network is expected to have over 25 packet exchanges with some 9600 installed ports.

Further expansion of the network in a flat network architecture is not possible while maintaining high network performance objectives (ie. call set up and delay times). This is because as new exchanges are added, more of each of the existing exchanges termination capacity is required to interconnect (or trunk) to the new exchanges. Planning has therefore commenced on introducing new switching technology to perform a transit switching role in a very large "2 level" network. This transit/terminal exchange architecture is expected to be introduced in about 1987/88 and provide a manageable path to a relatively open-ended large public packet switching network.

7. CONCLUSION

AUSTPAC is a nationwide public switched data service that has become a vital infrastructure for a wide range of public and private computer communication services. Significant new user applications such as electronic funds transfer are also being developed on this switched data network.

The utility of AUSTPAC is planned to be substantially increased by providing interworking units between the network and the TELEX, Teletex and public telephone networks.

In the next few years the number of network ports is expected to grow very rapidly and in order to maintain AUSTPAC's high levels of switched data performance a new generation of fast transit switching exchanges is planned to be introduced.

8. ACKNOWLEDGEMENT

The permission of the Chief General Manager, Telecom Australia to publish this paper is acknowledged.

REFERENCES

1. D. Gannon and G. Crayford "Plans for the Introduction of Teletex in Australia" **ICCC Proceedings** 1984.

ANSWERS TO EXAMINATION PAPERS

The answers to examination papers are not claimed to be thoroughly exhaustive and complete. They are, however, accurate so far as they go and as such might be given within the time allowed by any student capable of securing high marks.

EXAMINATION No. 2024.—FOR PROMOTION AS SENIOR MECHANIC, TELEPHONE INSTALLATION AND MAINTENANCE SECTION.

C. R. COOK, A.M.I.E.Aust.

QUESTION:

1. (a) Define:—(i) Impedance; (ii) Dielectric; (iii) Farad.

(b) Explain the following terms and give an example of the application of each:—(i) Electro-polarised relay; (ii) Eddy Currents; (iii) Mutual Induction.

ANSWER:

(a)—

(i) **Impedance** is the effective resistance offered to the passage of an alternating current. It is dependent upon frequency, inductance, capacitance and resistance. It is measured in ohms and its value "Z," for a circuit of "R" ohms resistance, "L" henries inductance, and "C" farads capacitance at a frequency of "f" cycles per second is:—

$$Z = \sqrt{R^2 + \left(2\pi f L - \frac{1}{2\pi f C}\right)^2}$$

(ii) A **Dielectric** is a substance which offers a high resistance to the passage of an electric current and which can withstand the application of considerable potential difference without breaking down and allowing a discharge to take place through it.

(iii) A **Farad** is the Practical Electro-Magnetic Unit of capacity; a conductor has a capacity of 1 farad if a charge of 1 coulomb raises its potential by 1 volt.

(b)—

(i) An **Electric-polarised Relay** is one which is polarised by an electric current of fixed direction flowing through one of its windings while the current in a second winding may flow in either direction to oppose or assist the magnetic effect of that flowing in the first, resulting in a normal or operated condition of the relay depending on the direction of the current in the second winding.

Such a relay is used as the F relay in an Auto-Auto Repeater.

(ii) **Eddy Currents** are induced currents in a mass of metal under the influence of a varying magnetic field.

The release of the B relay in a final selector is governed by the effect of eddy currents in the copper slug of the relay.

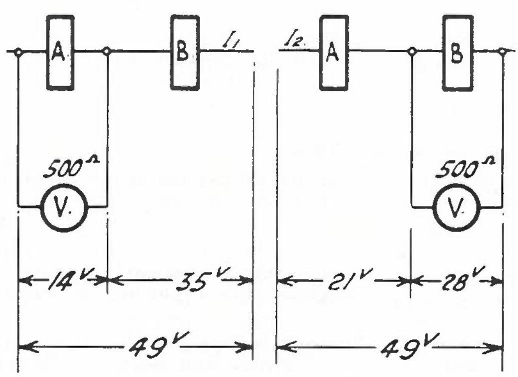
(iii) **Mutual Induction** is the electro-magnetic effect whereby a change of current strength in a circuit will produce another current in an adjacent but insulated circuit. The induced current always opposes the current which produces it.

The induction coil in a subscriber's telephone is an application of this principle.

QUESTION:

2. Two relays A and B are connected in series with each other between battery terminals giving a constant potential difference of 49 volts. When a voltmeter of 500 ohms resistance is connected across A and B in turn, the readings are 14 and 28 volts respectively. Calculate the individual resistances of A and B.

ANSWER:



VALUES WITH VOLTMETER ACROSS "A". VALUES WITH VOLTMETER ACROSS "B".

Voltmeter across "A."

The current flowing when the voltmeter is connected across A is:—

$I_A = (14/A + 14/500) = 35/B$-by ohms law.

Taking a common denominator for the LH side of the equation—

$(7000 + 14A)/500A = 35/B.$

Divide both sides of the equation by 7, thus giving—

$(1000 + 2A)/500A = 5/B$ or

$(500 + A)/250A = 5/B.$

Now multiply the equation by 250 AB and obtain—

$500B + AB = 1250A$, from which

$AB = 1250A - 500B$ . . . . . . (1).

Voltmeter across "B."

The current flowing when the voltmeter is connected across B is—

$I_B = (28/8 + 28/500) = 21/A,$

from which as in the foregoing $AB = 375B - 500A$.

Equate both values of AB

$375B - 500A = 1250A - 500B,$

from which $B = 2A$.

Substitute 2A for B in equation 1.

$2A^2 = 1250A - 1000A$, from which

$A = 125$ **ohms,**

and as $B = 2A$, therefore

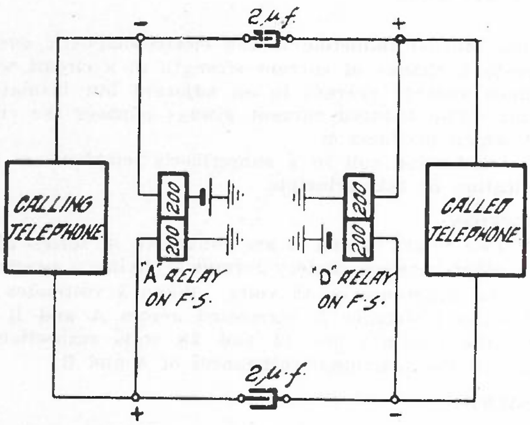
$B = 250$ **ohms.**

QUESTION:

3. (a) Show by means of a schematic diagram the manner in which speaking battery is supplied to two subscribers connected to the same automatic exchange when they are conversing with each other.

(b) In the power supply system of an exchange, what methods and precautions are adopted to prevent:—(i) Crosstalk; (ii) Ringing induction; (iii) generator noise?

ANSWER:



(b) Crosstalk is prevented by—

(i) Employing a secondary battery of negligible internal resistance, and utilising busbars, cables, switches and protective equipment so designed that there will be a drop of not more than 1 volt between the battery terminals and the subsidiary distribution points in the exchange.

(ii) Ringing leads consist of twisted pairs which are isolated from power leads and conductors carrying speech currents.

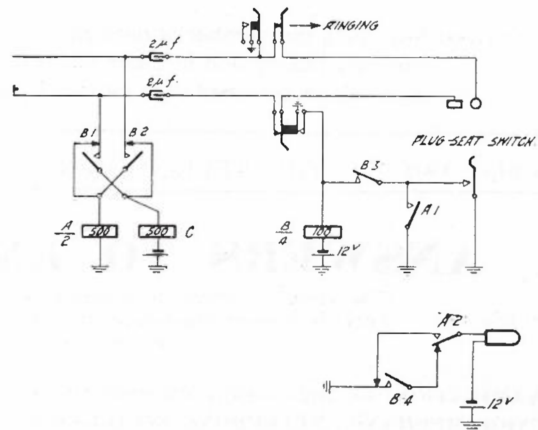
(iii) If the batteries are floated, a special telephone type generator is used and if necessary a choke coil or electrolytic condensers are connected in the output circuit of the machine. Both the charge and discharge leads for each battery are run as far apart as practicable. The positive and negative discharge cables from each battery should be of equal length and bonded together.

QUESTION:

4. Draw a schematic circuit of the manual end of any automatic to manual junction arrangement with which you are familiar. Explain its operation.

ANSWER:

When the loop is placed on the line at the repeater in the automatic exchange, battery from retard coil C flows around this loop to operate relay A. The calling lamp circuit is completed via B4 and A2. The telephonist operates the speaking key, ascertains the number required, inserts the plug in the jack and rings. The extra contacts on the ringing key complete the circuit of relay B. B4 opens the calling lamp circuit; B1 and B2 reverse the battery over the junction and cause registration of the call against the calling subscriber, whilst B3 provides a holding circuit for B via A1 and the plug seat switch in parallel. When the calling subscriber clears, relay A releases and the calling lamp glows, the circuit being via A2, B4 operated, and ground. Relay B holds so long as the plug seat switch is operated and also holds the repeater in the automatic exchange. When the plug is replaced, relay B releases, the calling lamp circuit is opened and the removal of battery from the positive side of the junction clears the repeater in the automatic exchange.



QUESTION:

5. List the functions of each relay on a straight line final selector with which you are familiar.

ANSWER:

The designations and functions of the relays on a final selector are:—

A. Impulsing Relay feeds battery to the calling subscriber and closes the circuit of "B" relay. Responds to impulses from the subscriber's dial and causes the vertical and rotary magnets to operate. When released it prepares the circuit for the release magnet.

B. Guard and Release Control Relay connects ground to release trunk to hold switches in previous ranks and to guard the call against intrusion. Its release closes the release magnet circuit.

C. Impulse Steering Relay operates during the vertical train of impulses and releases at the end thereof, preparing the circuit for the operation of the rotary magnet.

D. Supervisory and Battery Feed Relay feeds speaking battery to the called subscriber and reverses battery from relay A back to previous switches in the connection to provide for supervision.

E. Rotary Control Relay releases at the end of the rotary impulses and prepares the circuit for the testing of the condition of the called subscriber's lines.

F. Ring Trip Relay operates when direct current flows through the called subscriber's loop and cuts off the ringing current and allows the operation of the D relay.

G. Busy Control Relay tests the called party's line for an engaged condition and if such exists informs the calling subscriber by transmitting the busy tone.

H. Wiper Cut-in Relay operates when the subscriber's line is disengaged and connects the wipers to the speaking and ringing circuit after the K (cut-off) relay of the subscriber's line switch has operated.

J. Meter Control Relay controls the period for which the booster battery pulse is applied to the private wire to operate the subscriber's meter.

QUESTION:

6. A subscriber has an exclusive magneto service. Describe the necessary arrangements at his premises before and after the conversion to automatic working of the exchange from which his service is provided.

Plans for the introduction of Teletex in Australia

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Telecom Australia

This paper outlines plans for Teletex in Australia. The paper discusses the market potential for Teletex in Australia and the approach taken by Telecom Australia in developing the Teletex service. The paper also discusses the architecture of the proposed system and its relationship to other existing and proposed message handling services.

1. BACKGROUND

The transfer of information by mail and telecommunication services is now vital to the operation of a modern nation. It is impossible to conceive how our society or the economy would function without such services.

In the last few decades the use of electronic text communication services has increased rapidly. In recent years the word processor and the personal computer have become an accepted part of the modern office. Although these devices are currently used primarily to undertake local functions, such as computing, filing and text preparation the devices can also be configured as communication terminals. This provides an opportunity to transform business. There will be a terminal in every office which potentially could be used for electronic mail, electronic funds transfer and other inter-business communications.

Unfortunately, the proliferation of different devices, based on different standards makes the realisation of effective inter-business communication difficult. In such an environment, inter-business communications is facilitated by the provision of standard communication services.

In Australia, electronic text communications has been dominated by the Telex service. The Telex service was introduced in the 1950s and had grown to accommodate more than 40,000 customers by 1983. In recent years the Telex growth rate has declined due to the impact of new technologies such as office word processor systems. These systems offer customers capabilities not available on Telex such as the convenient transmission of letter-quality documents with the full office typewriter character set.

2. MESSAGE COMMUNICATION MARKET

Telecom carried out a major market research study during 1983 to determine how the text communication market would develop in Australia. The study revealed that the new generation of text communication services would have a substantial impact on business communication services and substitute for both voice and mail communication.

Consider, for example, the various communication transactions involved in purchasing (see Table 1). Purchasing involves the transfer of information between a record system in the company (a database) and record systems in other organisations. Today this information is transferred between the companies either by the telephone or by mail. People play a key role in this communication process. People translate the format and procedures used in one organisation to those of the other. Data communications could be used in this application once the problem of interfacing the different organisational structures is solved.

Transaction	From	To
Enquiry	Purchaser	Supplier
Quotation	Supplier	Purchaser
Order	Purchaser	Supplier
Acknowledgement	Supplier	Purchaser
Invoice	Supplier	Purchaser

Table 1 — The Purchasing Process

There are several other major applications — ordering, billing, progress checking — where businesses will increasingly substitute various forms of data communications for voice and mail.

The market research indicated two key sectors of the future text communication market.

Firstly there is a need for a high integrity text communication service which can be used with confidence for business transactions. Such a service should provide:

- identification of the sender and receiver;
- assurance of message delivery;
- assurance that the received document is the same as the transmitted document; and
- transmission of documents with the full character set.

Secondly there is also a need for a service which supports communication between the large population of word processors (WPs) and personal computers (PCs) now spread throughout the business community. Such a service needs to address the problem of incompatibility between different types of terminals.

These two market sectors point towards different solutions to resolve the interconnectivity problem alluded to previously.

2.1 Teletex Service

The requirements of the high integrity market sector dictates a terminal-based solution whereby the communication functions of the terminals are standardised. This is a similar approach to that used for the Telex service where the direct interconnectivity of more than one million terminals world-wide is guaranteed. However, the standard needs to be more in keeping with the requirements of the modern office environment and overcome the limitation of Telex. These limitations include slow speed (50 bit/sec), restricted character set, poor presentation and the requirement for a special purpose network.

The Teletex service as defined by the international telecommunications standards body (CCITT) overcomes these limitations and meets all the requirements identified by the market research for a high integrity text communication service.

The basic Teletex service is an international text communication service operating at 2400 bit/sec (approximately 300 characters/sec). It permits the automatic memory-to-memory exchange of documents comprising a number of pages over data telecommunications networks. These networks include Public Switched Telephone Networks (PSTN), Packet Switched Data Networks (PSDN or, in the Australian context, AUSTPAC) or Circuit Switched Data Networks (CSDN — Telecom Australia has no plans to introduce such a network).

The Teletex service is defined in such a way that it provides speed, realiability, quality and flexibility of presentation, low communications cost, international compatibility and, most importantly, a guaranteed interworking capability with equipment from any supplier which complies with the standard.

The above mentioned market research identified that the Teletex market comprises three main segments:

- The Telex Replacement Segment. This segment includes users who transfer from Telex to Teletex because it offers more cost-effective communications.
- The General Correspondence Segment. This segment comprises users who use Teletex to support communication between word processors. Teletex becomes a substitute for the physical transfer of documents.
- The Special Applications Segment. This segment uses Teletex to support the communication of information between record systems in different organisations. Teletex becomes a substitute for some forms of voice communication and to replace the widespread use of forms in industry and commerce.

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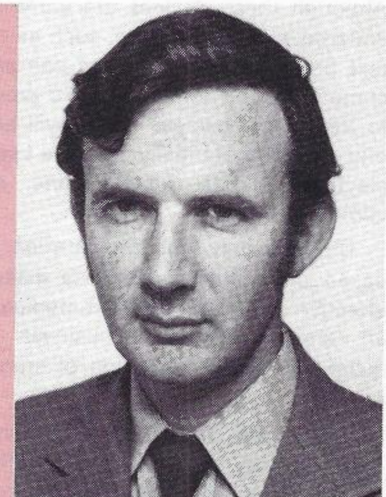
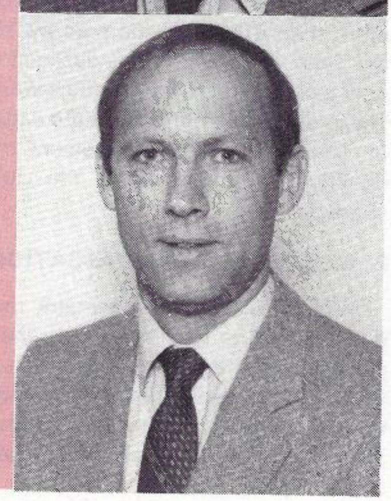


GRAEME CRAYFORD is currently working as the Superintending Engineer, Text Services Engineering Branch, on the implementation of new text communication services. He joined Telecom Australia in 1968 as a Cadet Engineer, obtaining an Associate Diploma of Elect. Eng. (Geelong) in 1969, a Bachelor of Engineering (RMIT) in 1975 and a Master of Administration (Monash) in 1982. Since commencing work as an Engineer with Telecom he has been involved mainly with projects in the telegraphs and data field.



The market research indicated that the special application segment is potentially the largest market for Teletex.

2.2 Computer-Based Message System

A more pragmatic solution is required to satisfy the requirements of the second market sector, namely, to provide a means of exchanging messages between data terminals employing different communication standards. In this case a network-based solution is required to mediate between terminals with different requirements and carry out the necessary speed, code, format and protocol conversions to provide interworking between incompatible terminals. This intermediary function can best be performed by centrally located computer facilities which are commonly referred to as Computer Based Message Systems (CBMS) or more colloquially as Electronic Mailbox services.

As well as mediating the actual communications the CBMS provides the user with facilities for creating and reading messages. Messages are normally held in the recipients "mailbox" within the system until the recipient elects to read them, thus eliminating the need to establish a direct connection between the terminals of the originator and the recipient.

It should be noted that international standards are being developed to enable CBMSs to interwork as part of an integrated Message Handling Service (MHS). These MHS standards will allow for service interworking at both the national and international level by defining the necessary protocol and addressing structures.

3. NATIONAL TEXT STRATEGY

Telecom Australia has formulated its text communication strategy so that it provides a comprehensive range of text communication services which facilitate business communications. The strategy comprises four major initiatives:

Telex — The existing Telex service will be made more attractive to encourage customers to stay with Telex. This is being achieved by introducing screen-based teleprinters and additional network facilities based on SPC exchange technology.

Teletex — A Teletex service will be introduced as a high integrity business communication service targeted at the inter-business communication market. A basic Teletex service, without access to Telex, will be introduced in Melbourne and Sydney in mid 1985 and will be extended to other major centres by mid 1986.

Although Telecom will provide a Teletex terminal other vendors will also be encouraged to market Teletex compatible terminals.

Interconnection will also be provided with the Telex service through a Conversion Facility, currently planned for implementation in 1986.

Telememo — Telecom will introduce a Computer Based Message Service (to be marketed as Telememo) as soon as practical, to support communication between interactive terminals, PCs and WPs connected to the public telephone network. This service will interface with the existing Telex service and, at a later date, with the proposed Teletex service.

Service Interworking — Standards are currently being developed overseas to facilitate interworking between the various text services. Telecom will provide for interworking between the three major text services (Telex, Teletex and Telememo) as soon as practical.

Further work will be required by Telecom to develop a more broadly based Message Handling Service embracing interworking with:

- other Telematic services including facsimile and videotex;
- other public and private mailbox services;
- electronic directory services; and
- computer-based information services.

4. KEY ISSUES

The introduction of Teletex, which can be seen as an eventual successor to Telex, presents some interesting commercial problems. The long term national interest is served by encouraging Teletex because it provides more effective text communications. However, the introduction needs to be carefully planned to ensure that Teletex is correctly placed in the market alongside the other text services. Teletex is aimed at the high integrity, high reliability end of the market. Teletex, Telex and the Telememo service together cover a spectrum of text communication needs. This strategy allows for future enhancements to the text services by the addition of Value Added Services, as well as the flexibility to cope with any shift of market emphasis due to customer demand for one text service ahead of another.

The Australian telephone network is being updated progressively using digital switching and transmission facilities. These digital facilities are referred to as the Integrated Digital Network (IDN). Teletex in Australia will be supported on a functionally separate network within the IDN. This arrangement, which will allow the Teletex network to be established as a closed user group within the IDN, is particularly attractive because it:

- provides a uniform high quality, high performance service across the whole country;
- can support a high integrity service with checking of calling and called parties;
- can be expanded rapidly to meet unforseen changes in the pattern of demand;
- minimises capital investment;
- can be merged in the future into the Integrated Services Digital Network (ISDN) supporting voice, data and text communications services;
- provides an evolutionary path for progressive enhancement of Teletex using the 64 kbit/sec transmission capabilities which are an inherent part of IDN; and
- provides an opportunity for introducing a separate tariff structure suited to the needs of Teletex.

5. TELETEX NETWORK IMPLEMENTATION

The rapid introduction of the Teletex service requires that the service be supported on a separate network until the IDN closed user group can be implemented.

Phase 1 — A basic service without access to Telex will be introduced in mid 1985 by installing digital telephone

(AXE) exchanges in Melbourne and Sydney (**Fig. 1a**) linked by a duplicated 2 Mbit/sec digital transmission system. Teletex customers will initially be directly connected to these exchanges using standard analogue lines employing tone (VF) calling techniques.

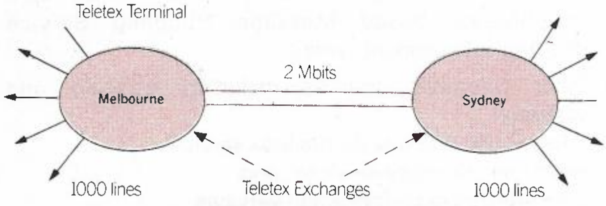


Fig 1a: TELETEX Network Phase 1

Phase 2 — By mid 1986 the service will be extended to all mainland capital cities with the installation of additional exchanges (**Fig. 1b**). During this phase customers will continue to be directly connected to the dedicated Teletex exchanges. However, it should also be noted that remote subscribers stages can be outposted from these exchanges to increase their geographic coverage where this can be economically or strategically justified.

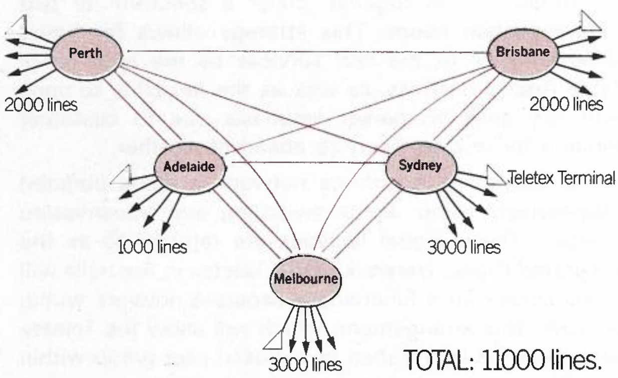


Fig 1b: TELETEX Network Phase 2

Phase 3 — Proceeding in parallel with the establishment of the dedicated Teletex exchanges will be the development work necessary to establish the Teletex service as a closed user group within the telephony IDN. When this work is completed standard digital telephone exchanges (AXE) located throughout the telephone network will collect and mark all Teletex traffic and feed it into the special purpose Teletex exchanges established during Phases 1 and 2 (**Fig. 1c**). The Teletex exchange interrogates all incoming calls, establishes the charging rates, and then trunks the call via the IDN to the terminal exchange of the called party.

When Phase 3 is established, currently scheduled for late 1986, Teletex customers will be able to be connected to the nearest IDN local exchange. That is, the nearest exchange with access to the Teletex network. This will offer significant cost reductions over the cost of directly connecting Teletex customers to the nearest Teletex exchange.

To simplify the centralised collection of call records and to provide for the screening of Teletex calls it is advantageous to carry out these and other specialised Teletex service functions at a limited number of transit exchanges. Consequently it has been decided to operate

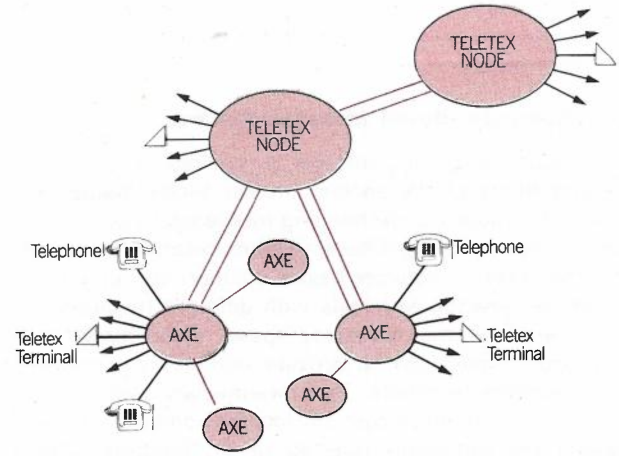


Fig 1c: TELETEX Network Phase 3

the Teletex network as a hierarchial network with all calls being routed through centralised Teletex exchanges.

A uniform, high quality Teletex service is thus achieved in which all calls are set up quickly in a high integrity network which provides a national closed numbering scheme, freedom of interference from non-Teltex customers and in which all calls can be recorded automatically at a central location. All Teletex billing information, including all call records, will be available to a customer on a single bill from a centralised facility.

At a later stage the Teletex service will be able to take advantage of the emerging ISDN. As the ISDN will extend high speed digital working to the customer this will be particularly useful for mixed mode Teletex (documents comprising both text and graphics).

6. TELETEX TERMINAL SPECIFICATION

Telecom Australia has adopted the international Teletex standards recommended by CCITT for application on the Telephone Network. To these standards are added the particular requirements for operation on the Australian network and the result is the Australian Teletex Terminal Specification.

All terminals must be compatible on at least the basic level. That is:

- send a selection of basic characters;
- receive and print all basic characters;
- respond to all basic control characters;
- handle paper in vertical and horizontal formats;
- have fully automatic transmission and reception capabilities; and
- provide the capability of interworking with Telex.

The above list relates to the "local part" of the terminal (see **Fig. 2**). The specification relating to the "communication part" of the terminal requires:

- adequate message storage;
- transmission and reception at 2400 bit/sec;
- X.25 based network protocol;
- line modulation in accordance with CCITT Recommendation V.22 bis; and
- automatic call and answer procedures in accordance with CCITT Recommendation V.25.

The recently developed V.22 bis modem (2400 bit/sec, full duplex) coupled with automatic callers employing tone (VF) calling techniques, will interact with

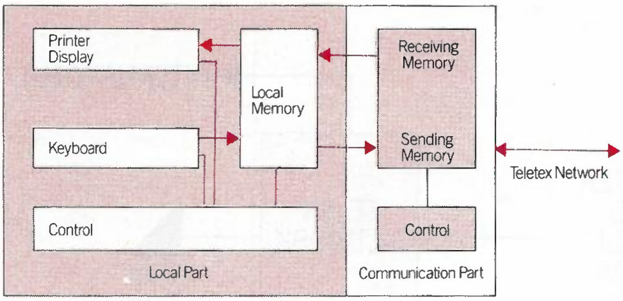


Fig 2: **STRUCTURE OF THE TELETEX TERMINAL**

the IDN to ensure that calls are set up quickly to provide a high quality, low error rate transport service.

Telecom Australia is working closely with prospective Teletex terminal suppliers to develop a detailed technical specification for the Australian Teletex terminal. In virtually all respects the terminals will have specifications identical to those in the other mass markets of Canada (Telecom Canada) and the UK (British Telecom) where Teletex is being implemented on the telephone network.

7. NETWORK ARCHITECTURE

7.1 Teletex Service

Although the majority of Teletex customers are expected to be connected to the Teletex network it is anticipated that a number of customers, primarily those with high calling rates or with existing data networks, will also wish to connect to AUSTPAC. Consequently, Telecom Australia will offer both networks for connection of Teletex services **(Fig. 3)**.

As indicated previously it is proposed to establish both-way interworking between the Teletex network and the national and international Telex networks in 1986. This will be achieved using a Conversion Facility which will operate on a store and forward basis (Fig 3).

7.2 Telememo

The Computer Based Message System used to provide the Telememo service will be directly connected to AUSTPAC via an X.25 link and to the Telex network. Customers will be able to access the Telememo service from data terminals connected to the public telephone network via dial-up PADs on the AUSTPAC network **(Fig. 4)**. Such an arrangement will provide nation-wide coverage with uniform charging arrangements (distance independent). Access will also be available to customers directly connected to AUSTPAC and from other overseas packet networks.

7.3 International Teletex

In line with international recommendations, international Teletex interworking will be provided via the international packet switched data network. To this end Telecom Australia is planning to establish a both-way gateway between the Teletex network and AUSTPAC **(Fig. 5)**. This will provide for interworking with AUSTPAC-based Teletex terminals as well as international access. Telecom is currently studying the technical and commercial requirements that must be satisfied to implement this gateway (Reference 1).

7.4 Service Integration

In order to provide for interworking between Telememo customers and Teletex customers it will also be necessary to establish a bothway interface between the Teletex network and the CBMS (Fig. 5). Telecom is also committed to establishing this connection.

By the time the interfaces between the Teletex network and both the CBMS and AUSTPAC are established Telecom Australia will be providing an integrated text services package comprising Telex, Telememo and Teletex with full interworking capability.

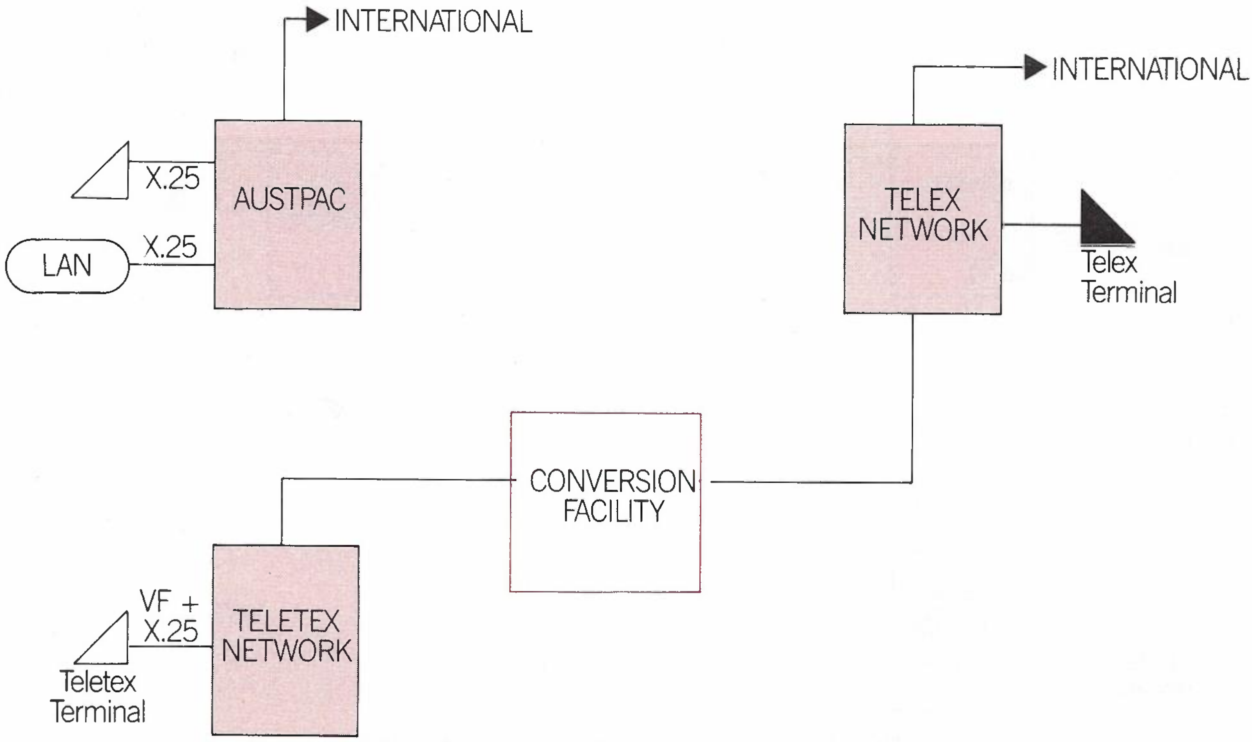


Fig 3: **TELETEX NETWORK ARCHITECTURE**

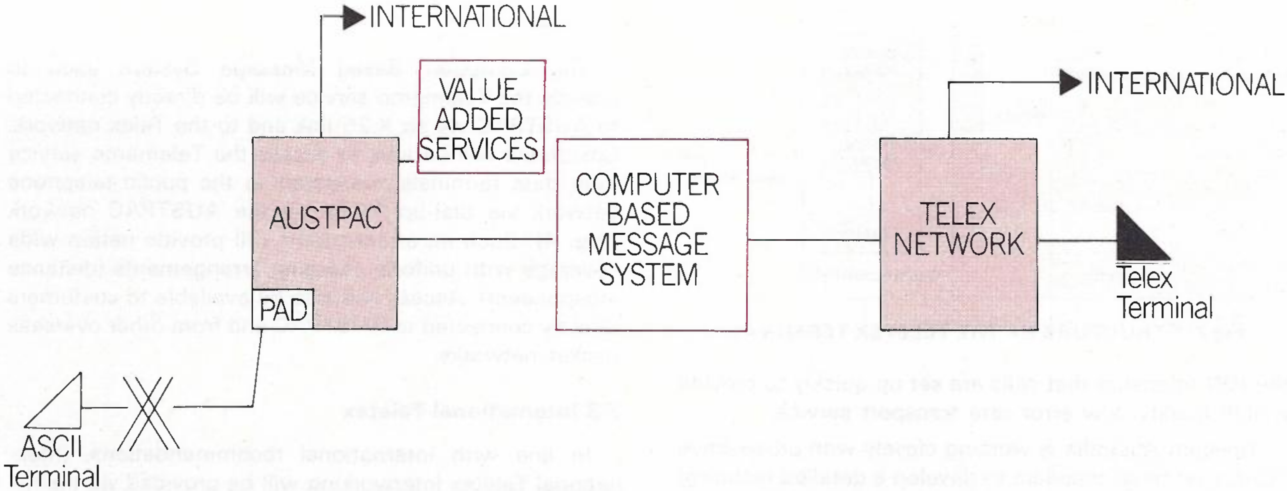


Fig 4: TELEMEMO NETWORK ARCHITECTURE

This will form a solid base from which Telecom will be able to pursue the long term objective of providing a more broadly based Message Handling Service with access to additional value added services.

8. CONCLUSION

Telecom Australia recognises the great potential of Teletex for business communications and has ensured that the service is based on a sound and reliable network.

The unique implementation of Australian Teletex, based on the telephony IDN, ensures widespread coverage at minimal expense to the user and also provides an evolutionary path to the future — to the ISDN — the key to a new generation of business communication services.

The new Teletex and Telememo services will complement the existing Telex service to form an extended text communications infrastructure which will serve to make business in Australia more effective.

REFERENCE

M. J. Harrison, New Data Communication Services and the Development of AUSTPAC, ICCC Proceedings 1984.

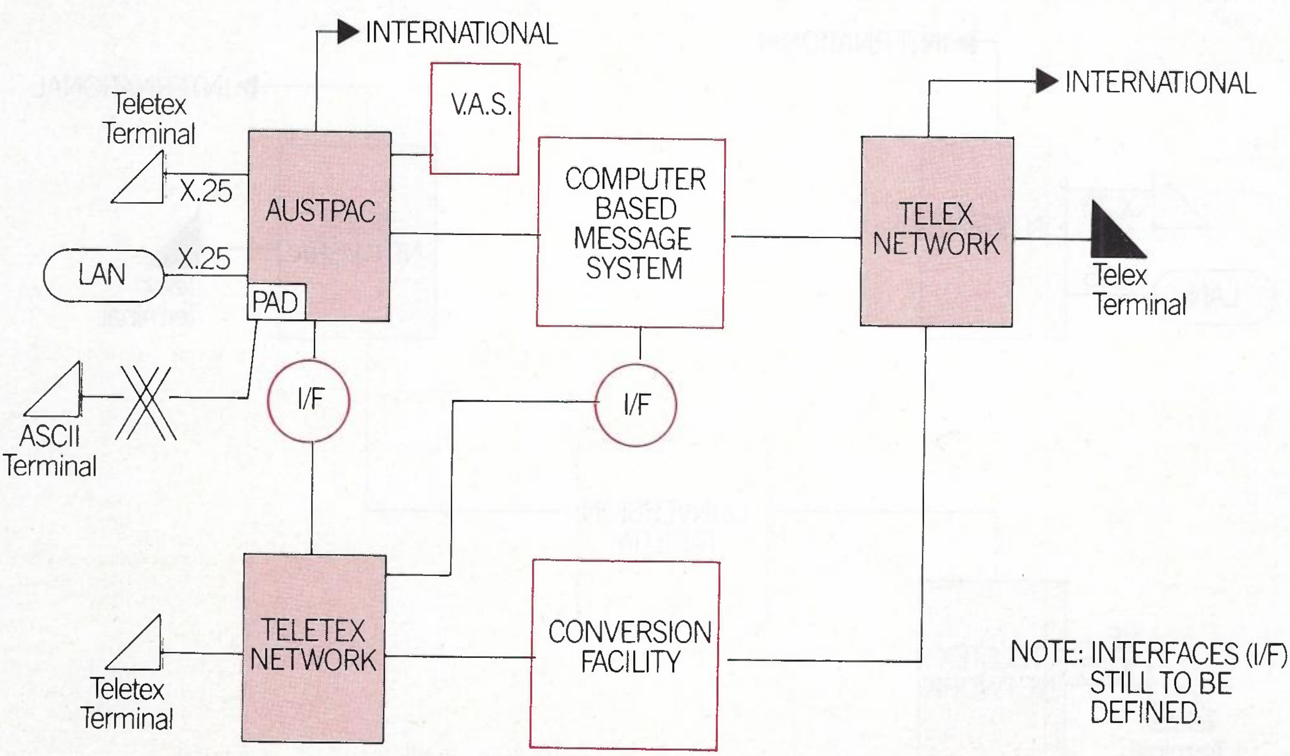


Fig 5: TEXT SERVICES NETWORK ARCHITECTURE

Development of a Solid State "Speaking Clock"

J. P. COLVIN B.E.E.

This article describes the design of a prototype solid state speaking clock.

1.0 INTRODUCTION

The current speaking clocks being operated by Telecom Australia are nearing the end of their useful life. The announcing machine uses an optical disc system for the production of speech; these have deteriorated badly and it is not considered practicable to replace them. With this consideration, investigations have been proceeding within the Telecom Australia Research Laboratories to find a suitable speaking clock as replacement. The work has culminated in a prototype announcing machine capable of the same output phrases and equal intelligibility as the previous speaking clock, with the added advantage of it being a completely solid state device under microprocessor control. This approach also has space and cost saving advantages on the initial unit.

2.0 OVERVIEW

The requirement is for an announcing machine that has a natural sounding voice, not the mechanical speech of most synthesizer chips. It may also be necessary to later change the basic announcement on the machine or to add advertisements into the announcement. To this end a stored speech machine was chosen over a synthesized speech machine. A stored speech machine has already been developed within Australia by South Australian Regional Operations Branch (Ref. 5). This machine is based on a Nova Minicomputer and "core" memory. Current technology is centred on the more efficient use of microprocessors and solid state memory.

Initially the software routine for phrase announcement and storage was developed in modules to make for ease of understanding of the routine and to enable ready checking of function of parts of the program with ease of correction. The subroutine structure also serves to conserve memory space.

The hardware has been developed about a specialized delta modulator chip with filtering sections aimed at optimizing the voice quality from the delta modulator chip, to the end of producing a "human" sounding voice.

2.1 Recording of Phrases

The recording of the announcement has been organized such that a skilled operator is not required. This is because of the use of prompts appearing on a visual display unit (VDU) in front of the operator during the recording of announcements. Hence the operator awaits the prompt and performs the required operation. At present the "optimum level" of voice is determined by visually monitoring of a light emitting diode (LED) driven directly by the integrated delta modulator "chip". The aim is to control the volume of recording such that the LED is just illuminated during the phrase recording, indicating an "approach of overload condition". The recording is then "echoed", i.e. replayed from the random access memory (RAM) as a check on voice quality. If the voice is acceptable, it is then recorded on EPROM. The length of memory must be noted by recording start and end address of location at which the phrase is recorded. Once the whole vocabulary has been entered into EPROM, a list is compiled of start and end addresses of phrases, a "look up table". The software routine requires the start and end location in order to differentiate between phrases. The recording scheme is shown in block diagram form, **Fig. 1**.

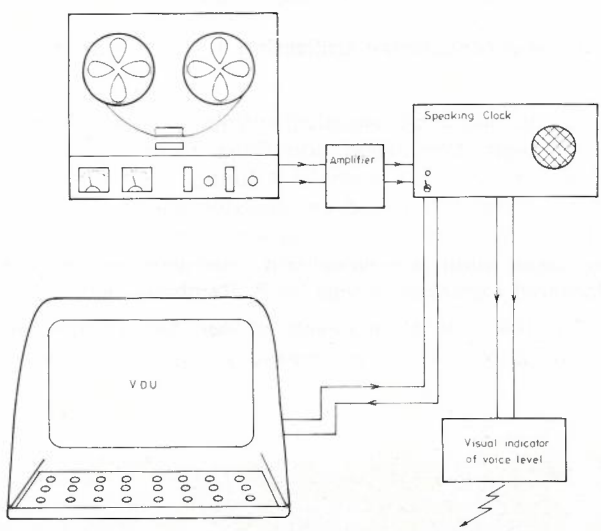


FIG. 1 RECORDING FACILITY.

2.2 The Generation of Announcements

The announcement is of the type "at the third stroke it will be nine thirty and ten seconds", exactly the same format as the present speaking clock. On receiving a strobe from the civil time receiver (CTR) the binary coded decimal, time information is read by the microcomputer via a specialized I/O device in a sixteen bit parallel code. The reading is then partitioned by software masking and each hour, minute and ten second reading is decoded. The relevant times are then placed in the standard phrase by using the values obtained from the (CTR) reading as software pointers accessing a look up table to determine start and end location in memory of the relevant phrase or numeral. The sequence of phrases and numerals are then organized in the sequence they are to be outputted. The relevant delays between phrases are based on the delays used on the present speaking clock. There are two or three delays required dependent upon the numeral being announced. The delay being implemented by a software loop the different delays occurring by changing the parameter in the loop.

The announcement routine (software) has been written in a structured form. It consists of a number of programs each relevant to particular stages in preparation for the speech output. This has been done initially as it meant that each process of the clock could be tested before continuing with further phrases in the development. In this manner major faults and the difficulty in tracing them was virtually avoided. This procedure has advantages in the final clock in that testing of the operation by analysers or following the logic of the program is simplified.

The program is ordered in such a way that we have

i. A program for reading time of day information from a civil time receiver (CTR);
ii. A program for outputting phrases to a delta modulator;
iii. A delay routine for determining time delay between phrases;
iv. A sorting routine for determining actual phrases to be used from (CTR) information.

2.3 Delta Modulation Utilization in Voice Transmission

Of the methods of encoding analogue signals to digital form, Delta Modulation and Pulse Code Modulation (PCM) are the most suitable. A further choice between these methods is based on available memory and the performance criterion in a noisy environment. Initial work on solid state announcement machines within the Research Laboratories was by P. Bernhard. (Ref. 4.0).

For the type of processor chosen two criteria are important: minimum memory and acceptable performance in an impulsive noise environment. Delta modulation was chosen over PCM because of its much lower memory requirement at a given sampling rate and better impulsive noise performance.

The bandwidth of the switched telephone network is 300 Hz — 3.5 kHz, if the signal is bandlimited to 3.5 kHz then by sampling theory the Nyquist sampling rate for the signal to be recoverable is at least 7 kHz (ie. twice the highest frequency component).

In practice for reasonable intelligence the original signal must be sampled at 4 to 8 times the highest frequency component.

For an 8 bit PCM A to D convertor the memory required to store the ten seconds worth of encoding data is calculated as:

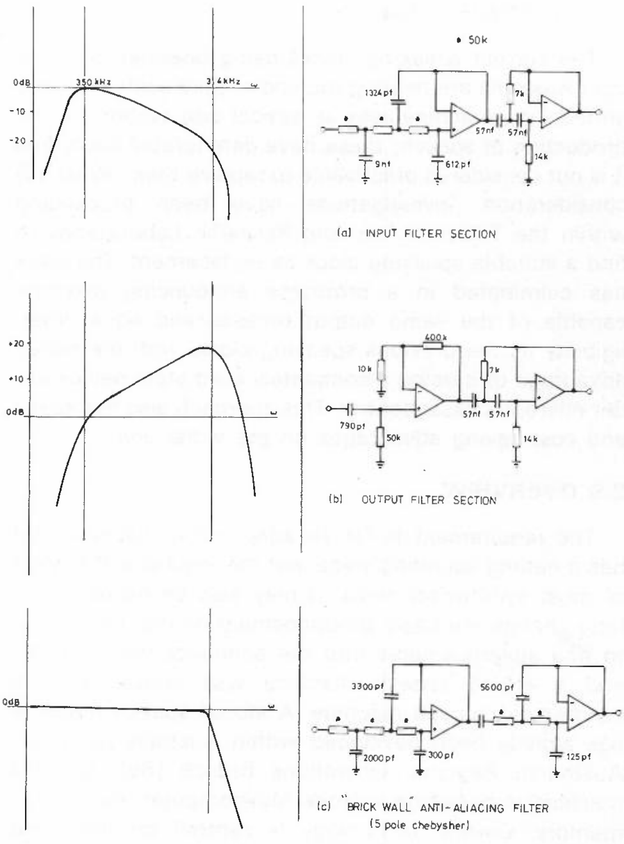
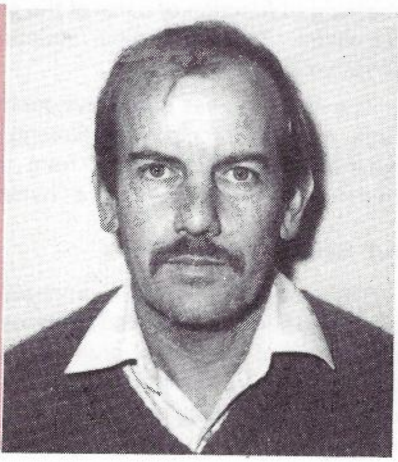


FIG. A1 FILTER SECTIONS

JIM COLVIN completed a Diploma in Electronic Engineering at Bendigo Institute of Technology in 1970, then graduated as a Bachelor of Electrical Engineering at Melbourne University in 1972. He joined the Australian Post Office Research Laboratories in 1973. Initially he worked in the Guided Media Section assessing the capability of millimeter waveguide and optical fibres as transmission media.

Since 1975 he has worked in the Reference Measurements Section, initially in the development of precision controlled oscillators. To date he has been involved in the assessment of current announcing machines and the development of the solid state speaking clock.



Memory required = Sampling rate x Bits/ Sample x Period

$= 16 \times 10^3 \times 8 \times 10$

$= 1280 \times 10^3$ bits

$= 160$ kbytes.

Similarly for delta modulation, the memory required is given by:

Memory required = Sampling rate x Bits/ Sample x Period

$= 16 \times 10^3 \times 1 \times 10$

$= 160 \times 10^3$ bits

$= 20$ kbytes.

That is a factor of eight difference in amount of memory required. Hence on memory requirement alone, delta modulation is the better choice.

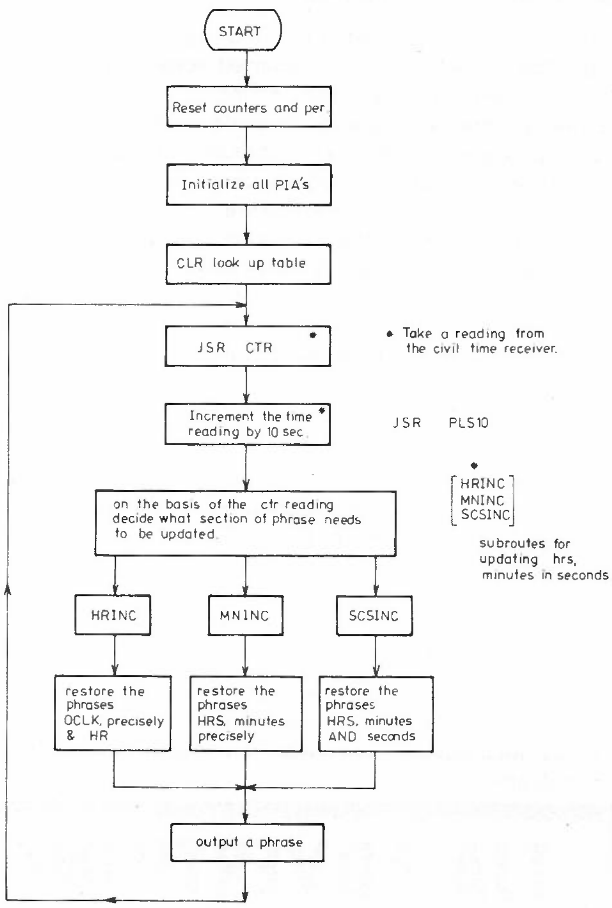
In the area of application (impulsive noise environment) a PCM system has unequal weighting on each sample, hence if an error occurs in a most significant bit a sharp change in output will occur. With delta modulation each bit has equal weighting. If an error occurs in the digital bit stream being fed to the demodulator the error becomes one of a d.c. offset rather than a sharp glitch. In terms of listener tolerance the effect of impulsive noise on PCM becomes rather annoying whereas for delta modulation it is unnoticeable.

Because of its fixed integrator output slope the simple delta modulator is less than ideal for encoding human voice which may have a wide dynamic amplitude range. The integrator cannot track large high frequency's signals with its fixed slope. A more serious limitation is that voice amplitude changes, which are less than the height of the integrator ramp during one clock period, cannot be resolved. Dynamic range is therefore proportional to clock frequency and satisfactory range cannot be obtained at desirable low clock rates.

The delta modulator chip used requires a sample rate of 32 kbits/sec for voice intelligibility to be similar in quality to that of the present speaking clocks. The chip used is a continuous variable slope type (CVSD) delta modulator. CVSD is achieved in the digital phase of the encoding. The digital (CVSD) has a number of advantages over its analogue counterpart and has desirable features which would otherwise require additional circuitry. No bulky external precision resistors or capacitors are required for the integrator; time constaints of the digital filter are set by the clock frequency and do not drift with time or temperature. An added feature is automatic quieting, where if the digital to analogue convertor input would be less than 2 least significant bits the quieting pattern is generated instead. This has been found to aid intelligibility.

2.4 Filter Section Requirements for Delta Modulation

Even with the variable slope delta modulator it was found necessary to use special filter sections for the encoding and decoding of speech for delta modulation format. It can be shown mathematically that for a signal with fixed amplitude slope overload can occur at the highest end of the spectrum first. So that if the voice spectrum is assumed nominally flat and a recording made, then the delta modulator overload indicator will indicate only what has occurred due to signal at the upper end of the spectrum. To overcome this problem a weighting must be introduced to the speech signal such that the slope condition of overload is equally likely from any region in the voice spectrum, so the indication from the delta modulator gives a measure of performance with equal weighting over the full audio band ie. equal signal level from any region 300 Hz — 3.3 kHz is likely to give the same overload condition. Theoretical indications are that a dominant pole is required at low frequencies approximately 300 Hz or lower, and that on the decoding phase a reciprocal dominant zero would be required at the same frequency. Also at the decoding stage a brick wall filter is required in cascade to overcome the aliaising problem that occurs with sampled data. The filter section chosen was a five pole Chebychev. The reciprocal filters being designed by referral to [ref. 3]. Filter sections are described in Fig. A1.



Flow chart for choice of phrases of announcements.

2.5 Hardware requirements

The system has been implemented with a printed circuit board system that is compatible with a commercially available module family for microcomputers.

The present requirement is:

i. A main board, containing microprocessor, 2 Peripheral interface adaptors, parallel ports (PIAS) and a Serial Port (ACIA) (I/O devices) for communication with the outside world and control of the clock.

ii. Two memory boards of 32 k of EPROM on the upper memory board and 30 k of EPROM on the lower memory board. The majority of these being required for storage of speech. The memory locations 0000-07FF being RAM or "scratch pad area" containing the "look-up" table of organized phrases (showing start and end address). The memory locations 07FF-0FFF contain the main program which occupies about 600 bytes and can be expanded to 1000 bytes for further requirements.

iii. A specialized delta modulator encoder-decoder board has evolved. This contains all relevant delta modulator interfacing requirements and filter sections. It has been designed such that recording and announcing can be done using the one board.

Hence the clock can become a recording machine as well as an announcement machine with no modification.

2.6 Results of Development

This work has culminated in the design of a speaking clock. The voice itself is in recorded speech format, it does not have the mechnical sound of some present synthesized speech machines. In some ways it should be easier to generate a new vocabulary than with a synthesized type chip which requiresn in the case of phonetic type chips experimental combination of phonems to determine the 'optimum' sounding word. In any case the machine is structured such that if synthesized speech is improved, the present announcement routines are still valid and a new printed circuit board can be substituted for the present delta modulator card.

3. CONCLUSION

The investigation into an alternative speaking clock has resulted in the construction of a demonstrable prototype. A voice similar in quality to commercially available machines has been achieved in a reliable and economical package.

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APPENDIX A

Filter Sections

Assuming that phrases have a nominally flat spectrum over the audio range (300 Hz — 3.3 Hz) and if voice consisted of a flat spectral content over this range of Amplitude A, then the individual components of the signal could be considered of the form

$$\text{Amplitude} = A \sin w_s t$$

If we use delta modulator encoding, we need to consider the rate of change of signal, this being an important criterion when considering the possibility of ramp overload.

Maximum rate of change of signal is determined thus:

$$\frac{d\ \text{Amplitude}}{d\ \text{times}} = A W_s . \cos w_s t$$

$$\frac{d\ \text{Amplitude}}{d\ \text{time}} \ {}_{max} A W w_s$$

Hence without any pre-emphasis filtering ramp overload is likely to be caused by signals at the upper frequency level of the audio spectrum. To use the level sensing available on the specialized chip, we require that overload be of equal probability at all regions of the spectrum. Assuming that the phrases have a relatively flat spectral response over the audio range we then require a filter with a form of response.

$$f(w) = \frac{k.}{w}$$

For this effect over the band of interest we require a dominant pole in the filter section at a very low frequency before the encoding of speech and the reciprocal dominant zero at the decoding of the speech.

Forecasting Telephone Traffic — Some Recent Developments

M. J. ALLISON, FRMIT, Grad. Dip. Qual. Tech.

The complexity and variability of telecommunications traffic pose some interesting forecasting problems. Until recently, lack of sufficiently frequent measurements allowed the use of only a few formal statistical methods. New measurement techniques allow the use of more statistical methods in some areas although many aspects of teletraffic forecasting still involve empirical methods. This paper describes some forecasting and quality control techniques used in the Planning and Programming Branch of Telecom's Engineering Department in Victoria. The unusual nature of the forecasting subject is illustrated and some situations are shown where quality control methods can enhance the forecasting process.

Telecommunications traffic contains diverse and dynamic quantities. Telephone, data, radio and video signals are propagated in large volumes and in many directions. Considering telephone traffic in the State of Victoria only, some 1100 terminal exchanges originate approximately 2100 million calls per year, destined for terminating exchanges in Victoria, other Australian states and overseas. In order that the switching and transmission equipment to handle this traffic should be adequate, it is necessary to have forecasts of traffic.

Some telephone equipment items require long lead times for procurement. Major buildings may require 20 years from identification of the requirement to commissioning of the installation. Where population growth necessitates revised numbering plans, demographic forecasts up to 50 years ahead may be needed. Telephone traffic, as such, is rarely forecast more than 25 years ahead.

Equipment requirements are an engineering matter. Revenue is a commercial matter. The amount of revenue earned depends on the number, duration and destination of calls, whereas equipment requirements depend on the number of simultaneous calls between switching points. There is an important relationship between these two aspects of telephone traffic. If calls are made in concentrated clusters, the plant necessary to handle the traffic may be greatly under-utilised at other times, leading to high cost. Commercial and engineering personnel therefore need to work cooperatively towards achieving an optimum distribution of calls.

The need for forecasting accuracy arises from the consequences of errors, which may be: forecast higher than actual; forecast lower than actual. If a forecast is higher than the realised traffic, too much equipment may be installed and the excess investment will incur interest charges without corresponding revenue, until traffic growth takes up the slack. Conversely, if the forecast is lower than the realised traffic, congestion and customer dissatisfaction may result, which in turn may lead to loss of revenue. Since the network is large, a small error at the macro level can mean substantial cost penalties. Consumers of traffic forecasts naturally seek more "accurate" forecasts, but it must be understood that the probability of a forecast exactly matching a measurement is zero.

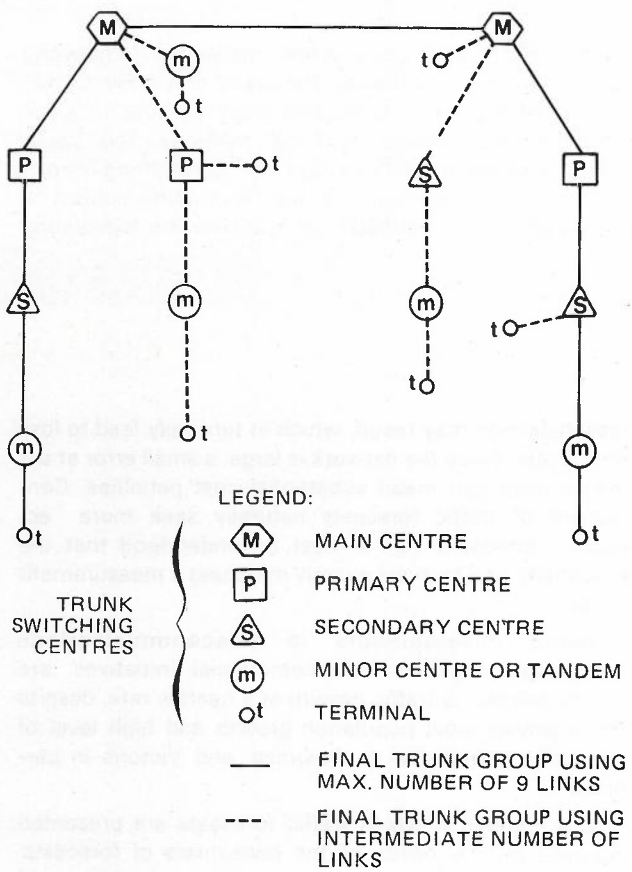
Rapid developments in telecommunications technology, together with commercial initiatives, are driving telephone traffic growth at a healthy rate, despite the relatively slow population growth and high level of telephone penetration in Australia, and Victoria in particular.

The manner in which traffic forecasts are presented depends on the needs of the consumers of forecasts. These consumers are located in the engineering and commercial departments. This paper is concerned with the engineering aspects of traffic forecasting, but commercial needs affect the manner in which the forecasts are prepared and presented.

THE ENGINEERING ASPECTS OF TELEPHONE TRAFFIC

A distinction must be made between traffic volume and traffic intensity. Traffic volume is the aggregate of all calls and their respective holding times, measured as Erlang-hours, which affects revenue. Traffic intensity is the number of simultaneous calls between an origin and destination of interest and affects equipment requirements, which are defined by engineering. The unit of traffic intensity is the Erlang, named after the Danish pioneer of teletraffic theory, A. K. Erlang. In the remainder of this paper, unless otherwise stated, "traffic" should be taken to mean "traffic intensity".

Engineering requirements for traffic forecasts are dictated, to a large extent, by the nature of the switched telephone network. The nature of telephone traffic and the customer habits underlying this nature, also affect the method of forecast presentation. In the present Australian network, telephone calls are switched through a hierarchy of exchanges to reach the destinations (**Fig. 1**). Designers may wish to study traffic at a terminal exchange level or grouped in, say, terminal to minor switching area, minor switching area to secondary switching area, main area to main area, or other forms. Traffic varies across the day, month and year, as illustrated in an earlier paper (Ref. 1). Hence traffic has the dimensions of Erlangs, time and direction.



To describe the dimensions of traffic, measurements are made of the OCCUPANCY of circuits at various times and the destinations of calls from an exchange are recorded to form a DISPERSION.

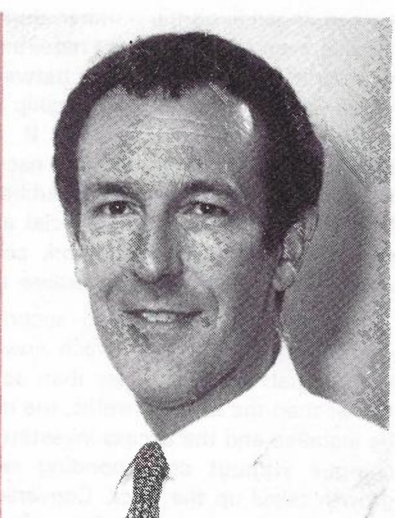
THE EFFECT OF INCREASING COMMERCIAL ORIENTATION

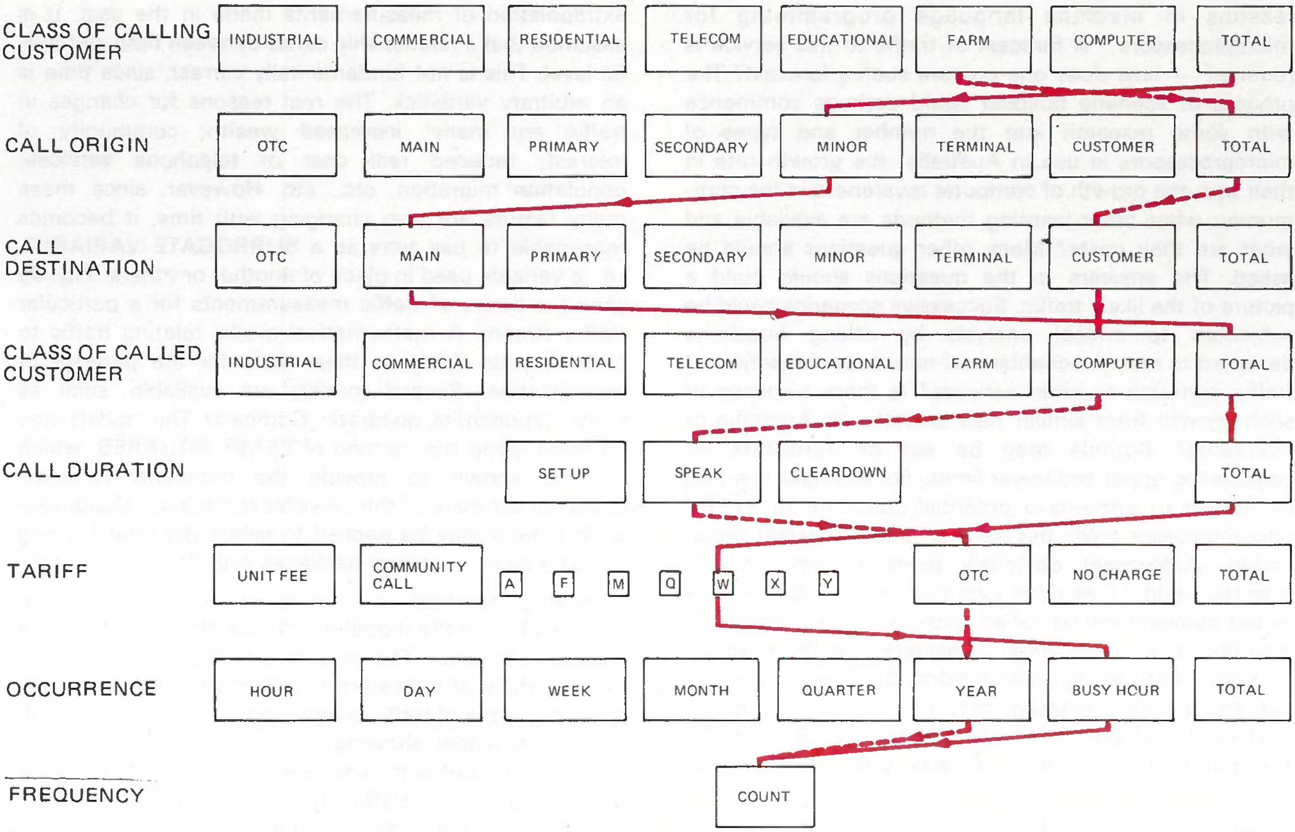
Telecom Australia has undergone, and continues to undergo, substantial changes in its commercial orientation. As a result, the responsiveness of Telecom to customer's demands is changing, as is the manner in which telecommunications products are offered to the public. The way in which tariffs are structured to meet competition, together with the requirements of Telecom's Charter, are also affected by these commercial changes.

This has an indirect bearing on the type of forecasts sought by engineering and creates a new demand for forecasts which provide information relating to the interface between marketing and engineering. Marketing needs to know what effects might flow from a proposed new marketing strategy. It needs to know where spare capacity could be taken up through selective advertising and general concessions. The results of marketing initiatives must also be monitored. Marketing, therefore, can make use of traffic forecasts developed primarily for engineering use, provided due account is taken of the marketing needs.

A huge increase in the complexity of forecasts could result if all possible marketing and engineering requirements were incorporated and some practical compromise must be reached. To illustrate the kind of information that may be of interest to marketing and engineering, a MORPHOLOGY CHART is used to show some of the attributes of telephone calls and their corresponding elements (**Fig. 2**). This non-exhaustive chart contains 1 572 864 different types of information, although not all may be meaningful. The path taken by the solid line represents the question "what is the W rate traffic from Melbourne to the New South Wales main switching area at the busy hour?" The dashed line represents the question "what revenue do we get from farmers calling the UK videotex world weather service?"

MIKE ALLISON has held various positions in design, research, quality control and manufacturing in the automotive, aerospace and heavy engineering industries of Australia, the United Kingdom and the United States of America. In 1978, he joined Telecom in the Planning and Programming Branch (Victoria) as a traffic forecaster, developing mathematical models for the traffic to be used as a basis for dimensioning the Victorian Network. Presently, he is the Acting Principal Engineer, Traffic Forecasting and Analysis Section of the Planning and Programming Branch. He has a particular interest in quality control methods and is a Council Member of the Australian Organisation for Quality Control (Victoria Division).





THE EFFECTS OF TECHNOLOGICAL DEVELOPMENTS

Technological developments, from a forecasting standpoint, affect two broad areas. New technology affects services to customers and hence traffic. At the same time, other technological developments make possible the production of forecasts that were previously impossible or impractical.

In the customer area, new technology has allowed reductions in tariffs for long distance trunk calls, resulting in greater stimulus to use the long distance network. More attachments and "fancy phones" are available. The introduction of home computers and other equipment has increased the amount of data being transmitted on the voice network through the use of acoustic modems. The film "War Games" suggested heavy use of the network under the control of customers' computers and already this is causing serious concern in the North American network.

In the area of forecast production, new technology has permitted the automatic measurement of traffic and the storage of large amounts of data in readily accessible form. At the same time, we are able to perform massive "number crunching" operations relatively cheaply.

An important example of the effect of new technology is afforded by the change in the manner in which traffic measurements are collected. Until recently, measuring the traffic at a telephone exchange involved sending a team of technical people to the exchange, performing time consuming wiring and testing, followed by measurements for one or two weeks, the busiest five consecutive days being selected for processing. The resource constraints of this method resulted in an average delay between successive measurements of Metropolitan exchanges of approximately 2.5 years. The measurement so taken was only for a particular week, not necessarily the week of primary interest to a designer. New technology enables some selected measurements of exchanges on a daily basis, dramatically increasing the usefulness of measurements and permitting the use of some statistical techniques for monitoring purposes.

FORECASTING TECHNIQUES

There are many ways of preparing a forecast and the process often comprises a mixture of mathematical techniques and judgements. For all methods, the results must satisfy tests of reasonableness and, indeed, reasonableness tests form part of the forecasting process.

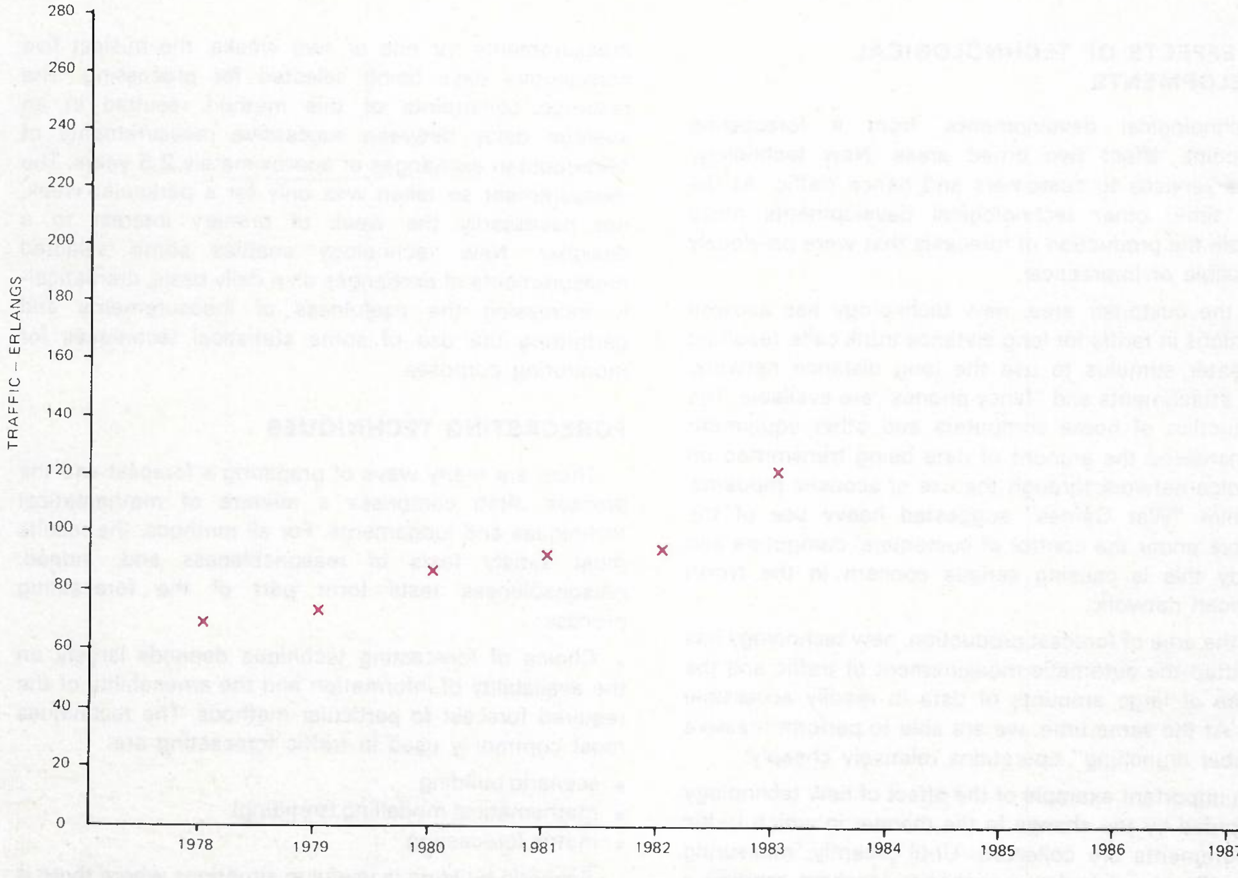
Choice of forecasting technique depends largely on the availability of information and the amenability of the required forecast to particular methods. The techniques most commonly used in traffic forecasting are:

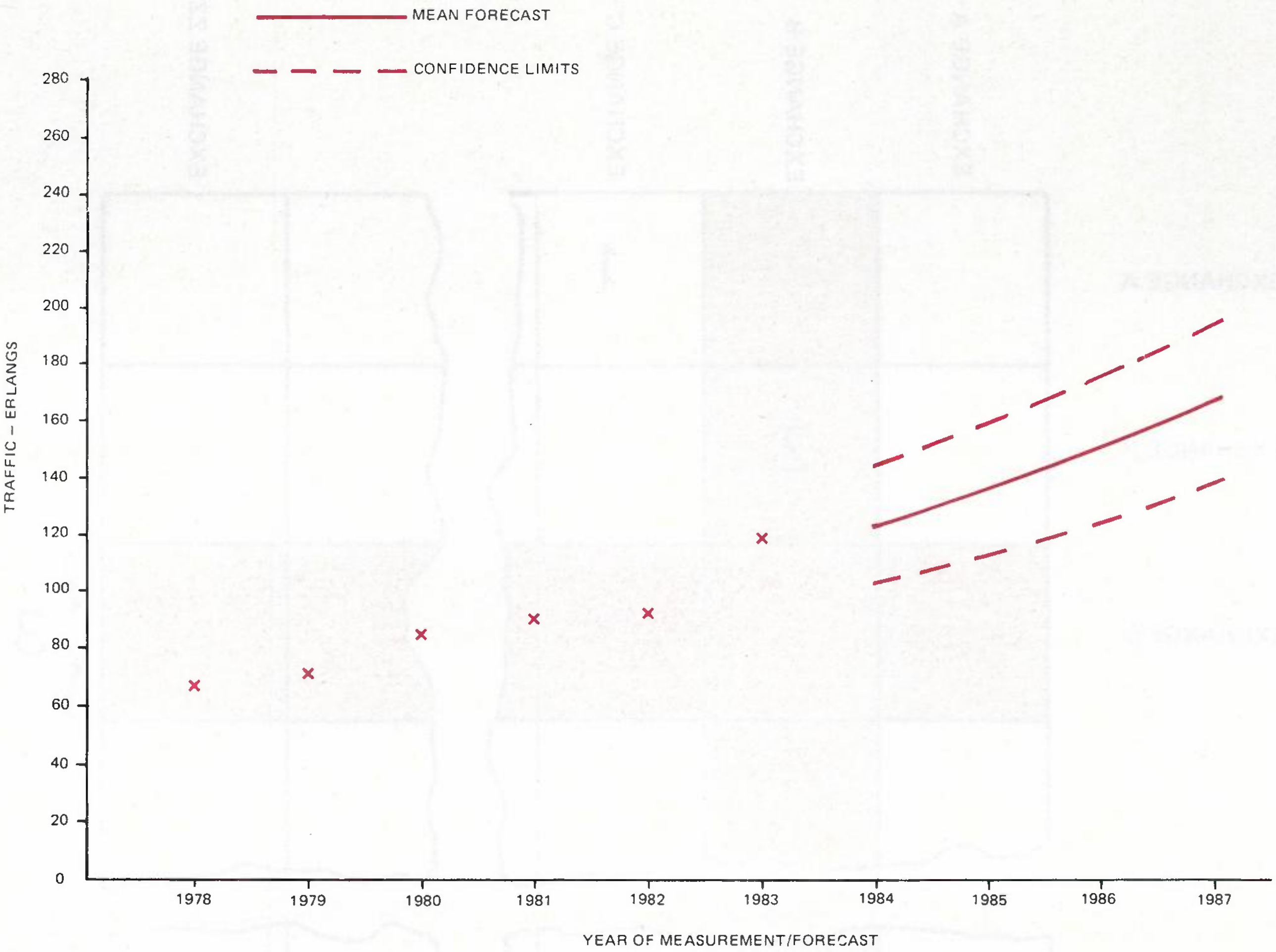
- scenario building
- mathematical modelling (trending)
- matrix forecasting

Scenario building is useful in situations where there is little or no information. Suppose, for example, Telecom were to introduce a hypothetical new product "recorded lessons in machine language programming for microprocessors". A forecast of traffic to this service is required — how does one prepare such a forecast? The process of scenario building could perhaps commence with some research into the number and types of microprocessors in use in Australia; the growth rate in their use; the growth of computer awareness in the community; what other learning methods are available and what are their costs? Many other questions should be asked. The answers to the questions should build a picture of the likely traffic. Successive scenarios could be subjected to critical analysis by asking questions designed to test reasonableness: how does the projected traffic compare to other services? Is there evidence of such growth from similar new services (in Australia or overseas)? Bounds may be set on forecasts by considering upper and lower limits. For example, it would be absurd to attribute a potential customer to EVERY microprocessor sold: this sets an initial (coarse) upper bound. Judgement obviously plays a large part in scenario building, as does informed opinion. Sometimes expert opinions will be called upon to aid the process. To quantify the uncertainty associated with scenario building and to aid decision making, the final results of a scenario building exercise may often be presented as high limit scenario, low limit scenario and most likely scenario (not necessarily mid-way between high and low).

Mathematical modelling is widely used where measurements of traffic and other related factors are available. The simplest technique is trending or extrapolation of measurements made in the past. It is assumed that a relationship exists between time and traffic level. This is not fundamentally correct, since time is an arbitrary yardstick. The real reasons for changes in traffic are many: increased wealth; community of interest; reduced real cost of telephone services; population migration, etc., etc. However, since these many factors are also changing with time, it becomes reasonable to use time as a SURROGATE VARIABLE, i.e., a variable used in place of another or others. **Fig. 3a** shows a series of traffic measurements for a particular traffic stream. A mathematical model relating traffic to time may be fitted to these data for the purpose of extrapolation. Several models are available, such as linear, exponential, quadratic, Gompertz. The models may be fitted using the method of LEAST SQUARES, which can be shown to provide the minimum variance, unbiased estimate of the universe regression. Goodness-of-fit criteria may be applied to select the model fitting the data best — several packages exist for this purpose.

Having selected a mathematical model, simple extrapolation of the model to a future date of interest will provide a forecast. The prudent forecaster will however look carefully at indicators of reasonableness. Generally speaking, rates of traffic growth decrease with respect to time — a model showing an increase of growth rate would be viewed with suspicion. Comparison with other forecasts of similar traffic streams would also be made. Sometimes, elaborate mathematical models may produce excellent fit to the data, but show negative traffic on extrapolation — these would be rejected as



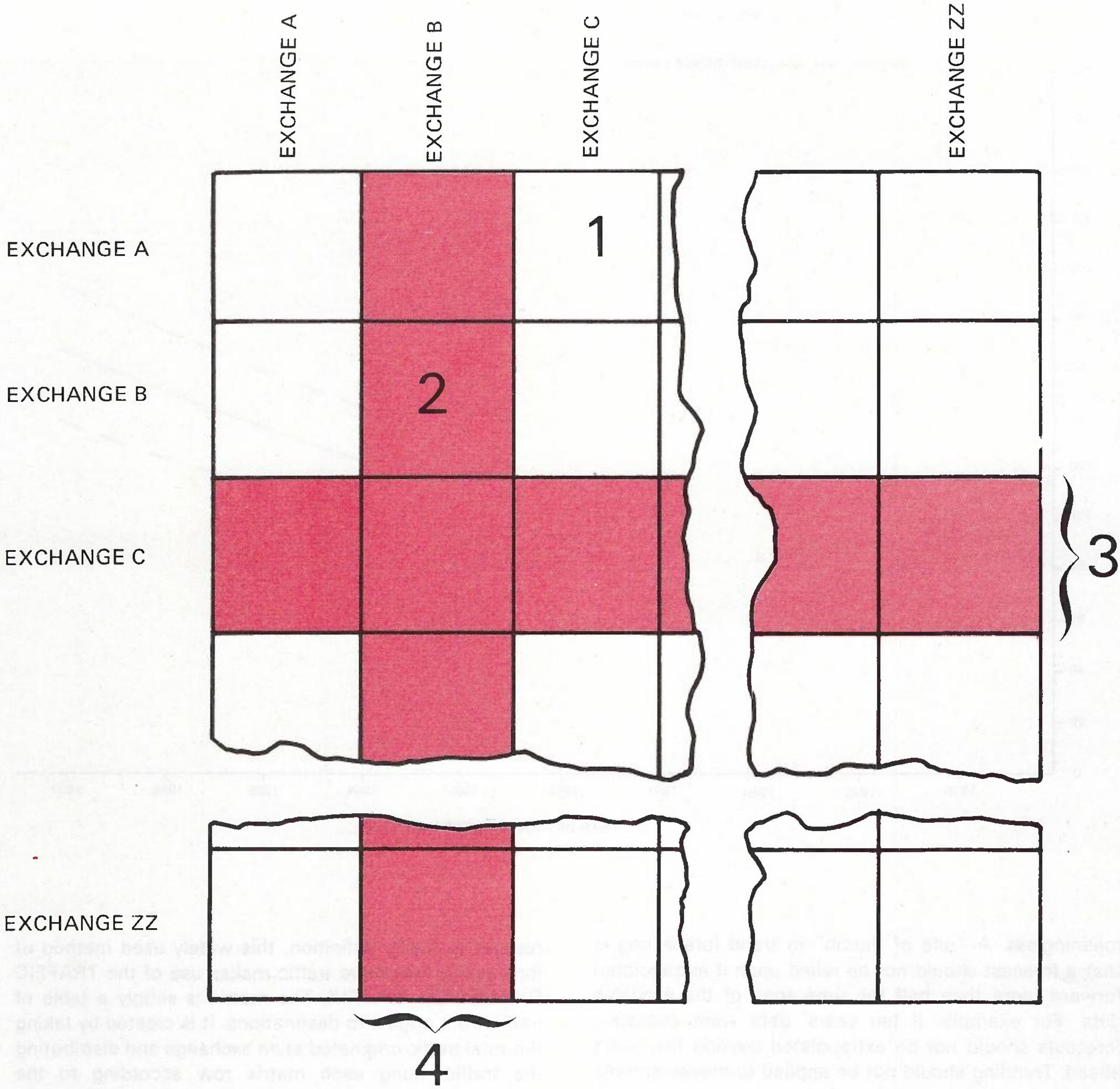


meaningless. A "rule of thumb" in trend forecasting is that a forecast should not be relied upon if extrapolated forward more than half the time span of the available data. For example, if ten years' data were available, forecasts should not be extrapolated beyond five years ahead. Trending should not be applied to measurements of traffic on second or higher choice routes, as such traffic is heavily dependent on network configuration. An increase in direct circuits will cause a sudden drop in traffic on the higher choice routes. An advantage of the trending technique is the ability to calculate CONFIDENCE LIMITS to provide an indication of the uncertainty associated with the trending technique. An extrapolated forecast from the data of Fig. 3a is shown in Fig. 3b.

A more fundamental approach to mathematical modelling is to employ the technique MULTIPLE REGRESSION. In this technique, the relationship between causes, such as telephone penetration, number of customers reachable for unit fee, etc., and traffic is sought. The model then relates traffic to all of the causes under consideration, with indicators of the relative importance of each cause. A disadvantage of multiple regression is the need for separate forecasts of the selected variables. These forecasts may themselves be subject to considerable uncertainties.

Matrix forecasting is employed to satisfy the descriptive requirements of Erlangs and direction in respect to traffic definition, this widely used method of forecasting telephone traffic makes use of the TRAFFIC DISPERSION MATRIX. The matrix is simply a table of traffic from origins to destinations. It is created by taking the total traffic originated at an exchange and distributing the traffic along each matrix row according to the measured dispersion. When this has been done for all the origins, the matrix describes originating and terminating traffic between all the exchanges included in the matrix (**Fig. 4**). The property of time is not satisfied by a single matrix, since it can only represent traffic flow at a particular point in time. Many engineering and marketing studies are concerned with traffic flow at different times. To fully describe the network traffic on the basis of individual hours would require an array consisting of all the terminal exchanges, for each hour of the year. Such an array is represented in **Fig. 5** and would require a prodigious amount of computer storage and processing time, being of the order 7 000 000 000 elements for the Victorian network alone.

In the practical situation, a compromise of one matrix for the morning and one for the evening of the busy season is found to cover most requirements. Even so, the work involved in preparing and forcasting from matrices approximately 300 000 elements in size is considerable. The following basic steps are carried out to produce forecast matrices:



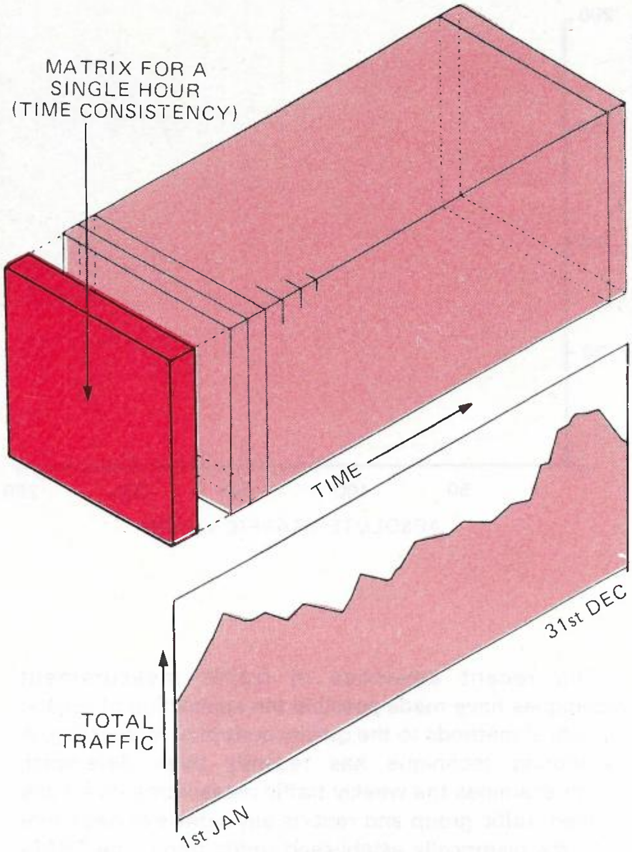
KEY:
1. THIS ELEMENT IS THE TRAFFIC FROM EXCHANGE A TO EXCHANGE C
2. THIS ELEMENT IS THE TRAFFIC FROM EXCHANGE B TO EXCHANGE B
3. THE SUM OF ALL ELEMENTS IN THE ROW FOR EXCHANGE C IS THE TOTAL TRAFFIC ORIGINATED AT EXCHANGE C
4. THE SUM OF ALL ELEMENTS IN THE COLUMN FOR EXCHANGE B IS THE TOTAL TRAFFIC TERMINATED AT EXCHANGE B

● CREATE BASE MATRIX

The base matrix is the matrix reflecting the current or most recently measured traffic values. It is built up from dispersion measurements and total originated traffic measurements as indicated earlier. The actual process of creating the base matrix proceeds throughout the year and involves a large amount of computer work in loading new dispersion readings, modifying total traffics in the light of new readings and checking the data for integrity.

● GROW THE MATRIX

Forecast matrices are conventionally prepared by multiplying each element of the base matrix by a COMPOSITE GROWTH FACTOR which takes into account the traffic growth of customers at both origin and destination. There are many composite growth factors, reflecting different opinions on how to accommodate the differential growths at origin and destination. Practically, however, the end results do not



differ greatly. The application of the composite growth factor produces a matrix containing more traffic than the base matrix and with different dispersions in each row. The changed dispersion results from the different growth rates at all exchanges. A recent innovation is the addition of a further change to some elements to account for the traffic growth stimulation resulting from tariff reductions. An algorithm is developed from advice of expected stimulation, relating the distance between exchanges to the stimulation. This is made possible because of the latitude and longitude associated with each exchange in the relevant files.

● BALANCE MATRIX

The term "balancing" often causes confusion. It is often misunderstood as meaning "making the sum of rows equal the sum of columns". In fact, all matrices are so balanced, at all times. Balancing in the forecasting sense refers to the KRUITHOF DOUBLE FACTOR method of balancing row and column totals against separately derived target values. This is a method of imposing the expected greater reliability of a MACRO estimate on MICRO estimates of traffic.

Other activities supporting the matrix forecasting process are:

● USAGE RATE FORECASTING

Usage rate is defined as the traffic originated or terminated per customer at a particular exchange during the busy hour. This fundamental source of traffic has been the subject of much discussion and various modelling techniques are used to try and predict the usage rate of an exchange in the future. Efforts in Victoria have concentrated on the differential usage rates of business and non-business customers as a source of information, since forecasts of future business/non-business exchange compositions are available. The importance of usage rate forecasting cannot be over emphasised, as it is generally the only aspect of traffic matrices completely under the control of the traffic forecasters. Customer forecasts are supplied by the marketing sections in cooperation with field engineering staff and are not under the control of traffic forecasters. Areas of research to be addressed by usage rate forecasters include the relationship between usage rate and:

- customer classification
- telephone penetration
- holding time
- traffic category:
  - own exchange
  - other unit fee
  - intrastate trunk
  - interstate trunk
  - OTC.

Customer classification alone is a substantial area of difficulty because of inconsistencies between designation and calling characteristics. For example, in general, customers classified as business generate about five times as much traffic as customers classified as residential. A farmer, however, may have a business classification, but may only generate as much traffic as a residential customer. Many sub-classifications could be made, such as Trade Unions, Library, Municipal Administration. At the fundamental level, it will be necessary to measure the calling habits of each class of customer. Such measurements would need to be conducted in a way which preserves the anonymity of the customer, while obtaining sufficient detail to permit useful analysis.

● NATIONAL MACRO FORECASTS

Forecasts of the trunk traffic between main areas are produced each year by headquarters, as an input to the NATIONAL MINOR TO MINOR MATRIX. These forecasts serve to provide further constraints on the forecast matrix and help to coordinate the efforts of States' forecasters.

● RECONCILIATION OF CALL HOURS AND TRAFFIC

The importance of consistency between engineering oriented traffic forecasts and marketing oriented calls forecasts has been recognised and a committee consisting of headquarters marketing and engineering representatives has developed an algorithm to produce an agreed set of macro forecasts for call hours and traffic. This agreed set has become a commercial forecast official target in a similar way to customer installation demand, forming the basis for State demand targets.

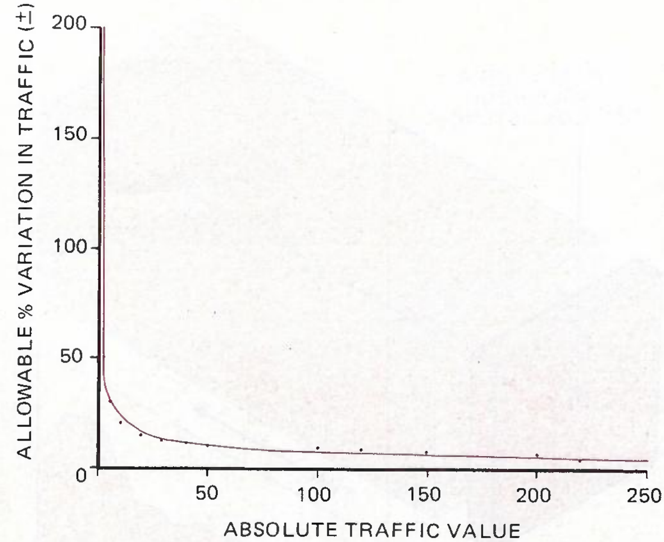
QUALITY CONTROL OF FORECASTS

Having produced a forecast, the questions now arise — how many errors may there be in the matrix (bearing in mind there are many opportunities for error) and how can the forecasts be monitored against subsequent measurements?

Control of traffic matrix quality is a particularly interesting problem, due to the sheer volume of data and the fact that some elements may have, of necessity, been inserted using judgement rather than measurements. A further problem is that, in industrial quality control, it is usual to verify that manufactured product conforms to specification. Clearly, there is no specification for the traffic forecasts available — that is why the forecasts are needed. Since there is no specification, an empirical method has been adopted for one aspect of quality control. On the assumption that each year's forecast of the traffic for the same time, point in the future (e.g. 1988) is simply another estimate of the same quantity, comparisons are made of successive forecasts, on an element by element or row by row basis. As new dispersion readings become available, errors are revealed or, if some unrealistic values have been imposed on the matrix by the forecasters, the comparison process will reveal these differences. It is expected that the differences between successive forecasts, expressed as root mean square error, will converge to a minimum with time.

The method used to arrive at an algorithm for flagging significant differences between successive forecasts is based on the knowledge of experienced traffic engineering personnel. These experienced people were asked what they considered to be a reasonable variation between estimates of traffic at various magnitudes. A curve fitting routine was applied to their estimates, to provide the algorithm for the computer, which reports only on an exceptions basis. The fitted mathematical function closely follows the given estimates (**Fig. 6**). An interesting point is that the fitted function closely approximates the theoretical accuracy of a traffic measurement (Ref 2).

Other quality control methods for matrix forecasting involve comparison of existing traffic dispersions with new readings, comparison of traffics in each direction (exchange A to exchange B versus exchange B to exchange A) and comparison of traffic aggregations. An example of a traffic aggregation is the total traffic from the metropolitan area to the country area of a State. A traffic aggregation may be compared to its complementary aggregation (traffic in the other direction) in the same way as individual exchanges. In accordance with good ergonomic practice, reports are generated on an exceptions basis, so that the repetitive work is performed by the computer and only exceptions are directed to human attention.



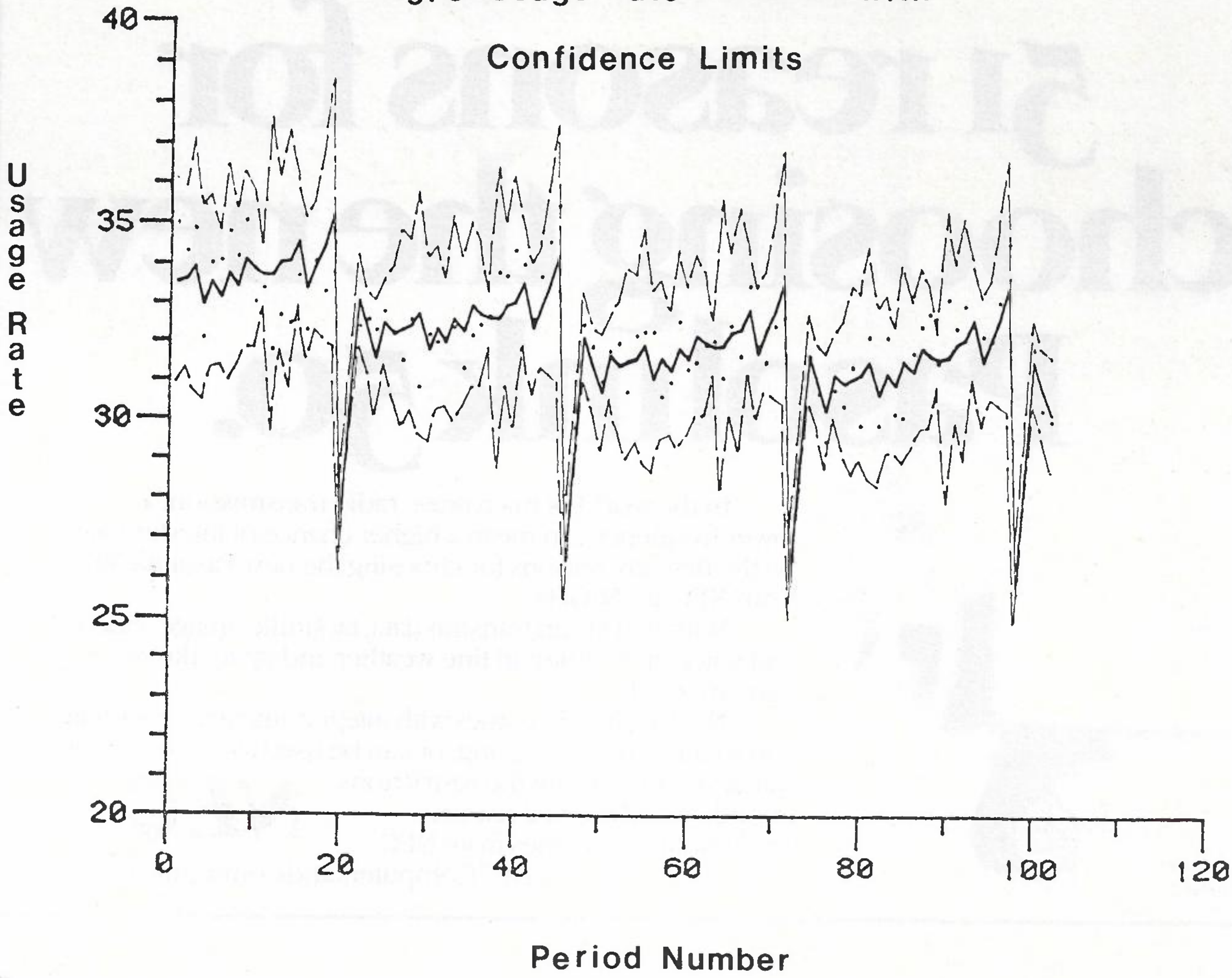
The recent advances in traffic measurement techniques have made possible the application of several statistical methods to the quality control of forecasting. A monitoring technique has recently been developed, which examines the weekly traffic measurements for any defined traffic group and reports any signals of departure from the historically established traffic trend. The TRAFFIC TREND ANALYSIS SYSTEM (TTAS) (Ref. 3), uses the method of classical decomposition to generate a mathematical model of traffic behaviour. The system is intended to use traffic data from the TADMAR system, described elsewhere in this journal (Ref. 4), but may also use measurements from other sources, including non-traffic data. New measurements are compared to the predictions of this model and a diagnostic report (**Fig. 7**) shows a number of statistical indicators, if indeed there are any such indicators. It is common practice in quality control work to use runs above or below two standard deviations from the mean, or single occurrences beyond three standard deviations, to indicate likely departure from control. These tests are built into TTAS, together with the non-parametric statistical SIGN TEST, which detects small but sustained shifts from the established mean, such as may result from a marketing initiative to reduce tariffs. Forecasts are also available from this system, with user-definable confidence limits (**Fig. 8**). The ability to perform monitoring and quality control of these types represents a very large improvement in

DIAGNOSTICS FOR TRAFFIC GROUP TEST 2

PERIODS BEFORE NOW	ABOVE 3 SIGMA COUNT	BELOW 3 SIGMA COUNT	ABOVE 2 SIGMA RUN	BELOW 2 SIGMA RUN	SIGN TEST RESULT	TREND ABOVE/ BELOW	WILD POINT FOUND
4	1	0	0	0	N/A	N/A	
8	1	0	2	0	0.3633	B	
12	1	0	2	0	0.1938	B	

Fig. 7. Diagnostic Report for Traffic Readings.

Fig. 8 Usage Rate Forecast with Confidence Limits



forecasting methods and is possible only because of the availability of Daily Traffic Recording (DTR), described in Ref. 1.

SUMMARY

Telephone traffic presents unusual problems in forecasting, because of the large amounts of complex data and the multiplicity of constraints applied to the forecasting process. New technology has made possible a large increase in the availability of data and, with this, the application of statistical techniques to control the quality of forecasts. It may reasonably be expected that further improvements in forecasting will take place as more automated data gathering and analysing techniques come on stream.

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SWITCHNET — A generalised circuit switched modelling tool

Y. M. CHIN, B.Sc. Hon, M.Sc., MIEE

SWITCHNET is the development of a widely applicable switched network dimensioning computer system used to assist the network planner in the network planning process. This paper deals with the broad description of the various data and computer modules which in totality provides the planner unfamiliar with computer systems relatively easy means of setting up of network models.

INTRODUCTION

Switched network dimensioning is concerned with the translation of point-to-point traffic demand into switched circuit requirements. The translation process requires the description of the network configuration, routing discipline, elementary network building block costs, etc. This network data essentially characterise a particular network. Thus, networks generally differ only in their switching characteristics between telecommunication administrations and between regional networks in a given administration. Also, network dimensioning processes have differing objectives; some must take into account practical short-term restrictions on circuit growth, others may be concerned only with evaluating the network macro parameters over a longer period.

In designing any network computing aid, the system designer has a choice of "hardwiring" the switching characteristics into the software, or providing means for the end-user to describe his network characteristics as data. The hardwired software has network information implicit in the computer program construction, while the other alternative implies a generalised program. SWITCHNET belongs to the generalised class and has been designed to take into account the various requirements of network planners for short-term and long-term dimensioning.

. . .

If exchange equals "Sydney" perform special routine.

. . .

If equipment equals "XB" overflow traffic to "AXE."

Example of hardwire programming

In Australia, the earliest version of computer program for network dimensioning appeared in the early 1960s. The COMET study, as it was known (1), in fact made use of a sophisticated hardwired dimensioning program for the calculation of the most economical tandems for the Sydney telephone network. Using the SILLIAC computer, the study demonstrated the value of computing aids for network strategy studies. Over the next decade, a number of similar programs began to appear within the Australian telecommunications industry. By the 1970s, it became evident that the hardwired systems, whilst they may be adequate at the time of design, often required alterations to the programs to reflect network changes, such as the introduction of new exchanges or changes to network trunking. Further, although the hardwired programs were sufficiently sophisticated, it was never simple to implement these programs outside the environment for which they were originally designed. For instance, the programs which were designed for the Sydney network need substantial alterations if the programs are to be adapted to another regional network.

As the Australian telephone network grew, this lack of a generalised, transportable dimensioning program became acute. Furthermore, the hidden costs of program maintenance as the number of slightly different version of a largely identical program, became evident. End-users too were beginning to distinguish the difference between the burden of general computing housekeeping procedures, such as file handling, file maintenance, etc, and the actual network study aspects.

Thus the evolution from a specialised to a generalised switched network dimensioning system was a natural progression. SWITCHNET, as a widely applicable telephony network dimensioning computer system, was conceived in the early 1970s and, by 1975, a prototype was produced. The system which is now in an adaptive maintenance mode, finds wide application in Australia, and was used as the major modelling tool in the study of the introduction of the AXE SPC switching machine to the Australian network (2).

The purpose of this paper is to broadly discuss the main features of the system, and to illustrate the typical information required to describe a network to SWITCHNET. Reports useful to a network planner are also briefly discussed and the further progression in development identified.

SYSTEM OVERVIEW

Broadly, SWITCHNET may be divided into the following modules: (Fig. 1)

- An Operating Environment which allows the user to create complex switching network models without worrying about the computer system. This consist of

  a Data Base Management System which allows the user to manipulate his network data; and

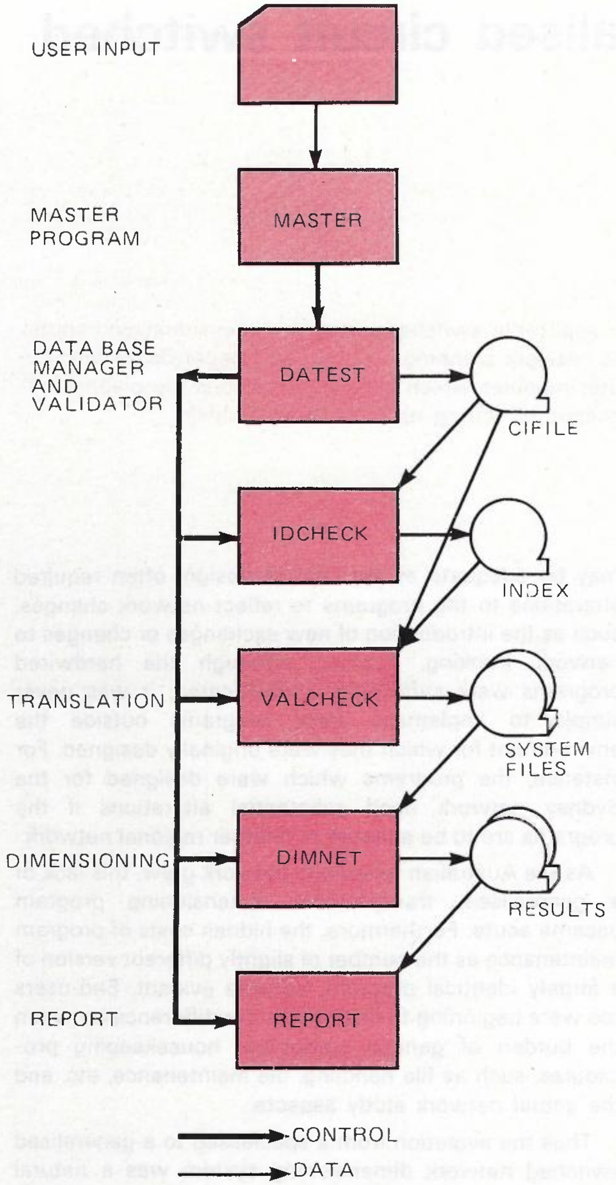

Fig. 1 SWITCHNET Modules

a Data Validation Processor which is used to perform data and syntax validation.

- A Translation Module to convert the user-oriented network description to a computer oriented description.
- A Dimensioning Module which performs the tasks of network dimensioning.
- A Report Module which produces formatted reports based on the network design produced by the Dimensioning Module.
- A Transfer Module which handles data transfer between SWITCHNET and an auxiliary network planning data base.

A discussion of the above modules follows:

THE OPERATING ENVIRONMENT

In any computer application, it has as its basic components a complex of programs and data files. In order to achieve a desired result, the user of an application has to decide what data he needs to input, which files need to be attached, and which programs need to be executed. The order of these events will usually have a critical effect on the result achieved. To instruct the computer in these requirements, the user normally has to be familiar with the job control language, the programs available in the application (and their functions), the file identities currently established which are relevant to the application, and the legitimate data sequences and data formats to be used for data input. To remove these mundane but necessary controls from the end-user, the Planning Language Executive (PLEX) language was developed. The language provides the user with a flexible operating language couched in terms relevant to the SWITCHNET application and removes the need for any specialised knowledge of the computer system being used.

Basically, PLEX provides the user with an application language consisting of:

(a) a series of commands to facilitate manipulation of files and execution of programs, and

(b) a series of descriptor to be used in defining and entering data.

Thus, with a vocabulary of valid execution commands and descriptor, the user may drive the system without further concern about the computer system. When operating, the PLEX system continually scans the input data and refers to a syntax table as a basis for checking legitimacy of data and execution of the appropriate SWITCHNET sub-routines.

User data is written on to an index sequential data base and, using the PLEX executive, the user may perform normal data manipulation such as updating, data alteration, etc. The Data Base Management System and

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Data Validation Processor may simply be considered to be an integral part of the PLEX system and will not be discussed further. Instead we will consider the data SWITCHNET required to characterise a network.

DATA REQUIRED FOR SWITCHNET OPERATION

The information required for any trunk and junction network planning system, and, indeed, including SWITCHNET, may be outlined as follows:

- Exchange locations and switching stages in each location.
- Types of switching equipment available.
- The switching function of this equipment within the network.
- The routing plan or the overflow patterns allowable in the network.
- The transmission plan.
- The available transmission media.
- The cost categories (components) in the network.
- The cost curves (structure) of switching and transmission circuits.
- Exchange boundary definition and the grouping of exchanges.
- The general dimensioning rules for given links of switch functions.
- Any specific dimensioning rules for specific cases.
- Traffic demand.

The above information is treated by SWITCHNET in the following description. Appendix 1 illustrates a sample network description employing the SWITCHNET vocabulary. Samples of PIEX commands are also included.

Switch Equipment and Switch Functions

A network is serviced by a variety of switching equipment. In Australia, for instance, the trunk network is largely served by the Metaconta 10C and ARM exchanges. This switch *equipment* is located at different levels in the switching hierarchy and thus serve different *functions* in the network. For example, the ARM could serve as Secondary originating and Secondary terminating functions, while the 10C could serve as a main switching function.

Nodes

Nodes information in the SWITCHNET context is a list of exchange LOCATIONS in the network. Thus, conceptually, each LOCATION may be an exchange building complex and, within each LOCATION, there may be switching STAGES. Each STAGE contains switches which serve different functions in the network.

General Links

The general link data section defines all possible and permissible links in the network. Each link is identified by a user defined name and is used to connect a pair of switch functions. It is a class of link for which all dimensioning parameters, dimensioning rules, route costing method and routing control are identical. Each general link may be defined by its TYPE. Two major TYPES of general link exist. DIR, or direct links are high usage links, which overflow some, or all of their traffic to other link and LR, or last resort links form which there is no overflow and which must be provided on a grade of service criterion. Each TYPE has a number of variants. Each general link specification includes parameters needed for dimensioning all links of that type. Parameters may be omitted, in which case values are taken from a user defined default file or system default values. Some typical parameters include the name of traffic tables to be used, the grade of service or cost factor and circuit provisioning controls such as maximum, minimum, increments, etc. Table 1 shows a list of parameters available to the user. This section is perhaps one of the most powerful areas of SWITCHNET, as it allows the user to define explicity the action he wishes the dimensioning program to take for a given origin-destination (OD) switch function pair. Further, as SWITCHNET allows the user to nominate a number of cost curves for a given OD switch function pair, they could be used as a means of selecting the cheapest transmission media for that OD pair. More will be said on this topic in the dimensioning module.

Routing Plan

The overflow section permits the user to describe the allowable routing pattern encountered in the network. It provides a flexible control of traffic handling in the network modelling process. Overflow patterns are defined by a user supplied pattern identifiers. Once defined, the pattern will apply in general to a given originating switching function and for a given set of destination switching functions described by a pattern.

The Transmission Plan

The transmission plan prescribes the allowable satisfactory transmission quality for a network. In order to attain the transmission performance, the appropriate transmission medium must be used for a given OD exchange pair. In SWITCHNET the transmission aspect and the costing of the route link is covered by the Cost Categories, Cost Curves and Distance sections.

Cost Categories

This section enables the user to split basic network components into individual parts. Typically, the categories could include transmission media length dependent parts and line length independent parts such as PCM terminals, repeaters, signalling relays, etc. The user can thus make use of this section of data to include the transmission component of the network.

Cost Curves

For each transmission medium a cost curve is used to describe the relationship between cost and distance. The cost at any point of the cost curve can be subdivided into a number of user specified cost categories which can then be used to subdivide the total network costs. Cost curves are usually used in conjunction with General Links. This section of data allows the user to relate the permissible transmission technology between switching functions.

Distance (Transmission Paths)

The distance section provides information regarding the distances over which direct transmission facilities are implemented between exchange locations. In order for SWITCHNET to determine the economics of direct path versus alternate route path, the shortest transmission path is found from information provided in this section and costed using the appropriate cost curves.

Switch Group (Exchange Boundary)

This section is used to define the parent-child relationship between switching stages. Thus, for a given parent tandem, a particular switch group will be used to list all the member stages for which this parent serves. Effectively, the switch group section contains information regarding exchange boundaries.

Specific Link

A specific link is a single member of a class of general links for which special dimensioning rules apply. Any parameters needed and not specified for a specific link are taken from the relevant general link. Thus, this section permits the user to specify particular links in the network for which specific actions, specific dimensioning rules or specific dimensioning tables should apply.

Demands (Traffic Interest)

The demand section is the traffic input to SWITCHNET. For each originating stage, the traffic demand to destination stages is listed.

Default Parameters

This section allows the user to define default dimensioning parameters. During dimensioning, SWITCHNET runs through an orderly search for the appropriate dimensioning parameter, using first information from specific links, then general links, user defined defaults and finally system defined default values.

THE TRANSLATION MODULE

The function of the translation module is to translate the user oriented network description to a computer oriented description. Also, this module generates a dimensioning sequence file which, when used during dimensioning, will ensure that the dimensioning module will operate in such a sequence that lower order switch functions will be dimensioned before those of a higher order. Thus, any overflowing traffic from the lower order switching stages will be collated correctly for the higher order switching stages. Topological sorting is used in this sequence generation. (3)

THE DIMENSIONING MODULE

SWITCHNET dimensions a network link by link using the dimensioning sequence determined by the translation module. Each link is dimensioned according to rules which are specified in GENERAL LINKS, or sometimes as specified by the user, from the SPECIFIC LINK data, with the offered traffic taken either from the traffic demands record, or assembled from the combined overflows of all routes overflowing to it.

The circuit dimensioning is performed in one of two ways depending on whether grade of service (GOS) or cost factor (commonly referred to as H value in Australia) parameter is specified for the general link TYPE.

GOS Links

GOS links are dimensioned using the appropriate dimensioning table, user specified GOS and other parameters. The dimensioning routines calculate the number of circuits, carried traffic and actual overflow traffic. Although overflow from a GOS link is of little significance to a network, it is, however, used by SWITCHNET in computing the end-to-end grade of service for any OD pair. Also calculated is the cost of the circuit. The method used will be discussed later. All calculated information is stored in the result file and used later for reporting purposes.

High Usage Links

High Usage Links are identified by the GENERAL LINK type DIR. The dimensioning process involves calculation of cost factors according to the traditional method used in Australia (4). However, for practical purposes, a simplified triangle approximation is used, where given a direct link and an alternate overflow link, a simple triangle is formed for the i-j (direct) and i-t-j (overflow) paths. Thus, in general, the cost factor H is:

$$H = B \frac{\text{Cost of direct route}}{\text{Cost of alternate route}} \quad (1)$$

Where B is a constant analogue to the marginal capacity. B is user definable, with a system default set at 0.75. In practice, this approximation is found to be satisfactory.

Switched Link Costing Method

In SWITCHNET, the costing algorithm depends on information derived from the COST CURVES and DISTANCE data sections. Since COST CURVES define transmission cost as a function of distance, and since the DISTANCE data section defines the distances over which transmission facilities are implemented (c.f. cable runs), SWITCHNET determines the shortest path between given OD pairs which have the shortest direct transmission facility between them, and applies the appropriate cost curves to work out the cost of the link. If a link has more than one permissible COST CURVE, then SWITCHNET will select the cheapest transmission media.

Technology Selection in SWITCHNET

Technology selection can be translated to cost curve selection. Generally, a link can have more than one curve specified (e.g., FDM, PCM and VF cost curves). Given an overflow arrangement, the dimensioning program will compare the economies of direct switching versus alternate route switching, using the various combinations of technologies. Thus, the resulting design represents the cheapest combination and information regarding the use of switching and transmission cost categories is available for summary reporting purposes.

THE REPORT MODULE

The report module offers the user a wide range of reports, with the capability to select particular areas or sections of the dimensioned network. Reports available include:

- Incoming/Outgoing trunking report
- Cost Report which summarises the cost of the network
- Link Report detailing transmission links between locations
- End-to-end grade of service reports.

THE TRANSFER MODULE

The transfer module enables the user to extract dimensioned results to update his network planning data base. It also allows the user to retrieve information from his data base to be loaded directly into a new SWITCHNET network description. Thus, the differences between planning and implementation of a network can be reconciled by taking into consideration information from the data base regarding installed circuits, committed circuits and any other practical limitations.

SWITCHNET IN ACTION

SWITCHNET has been in operation for some years now and is progressing towards the adaptive maintenance mode, where new user facilities are added and the system adapted to response to major changes in dimensioning philosophy. Perhaps the most exacting test for SWITCHNET occurred in 1978, when Telecom Australia embarked on network studies into the application of the AXE switching system in the Australian condition. SWITCHNET was used to model the Melbourne and Adelaide networks for the various combination of:

- Terminal and tandem exchanges with analogue group switching subsystem, GSS. — (AA network)
- Terminal exchanges with analogue GSS and tandem exchanges with digital GSS. — (AD network)
- Terminal and tandem exchanges with digital GSS. — (DD network)

The study undoubtedly proved the usefulness of this flexible system. In recent years, it was used as a teaching tool for ITU fellows on study visits to Australia and it was generally agreed that it serves as a good guide as regards

TABLE 1 — Sample of Dimensioning parameters available in SWITCHNET

CCCT — Committed circuit. Used to specify the minimum circuits to be provided regardless of the value of offered traffic. System default is zero.

UCCT — Up circuit. Parameter similar to CCCT with the exception that SHRINK (see later) will not apply. The only change possible for the specified number of circuit will be an increase.

RCCT — Required circuit. Used to specify a fixed number of circuits regardless of traffic offered.

MCCT — Maximum circuit. Specifies maximum number of circuits, regardless of how large the offered traffic.

MQ — Specifies the availability to be used for a limited availability route. An MQ rule can be specified. For full availability system, MQ = FULL.

TABLE — Dimensioning table to be used. System default is table "A" i.e., Erlang Table.

STINC — Starting Increment. The offered traffic level must attain such a level before circuits are to be provided. If CCCT is set, then STINC will apply from CCCT, otherwise it will apply from zero. System default is two.

GOS — Specifies the grade of service to be applied to the link. System default is 0.005. GOS is overridden by IGOS (see later) if the origin and destination stages of a grade of service route are at the same location.

H — Specifies the H factor (Marginal occupancy) of the link. If no H factor is supplied, then the route is treated as grade of service and the system default GOS of 0.005 applies.

MINC — Specifies the modular increment allowable if circuits are to be added. No system default. If CCCT is set, then MINC applies from the CCCT value, otherwise it will apply from zero. This parameter is used in conjunction with BKPT (see later).

BKPT — Specifies the breakpoint that determines when the next module will be added — used in conjunction with MINC. No system default value is set. An example of the use of MINC and BKPT is if MINC = 10 and BKPT = 6, then the traffic would have to require 6 extra circuits before the next module of 10 circuits would be provided.

SHRINK — Parameter used to control circuit provisioning in a shrinking network (eg., step by step network). Used in conjunction with CCCT, this parameter allows the user to control the range of circuit quantity variation before altering the committed circuit value. System default is zero.

AMIN — Specifies the maximum traffic for which provision of this link is permitted. System default is 4 Erlang. However, last resort link ignores this parameter.

IGOS — Specifies an internal grade of service for switching Stages within the same location. System default is 0.002. If set, IGOS over-rides GOS when the origin and destination stages are at the same location.

IMIN — Specifies the minimum traffic for which provision of a direct link within the same location is permitted. No system default exists.

BETA — Specifies marginal traffic capacity of the link. System default is 0.75.

to planning system development and data requirements for network planning purposes.

CONCLUSION

Network planning is a complicated affair, and it is an unnecessary burden for a network planner to acquire complex job control language in order to drive a hardwired network dimensioning system which is not responsive to network changes. SWITCHNET, together with PLEX, have shown to be useful network modelling tools, sufficiently flexible to allow the user to describe a network as data. Experience gained from the use of SWITCHNET in short-term planning environments and longer term network studies (2) confirms the value of this generalised system. With the introduction of the Integrated Data Network (IDN) in Australia nd the possible evolution to the Integrated Services Digital Network, the urgency to conduct careful network planning studies is mounting. With a flexible planning tool, no doubt the planner's job will be that much simpler.

ACKNOWLEDGEMENT

The permission of the Chief General Manager, Telecom Australia, to publish this paper is acknowledged.

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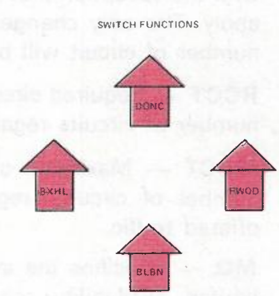
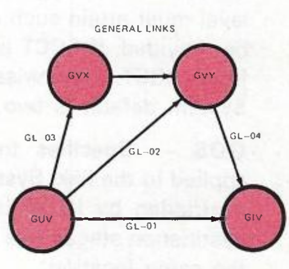
The following is a sample network problem as described to the SWITCHNET system. It is used here to demonstrate the various powerful features of the PLEX language. Note that PLEX is an English-like language which allows the network planner to describe his network to varying degrees of complexity.

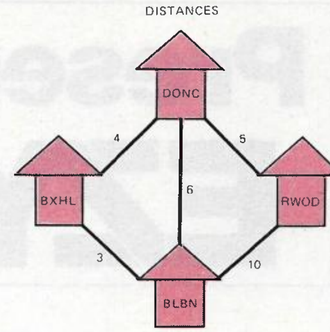
SWITCHNET Sample Problem

```
NEWSWNET      NETWORKS83                        CHIN
DATA
SWITCH FNS    GUV        ARF       ORIGINATING GV STAGE FOR TERMINAL EXCHS
              GIV        ARF       TERMINATING GV STAGE FOR TERMINAL EXCHS
              GVX        TANDEM    ORIG TANDEM CROSSBAR SWITCHING STAGE
              GVY        TANDEM    TERM TANDEM CROSSBAR SWITCHING STAGE
NODES
LOCATION      BLACKBURN            BLBN      BLACKBURN TERMINAL EXCHANGE
STAGE         S BLBN GSS           BLBN-GSS            GUV       GIV
LOCATION      RINGWOOD             RWOD      RINGWOOD TERMINAL EXCHANGE
STAGE         S RWOD GUV           RWOD-GSS            GUV       GIV
LOCATION      DONCASTER            DONC      DONCASTER TERMINAL EXCHANGE
STAGE         S DONC GUV           DONC-GSS            GUV       GIV
LOCATION      BOX HILL             BXHL      BOX HILL EXCHANGE
STAGE         S BXHL-GSS           BXHL-GSS            GVX       GUV
              GVY        GIV
GEN LINKS
LINK          GL-01      DIR                 DIRECT ROUTE BETWEEN TERMINALS
SWITCH FNS    GUV        GIV
PARAMS        H=0.4 MQ=20 MCCT=40 AMIN=6.0 TABLE=GVB
USE CURVES    CRV-VF
LINK          GL-02      DIR
SWITCH FNS    GUV        GVY
PARAMS        H=0.4 MQ=METRO TABLE=GVC
USE CURVES    CRV-VF
LINK          GL-03      LR                  BACKBONE ROUTE
SWITCH FNS    GUV        GVX
PARAMS        GOS=0.001 MQ=FULL
USE CURVES    CRV-VF
LINK          GL-04      LR                  HIGHER ORDER BACKBONE
SWITCH FNS    GVX        GVY
AND           GVY        GIV
PARAMS        GOS=0.002 MQ=FULL
USE CURVES    CRV-VF     CRV-PCM
```

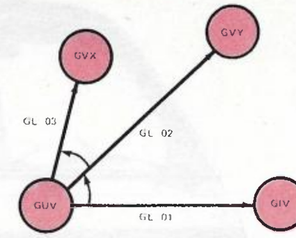




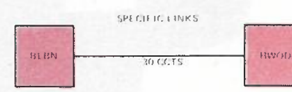
SWITCHNET Sample Problem




```
• DISTANCES
  LOCATION          BXHL
  CONNECTS TO       BLBN      3.0       DONC      4.0
  LOCATION          BLBN
  CONNECTS TO       BXHL      3.0       DONC      6.0       RWOD      10.0
  LOCATION          DONC
  CONNECTS TO       BXHL      4.0       BLBN      6.0       RWOD      5.0
  LOCATION          RWOD
  CONNECTS TO       BLBN      10.0      DONC      5.0

• OVERFLOWS
  PATTERN           OP-01     STANDARD METRO OVERFLOW PATTERN
  OSFUNCTIONS       GUV
  FROM              GIV                 GL-01
  TO                GVY                 GL-02
  TO                GVX                 GL-03

• SWITCH GPS
  LRGROUP           GP-01     BXHL-GSS  GVX       IC
  MEMBERS           BLBN-GSS  RWOD-GSS  DONC-GSS  BXHL-GSS
  LRGROUP           GP-03     BXHL-GSS  GVY       OG
  MEMBERS           BLBN-GSS  RWOD-GSS  DONC-GSS  BXHL-GSS
  LRGROUP           GP-05     BXHL-GSS  GVX       OG
  MEMBERS           BXHL-GSS

• SPEC LINKS
  LINK              BLBN-RWOD           SL0003    GL-01     BLBN-GSS  RWOD-GSS
  PARAMS            RCCT=30
  USE CURVES        CRV-PCM

• DEMANDS           1982                SMALL TRAFFIC MATRIX FOR NETWORKS 83
  ORIGIN            BLBN-GSS
  DESTNS            RWOD-GSS  20        DONC-GSS  15        BXHL-GSS  30
  ORIGIN            RWOD-GSS
  DESTNS            BLBN-GSS  15        DONC-GSS  25        BXHL-GSS  10
  ORIGIN            DONC-GSS
  DESTNS            BLBN-GSS  12        RWOD-GSS  14        BXHL-GSS  15
  ORIGIN            BXHL-GSS
  DESTNS            BLBN-GSS  33        RWOD-GSS  27        DONC-GSS  28

• DEFAULTS
  PARAMS            TABLE=A AMIN=5.0 GOS=0.003 BETA=0.6
• MQ RULES
  RULE              METRO
                    7         5
                    14        10
                    MAXIMUM   20
• COST CATEGORIES   TERMINAL  SIGNALLING ORIGIN COST
                    SWITCH    SWITCHING COST
                    LINE      LINE LENGTH DEPEDENT COST

• COST CURVES
  CURVE             CRV-VF    COST CURVE FOR VF TRANSMISSION MEDIUM.
  POINT             0.0       83.89
  CATEGORIES        TERMINAL  45.59     SWITCH    38.30
  POINT             25.00     266.73
  CATEGORIES        LINE      182.84
  CURVE             CRV-PCM   COST CURVE FOR PCM TRANSMISSION.
  POINT             0.0       203.04
  CATEGORIES        TERMINAL  164.74    SWITCH    38.30
  POINT             50.0      291.04
  CATEGORIES        LINE      88.00
  PARAMS            MINC=15 BKPT=FREEMAN1

• IDCHECK
• VALCHECK
• DIMENSION                   CSTCALCH0                     TRACE ON
• REPORT
  REPORT            COSTREP
  REPORT            LINKREP   PRINT PKTS
  REPORT            END TO END
• END
```



SWITCH GROUP

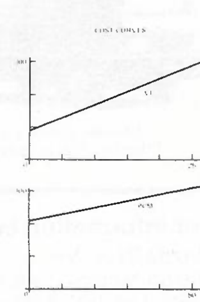


TRAFFIC DEMAND

ORIG \ TERM	BXHL	BLBN	DONC	RWOD
BXHL		33	28	27
BLBN	30		15	20
DONC	15	12		14
RWOD	10	15	25	

USER DEFAULTS

AVAILABILITY RULE



SWITCHNET COMMANDS

T.Q.C. or Managerial Fad?

JACK KEAVNEY & MICHEL LYRMONT

"Quality is free. It is not a gift but it is free. What costs money are the inequality things; all the actions that involve not doing jobs right the first time." (Phillip B. Crosby).

In our contemporary ethos, the dependence vested in Telecommunications by business, and indeed by the very social order itself is truly enormous, and, if anything, it is expanding. This means that in addition to the intensely turbulent climate caused by the impact of High Technology, the industry, and in particular its service arm, are both confronted with the added pressure of integrating exacting standards of reliability within a rapidly increasing level of responsibility and sophistication.

Against such a backdrop, the idea of a managerial approach which boasts the achievement of TOTAL QUALITY CONTROL (T.Q.C.), can only be timely, appealing and certainly very topical. So what is T.Q.C., and what can be reasonably expected from the T.Q.C philosophy?

T.Q.C. is associated with the name of W. E. Deming, an American Statistician who developed principles of quality control in the U.S.A. shortly before the outbreak of World War II. With the postwar industrial boom, Deming's work was generally ignored in his home country, but it was not lost on the Japanese. So successful was the approach that the Japanese Confederation of Industries established the Deming Prize for productivity which is awarded once a year to organizations whose record has been particularly impressive in the previous 12 months. The award is much sought after; the event is given considerable national importance and is broadcast live on the national television network. In 1950, Deming, at a meeting of industrialists in Tokyo, declared that if what he started was sustained and integrated throughout the Japanese industrial structure, Japanese goods would be second to none, and would be much sought after on the world market. It must be remembered that at the time, Japanese goods were reputed for their shoddiness, which makes the declaration somewhat dramatic in its prophetic character.

So what are the principles of T.Q.C.? For user, quality control is as old as the practice of organized effort, and statistics have been used in industry since their early development. This, however, does not guarantee success, and, according to Deming, current practices are often counterproductive.

Basic to the philosophy of T.Q.C. is the view that inspecting quality in by inspecting defects out is a sure way of programming defects in. The claim is rational enough. If the system is designed to inspect defects out, then, patently, the system is also programmed to manufacture them in. The conclusion is inescapable! The defect must be manufactured before it is inspected out. Granted that whilst in the straight manufacturing process quality inspection will prevent the defect from reaching the market, it will not prevent the immense cost which is associated with defective production and, furthermore, in many aspects of the service industry, it is not possible to introduce an inspection between output and end user. Going back to the illogicality of the approach which is structured to manufacture defects in, it also means that somehow, somewhere, sometime, defects will be manufactured which will either be outside the inspector's terms of reference, or which will only become visible further downstream.

A first principle of T.Q.C. then is that quality should be "built in", in contradistinction to having defects "inspected out". For all of its compelling logic, this approach is nonetheless contrary to the commonly accepted quality assurance and control programmes. Typically, in most western organizations, quality is the prerogative of the Quality Control Department, and it is thus removed from the operator. With the responsibility for the quality control thus removed from the workface, building "quality in" becomes elusive. If quality is to be built in, it should involve every person participating in the process. Easier said than done! And what is the definition of quality anyway?

In T.Q.C., quality can only be defined operationally. This too goes against some well established notions, particularly the notion that high quality must be equated with high cost, and that perfect quality is an unattainable ideal. In contrast, Deming has it that high quality leads to low cost, and evidently a different definition of quality is invoked. This alternative definition comprehends quality as compliance with well articulated standards, and high quality as consistent compliance with such standards. This, in turn, begs the question of how standards are defined and by whom.

Standards are defined by the consumer. To go beyond the consumer's requirements does not improve the quality and can only add to the cost. Evidently, with such an operationally based definition, the idea of quality as something which is necessarily associated with high cost can be safely dismissed, and so can the view that perfect quality is an unattainable ideal. For sure, markets must be segmented, and it is not meaningful to uphold a definition of quality which is universally satisfactory for all people at all times. This would vest quality with some kind of absolute dimension which is precisely what T.Q.C. denounces. Quality is customer rated, and customers are stratified. Within the target population there will be the odd instance of the customer with unrealistic expectations. No rational system can be designed to satisfy such marginal exceptions. Products and services are designed for demanding, discerning, but reasonable end users. Within such parameters, "Zero Defect" is fully attainable.

Whatever the target population however, no meaningful quality criteria can be enforced until such time as the output is stable. No improvement can be made until stability, which also means predictability, is achieved. Yet, typically, under the prevailing practices of quality assurance and control, this is generally ignored. The experts will specify upper and lower limits independently of the worker and of the idiosyncracies of the system. When these limits are exceeded, a witch hunt begins, hopefully for the purpose of linking up cause and effect; all of which is futile if not outright counterproductive says Deming.

Variations in any system are normal, even if such variations extend beyond the specifications given by the experts. This point is generally and hopelessly misunderstood, and the waste associated with various "tune ups", or the seeking of faults where none exist, is truly enormous. Figures published by ENTERPRISE AUSTRALIA claim that in this country, waste accounts for about 30% of the total cost of production. What is important then is to find out the capability of the system, and whether the system is under statistical control or not. If the system is under statistical control, that is, if it operates within the limits of its capability, then the present output is all that the system can do, independently of what the desired specifications may be. This is a fundamental feature of T.Q.C. A system has a limited capacity, and it is mindless to demand of the system what the system cannot deliver, specs notwithstanding.

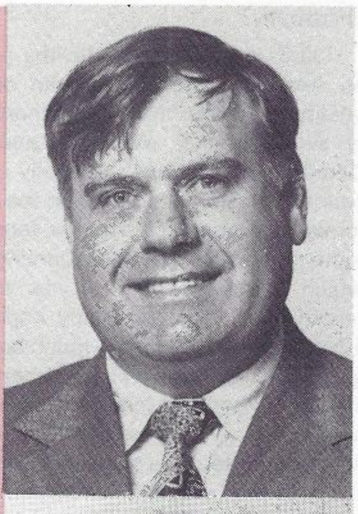
The capability of the system is determined by sampling the output, by calculating the mean of the samples, and by applying Deming's modified formula for the deviation from the mean. This provides the upper and the lower limits of the capability of the system. It is beyond the scope of this paper to go into the mathematical rationale of Deming's statistical formulae. The interested reader may wish to consult the references given at the end of this article or to contact the authors for further details in this respect.

This approach to quality control is evidently a far cry from established practices, and it will result in one of the following conclusions:

1: The system is not under statistical control, and it spills over its upper and lower limits.

2: The system is under statistical control, but it does not comply with the desired specifications.

3: The system is under statistical control and it complies with the desired specifications.



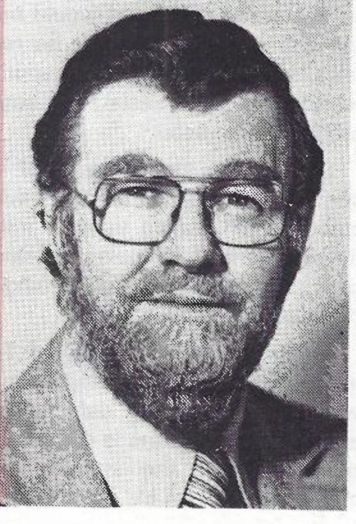
MICHEL LYRMONT: B.A. (Melb.), M.A. (Tas.)

Michel is a Staff Development Officer at Telecom HQ and Director of Studies of Telecom's Advanced Management Seminars.

Michel was born in France (Provence), and educated in Metropolitan France, in Casablanca, in New Caledonia, at the University of Melbourne and at the University of Tasmania.

His vocational profile includes 12 years as a psychologist in the Australian Department of Health, followed by four years teaching Administration at the University of Tasmania, and two years at the University of the South Pacific, Fiji. He joined Telecom in 1982 in his present position.

Michel has published several papers on administration and management and other interests include Management Education, languages (French, Russian and some forgotten Spanish), church activities, epistemology and nature oriented pursuits. He is married with one daughter.



JACK KEAVNEY: Enterprise Australia

Sicne 1983, Jack has been the Communication Consultant of Enterprise Australia and prior to this he was its Chief Executive. Enterprise Australia is responsible for mounting the "Australian for Quality Programme," launched by the Prime Minister on 2 April 1984, with Jack as Project Director.

Consistent with his high flying profile, Jack started his career as an RAAF Pilot during the war and spent many years in promoting and managing humanitarian causes. He has been a State Organiser of the Road Safety Council, the Secretary of the National Council of Promotion of the Church of England in Australia and the National Director of the Australian Freedom from Hunger Campaign. He also spent several years in business and for a while was the Managing Director of his own PR firm.

Jack appears frequently as a Guest Speaker at major conventions in Australia and overseas. His speech in Washington in 1980, to the National Association of Manufacturers was read into the US Congressional Record and led to the formation of Enterprise America. His speech to the American Economic Foundation, January 1981, was published in the prestigious publication "Vital Speeches of the Day".

When the system is not under statistical control, one obviously has to determine why. Two fundamental causes are possible. One is in the nature of the system itself and is referred to as the "Common Cause". The other possible source of variations is derived from factors such as the performance of the operator and other spurious events and is referred to as the "Special Cause". Common causes amount to about 85% of faults, and special causes to about 15%. These proportions are empirically determined. Yet, for all there is to observe, it is the special cause which is generally addressed whenever outputs are not up to specifications. It has thus become fashionable to mount various motivational programmes the purpose of which is to urge the workers to do more and to do it better. For all we know however, workers may already be doing their best, and it is management which is delinquent in that it has failed to provide the right vehicle for the workers' performance.

When the output is under statistical control but does not meet the specifications, the system is evidently inadequate for the desired performance and needs redefinition and restructuring. Attempts made at tuning up the system or at addressing special causes cannot change the capability of the system itself, even if at times the

INTERVENTION PROVIDES A SPURIOUS IMPROVEMENT.

When the system is under statistical control, and when it meets the prescribed specifications, improvements can still be achieved by narrowing the variation band between the upper and the lower limits. This effectively increases the uniformity of quality, and it enhances the predictability of output. When the statistical limits of the system are well within the specifications, should the system become destabilized, the operator, through his charts, is given some advance warning before the defective output is actually generated. Further assistance in this respect is provided through Deming's criteria of statistical control. The criteria postulate that when 7 or more sample readings are "running", that is, when they produce a straight line either up or down, then the system is out of control even though these 7 points may still be within limits. This criterion is justified on the evidence of massive empirical data.

Within such an operational philosophy of "built in" quality and the application of statistical charts, it should become apparent that satisfactory results cannot be achieved by remote control. If quality is to be truly built in, which also entails that the output has to stay within statistical limits, then the onus is on the operator to manage the process and to take the full responsibility for it. This, in turn, cannot be achieved unless the operator is trained in sampling techniques and in the production of accurate statistical charts. To equip the operator to perform accordingly, a massive education programme is required. The education programme should be pragmatic. It is not an academic course in statistics, but it is very much a course on how to sample the relevant outputs, how to calculate the means, and how to apply the relevant formulae and for what purpose. This alone however will not ensure a built in quality. To build quality in, the operator must be given the discretion to do so, and this becomes possible only after the "intent" of the process is clearly explained and demonstrated at each level. In particular, the operator should know what is the purpose of the operation in relation to the final outcome, how a specific operation meshes in with other operations downstream, and what are the reasons for the specifications. It is only after the operators are fully familiar with the process intent that the meaning of quality can filter through the various layers of the organization, and that an integrated quality final output can be expected. This point too has generally been lost on western organizations. Trendy contemporary managerial fads such as "Bottom Up Management", Quality Circles", "Team Building", "Zero Defect", "Kan Bahn" . . . are consequences of the T.Q.C. managerial philosophy. They do not cause quality. The introduction of "Kan Bahn" as such, independently of an integrated managerial approach, will probably be counterproductive. It will effectively push oversized inventories further upstream adding to the supplier's confusion. The supplier may be excused for reacting by playing it safe, increasing his own inventories, and charging the user for it.

On the other hand, when the system is predictable, and when upstream knows full well what downstream requires and when, the operator can safely depend on the quality and timing of incoming products and services. Under such circumstances, "just in time inventories" (Kan Bahn), evolve spontaneously. As already explained, with comprehensive quality control, high predictability is achieved. With high predictability there is no need to instal "Kan Bahn". It happens as a matter of course.

Other benefits from the operators' understanding of the integrated meaning of their function, from their mutual inderdependence, and from the fact that they are given both the competence and the discretion to control the output. When all these factors are present, not only will the operators perform up to quality standards and correct an aberrant system, but they will also take the initiative to improve on the status quo because now they understand the process intent. The precious habit of improving thus becomes ingrained in the organization. T.Q.C. effectively causes the emergence of a team spirit with a penchant for innovation. This is the genesis of the much vaunted Japanese "Quality Circles". Typically, in Japan, quality circles only emerged years after the introduction of T.Q.C. By contrast, the western organizations, obsessed as they are with short term expedients, have introduced quality circles for the purpose of creating a team spirit and quality improvement, which is obviously back to front.

Patently T.Q.C. challenges well established managerial practices, and it also challenges many vested managerial interests, particularly in middle and first line management. It would be fair to say that in Australia, there is a degree of alienation between workers and management. Because of this alienation, first line managers will certainly feel that their power is undermined when they are requested to both keep the operators fully informed on the process intent and relinquish the control of the process to the operator. To a lesser extent middle management will also feel threatened for the same reasons. Even with full cooperation all round, T.Q.C. still requires a drastic redefinition of first line management.

T.Q.C. is structured on principles which must be reasoned through within the specific culture of each organization. The techniques of T.Q.C. are the instruments which make possible the implementation of these principles. T.Q.C. degenerates into another management fad when the techniques are implemented without reasoning through the underlying principles. A key aspect of these principles is the development of a new managerial philosophy with ongoing commitment by top management to the constancy of purpose which is TOTAL QUALITY CONTROL. Deming abstracted the essence of T.Q.C. in the following 14 points.

1. Create a constancy of purpose towards improvement of products and services. Plan for the future.
2. Adopt a new philosophy which makes delays, mistakes, defective materials and defective workmanship unacceptable.
3. Cease dependence on mass inspection, instead use statistical evidence to ensure that quality is built in.
4. End the practice of awarding supply contracts based purely on price tag, instead measure quality and price together.
5. Find problems. Improve the system (design, incoming materials, composition of materials, maintenance, equipment, training and supervision).
6. Implement best methods of training on the job.
7. Enhance the supervisor's role to help improve quality and productivity.
8. Drive out fear, so that everyone may work effectively for the company.
9. Break down barriers between departments.
10. Eliminate numerical goals, posters and slogans asking for improvement without providing a method.
11. Eliminate work standards that prescribe numerical quotas.
12. Remove barriers that stand between workers and his/her right to pride of workmanship.
13. Implement a vigorous programme of education and retraining.
14. Create a structure in top management that will push every day on the above 13 points.

Thankfully there are significant changes in Australia which aim to uplift this country's competitive position through the philosophy of T.Q.C.

In April 1984, ENTERPRISE AUSTRALIA launched a major national programme to this effect. Two years were spent in planning the programme in consultation with leading industry associations, companies, and management consultants. An important function of this campaign which is called the "AUSTRALIA FOR QUALITY PROGRAMME", is that of raising the level of community awareness and understanding of the problems that face Australia. In support of this, the Federation Of Australia Radio Broadcasters voted unanimously at its 53rd Annual Conference in October 1983 to provide $5 million worth of advertising time for 1984. FARB's 136 member stations each broadcast twenty messages per week of 30 or 60 seconds each. These broadcasts made throughout the year, have generated many opportunities for public debates and talk back shows which resulted in the exploration of issues in greater depth, and TV and Press coverage. The success of the programme was given a further boost by FARB which pledged another $5 million for the year commencing 1st April 1985.

Politically, the AUSTRALIA FOR QUALITY PROGRAMME is fully supported by leaders of the Government and of the opposition. The Prime Minister, Mr Hawke, summed it up in the following terms when he launched the programme on a network of 136 commercial stations on April 2 1984: "It is not a Government programme, but it is one that I totally support", said Mr Hawke, and "... if Australians get behind it, we can produce the results, and we will all share the benefits".

This article started with a philosophical reflection on the cost of quality. It would only be consistent to conclude in the same vein.

"Quality is not only right, it is free. And it is not only free, it is the most profitable product line we have". (Harold S. Geneen).

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The SULTAN Customer Line Test Network — System Description

John McIntyre and David Belshaw
Telecom Australia.

SULTAN (Subscribers Line Test Access Network) has been designed and developed by Telecom Australia to provide customer line testing facilities. This system incorporates central minicomputers, and outposted test robots in terminal exchanges.

This article is a description of the SULTAN central processor system, and is the second in a series. A previous article describes the general application of SULTAN. An accompanying article describes the SULTAN Microprocessor Robot Tester.

All customer complaints are reported to Service Assistance Centre (SAC) operators on service code 1100. The SAC operators may access and check customers lines using SULTAN while the customer waits. The operator then advises the customer of the test result and reports faults to the Fault Despatch Centre. At the Fault Despatch Centre testing officers can use the SULTAN system to perform more comprehensive line testing prior to despatching the appropriate repair officer. (Refer to the article in the Telecommunications Journal, Vol. 34 No. 3, "Facilities and Operation of SULTAN — A Computerised Line Test Network for Telephone Lines" for a full system structure description.)

SULTAN SYSTEM STRUCTURE

SULTAN comprises a three level hierarchical structure of Communications Controllers and Test devices, as illustrated in **Fig. 1**. The Robot Tester devices perform the actual line testing function under the control of the Test Communications Controller (TCC). The TCC also supports the Visual Display Units (VDUs) used by the Fault Despatch Centre (FDC) Testing Officers. The Operator Communications Controller (OCC) provides the Service Assistance Operator positions with access to the SULTAN test facilities provided by the TCC and Robot testers.

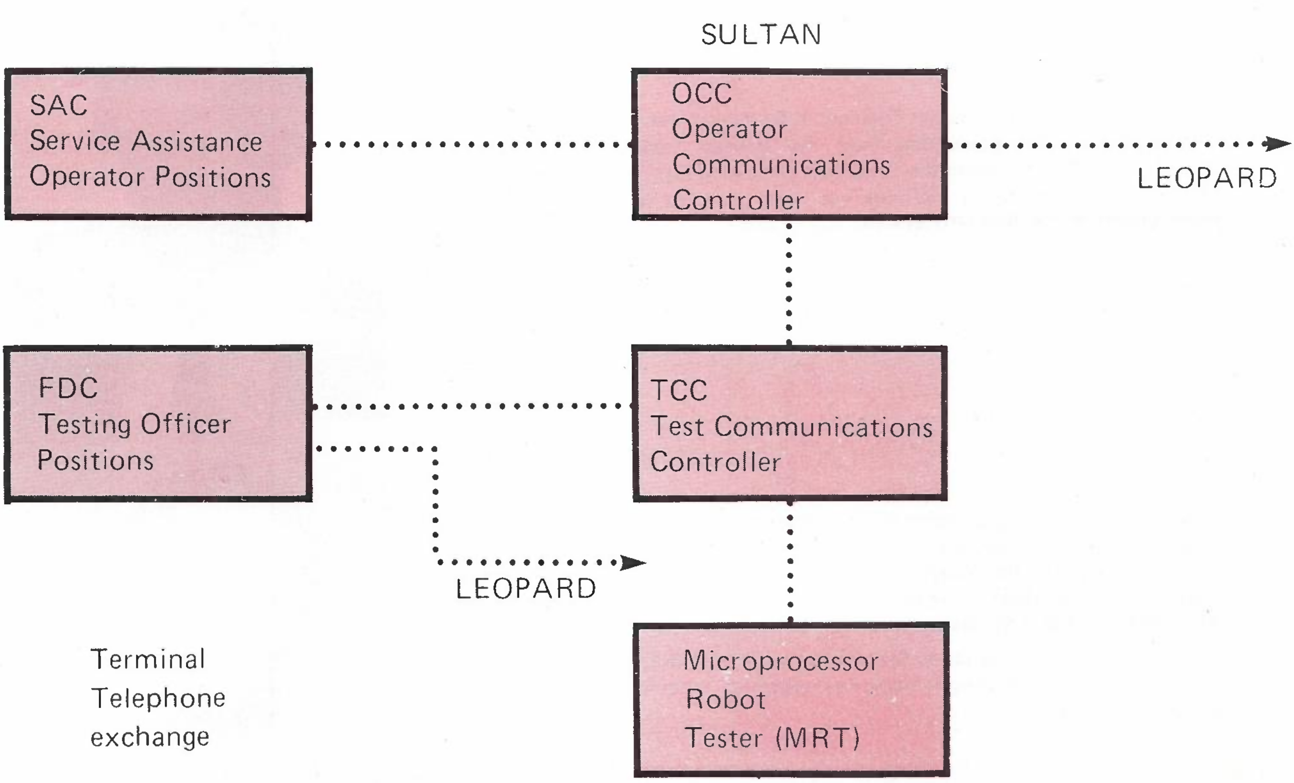


Fig. 1 SULTAN System Hierarchy

Micro-processor Robot Testers

The SULTAN Micro-processor Robot Tester (MRT) is a new Robot Test device specifically developed for the SULTAN system to test customers lines. In addition, several older style testers are also incorporated into the SULTAN network. The robot testers are located at the terminal telephone exchange with direct metallic access to the customer's line pair.

Testing Officer Positions

Each testing officers position is equipped with two VDU terminals. The SULTAN terminal has a custom designed keyboard including function keys for each available test. Facilities available to the testing officer include tests of the electrical characteristics of the customer's line, the ability to ring and speak to the customer, and to perform dial testing. The other terminal is connected to the LEOPARD (Local Engineering Operations Processing Analysing and Recording of Data) system and operates completely independent of the SULTAN system. LEOPARD is an on-line customer records data base with customer report handling functions.

Service Assistance Operator Positions

Each operator position is equipped with a VDU connected to the OCC by a direct data link. The same VDU is used for LEOPARD and SULTAN communications. The OCC examines all operator transactions and routes LEOPARD transactions accordingly.

TEST FACILITIES AVAILABLE TO THE TESTING OFFICER

SULTAN TEST REPERTOIRE

Facilities available to the testing officer include tests of the electrical characteristics of the customer's line, the ability to ring and speak to the customer, and to perform dial testing.

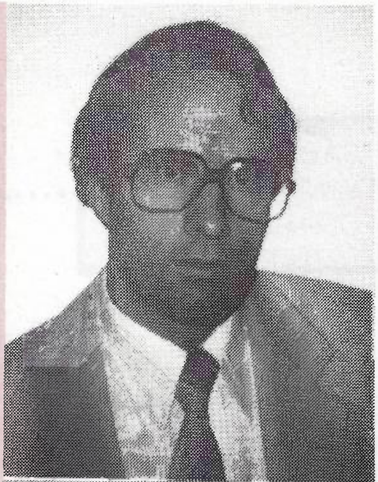
Most SULTAN tests are available in three alternative modes, (single, direct or block). These can also applied with the line reversed. **Table 1** lists the tests available and indicates the modes available for each test.

TEST RESULT DISPLAY MODES

Single Reading

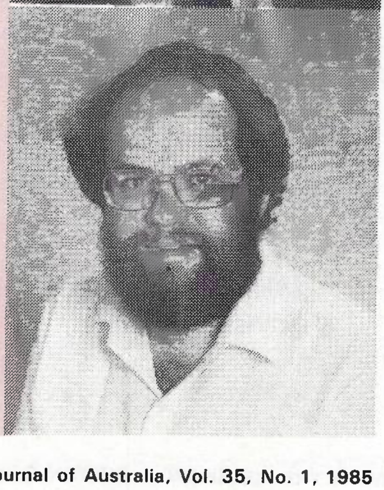
In the single reading mode individual readings recorded by the MRT are decoded at the TCC and displayed as a single result indicating the value at the time of the reading. In this mode the MRT records twenty individual readings over a period of 1 second. When the results are received at the TCC a graphical display is presented to the Tester. A special case of the Block reading is the Resistance Capacitance test.

JOHN McINTYRE 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.



DAVID BELSHAW graduated in 1970 from the University of Sydney with a honours degree in Electrical Engineering. After two years Army National Service he joined Telecom Headquarters in 1973. He spent six years in Switching Design Branch working on specification and approval of new designs for the ARF, ARE-11 and AXE systems.

In 1979 he was appointed to Section Manager Trunk & Exchange Control No. 2 Section (then Circuit Design) which has responsibility for all design aspects for the SULTAN system.



Direct Indication

In the direct indication mode the MRT continues to take readings from the line every 200mS. After each second the five previous readings are packaged up as a result message and returned to the TCC on the next poll request. The TCC displays the results as a bar graph updated 5 times per second, simulating an analogue meter display. On completion the next five readings are processed.

	MODES			Line
	Single	Block	Direct	Reversed
Package Test	X			
Foreign battery test	X	X	X	X
Low Resistance	X	X	X	X
Low Resistance to Ground	X	X	X	X
Resistance (Capacitance)	X	X	X	X
Resistance to Ground	X	X	X	X
Insulation Resistance (240v)	X	X	X	X
Insulation Resistance to Ground	X	X	X	X
Open Circuit test	X			
Speak				X
Ring Pulse then Speak				X
Interrupted Ring then Speak				X
Monitor (no ring or feed current)				X
Decadic dial test				X
VF dial test				X
Get and Break dial tone test				X
Apply howler				X
Private control — restore exch line				X
Selector Release (SxS exchanges only)				

Table 1. Sultan Tests

SULTAN package test

The MRT package test is used primarily by the SAC operator but may also be requested by the Testing Officer. This is a pre-programmed sequence of tests including examination for AC and DC voltages on both wires and a combined resistance/capacitance test on each wire.

SULTAN TEST COMMUNICATION CONTROLLER (TCC) STRUCTURE

The SULTAN system has been developed using modular techniques. The TCC is based on the application of a minicomputer and the major subsystems in the TCC are illustrated in **Fig 2.** Communication between these are carried out by software signals via the minicomputer operating system. For external devices, similar signals are used, with the operating system communicating with the required computer peripheral, and other external devices. Special hardware has been developed to interface with the Telecom network.

Testing Officer input transactions are entered via VDUs and handled by the Test Desk Request subsystem. When a number to be tested is received from a VDU the Translation subsystem determines the test robot to be employed. Control is then passed to the Call Handling, or MRT subsystem, to access the appropriate robot tester, and subsequently the customers line.

Where an MRT is involved, the Testing Officer enters the tests to be carried out, which are encoded into the appropriate MRT test code, and transferred to the MRT via the MRT subsystem. On receiving the results from the MRT at completion of the test, the Test Desk Request subsystem decodes and displays the results on the Testing Officer's VDU.

For the older style tone robot testers, the Call Handling subsystem sets up a Voice Frequency link via the Public Switched Telephone Network. The Testing Officer can then listen to the test results which are indicated as various tones.

Test Desk Subsystem

The Test Desk Request subsystem controls the overall access and test sequence, and interworks with other subsystems as appropriate.

This subsystem is also responsible for:

- the handling of all input transactions
- the formatting of screen displays
- the encoding of the requested test into the appropriate MRT test code.
- the decoding of test results and conversion to actual resistance, voltage or capacitance readings.

MRT Subsystem

The MRT subsystem is responsible for the allocation of the MRTs, their general supervision, and controls the data communications protocol with the MRTs. Where multiple MRTs are available in an exchange the allocation techniques ensures that where possible each subsequent test will employ a different MRT. In this manner MRT are loaded equally and, where a testing officer suspects that the result is incorrect, they can repeat the test using a different MRT.

The MRT data communications protocol, which is explained in the accompanying MRT article, serves two main functions:

- it provides parity and check sum validation of data transmitted to and from the MRT, with re-transmission in the event of an error.
- it allows up to eight MRTs to be connected on a multidrop data circuit.

Translation Subsystem

The Translation subsystem is used to determine, from the number entered, the following information:

- the type of robot tester (ie. MRT etc)
- the method of access to the robot tester (ie. dedicated link, PSTN)
- the PSTN access number or MRT data address.

This translation data is individual to each site and is prepared by the Administration using specially developed software utilities.

Call Handling Subsystem

The Call Handling subsystem is responsible for the control of the telephone network interface hardware. It is employed on all tests that require access through the

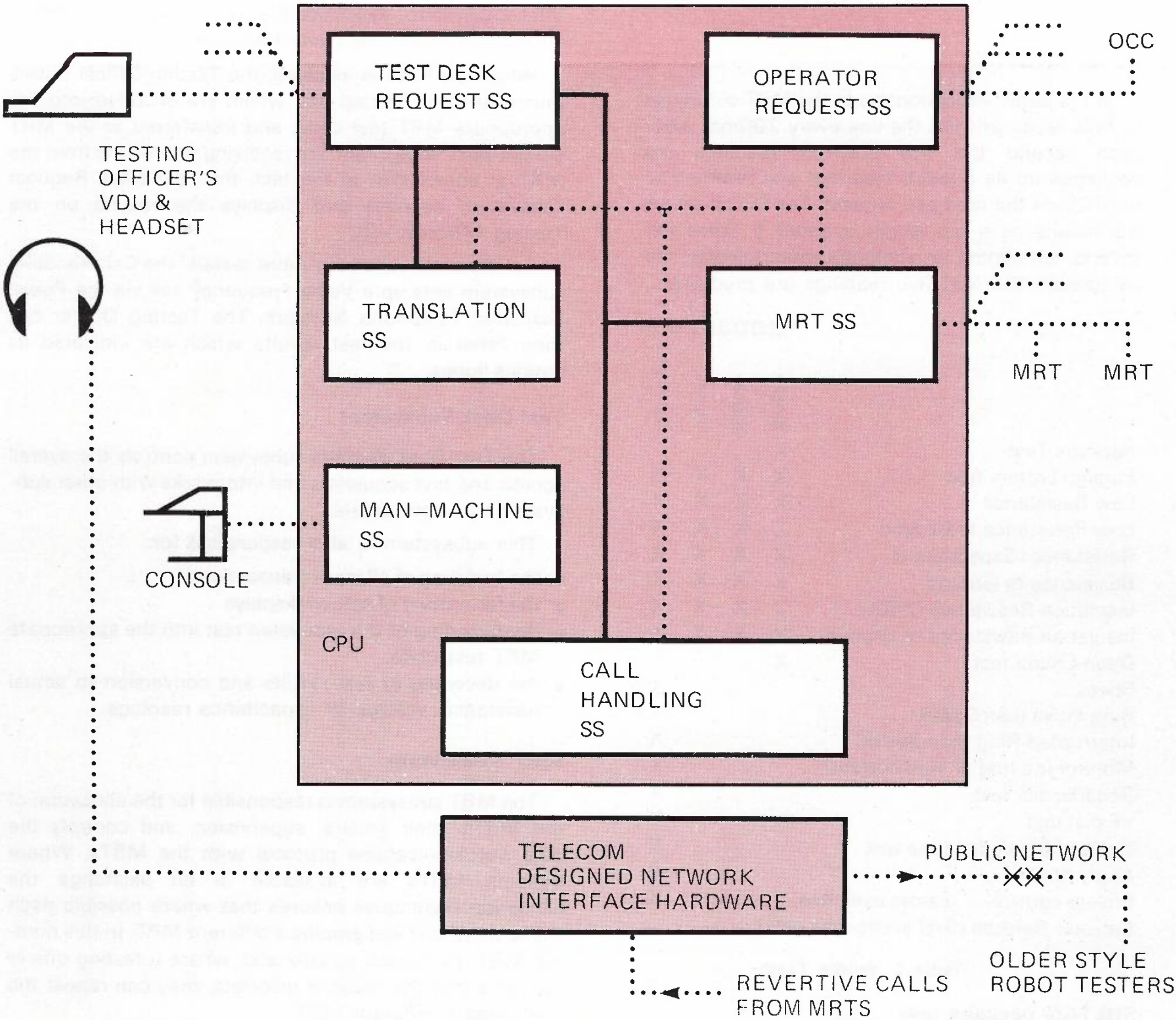


Fig. 2 Major TCC sub-systems

Public Switched Telephone Network (PSTN), and terminates the revertive call from MRTs. The main call handling software module is supported by other software modules responsible for each aspect of the hardware (eg. Senders, Relay drivers, Selector stage etc.) Hardware aspects are covered later in this article.

Man-machine Subsystem

The Man-machine subsystem allows system maintenance staff to enter commands to examine and modify data at the OCC or TCC. Man-machine commands may be entered directly at the console device. System command files may be created that are executed each time the system is restarted. These files are used to correctly initialise the TCC.

The following examples are typical man-machine commands:

SUL TRN 03/LI
List out the translation data for the 03 STD area.

SUL TRN 03,555,MRT,34 /IN
Insert robot tester 34 to serve the prefix 555 in the 03 std area.

SUL ROB /LI
List the status of robot testers.

SUL CH /LI
List the status of the user channels.

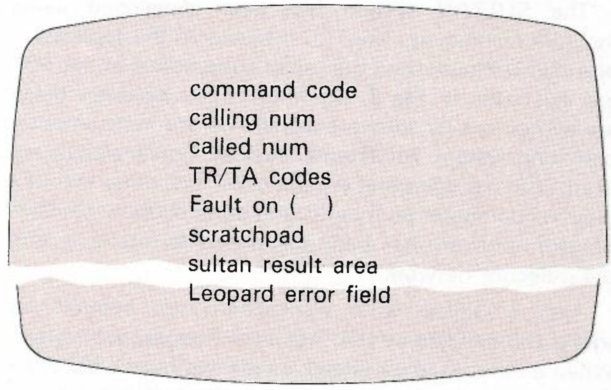


Fig 3. SAC Operator data entry form

FUNDAMENTALS OF SUBSCRIBER LINE TESTING

The ability to connect a measuring device across the line and to observe the readings is fundamental to Subscriber line testing. This implies that:

- The switching equipment must be capable of switching a direct metallic connection between the test access point and the line under test. This connection must be free of all other impedances and the usual transmission feed circuits. With digital switch blocks this connection is usually established by way of a separate test bus.
- The measuring equipment must be either located at the test access point and the results transmitted to the testing officer, or the test access point must be extended back to where the measuring equipment is located, via dedicated circuits to the central site. This latter approach was employed by previous testing networks whilst SULTAN employs remote robot test devices with transmission of test results to a central site.

A typical test on a subscribers service will check for:

- foreign potential on either wire.
- leakage to ground on either wire.
- leakage across the pair of wires.
- the presence of the 1.5 microfarad capacitor in the bell circuitry. This indicates that the telephone instrument is connected to the line.

The presence of the bell capacitor is usually observed from the current surge as the testing potential is applied, or reversed in polarity.

Further testing involves connection of a speech path to the subscribers phone with or without, ringing, or current feed potentials. The ability to test the telephone dial and to observe the progress of a call initiated by a subscriber is also required.

Pair Gain Systems etc.

With all pair gain systems, line concentrators etc, it is a requirement of the test equipment that the metallic path be provided to the line in question. A 200 mS break in line feed potentials has been selected as a standard signal to indicate the intention to perform a line test. On detecting this condition the line is metallically through connected and all parallel impedances are removed for a fixed time period. This same signal is used on all subscribers devices that employ batteries that are charged from line current.

SERVICE ASSISTANCE OPERATOR TEST FACILITIES

The SAC operator uses the same VDU to access LEOPARD and to perform SULTAN line tests.

To simplify data entry by the operator a form is displayed on the VDU. The operator fills in the details from the customer and then operates the SEND key to transfer the data to the computer. The form is illustrated in **Fig 3**.

The first four characters of all transactions from the VDU define a command code. This command code directs either LEOPARD or SULTAN to perform a particular function.

The operators use the following command codes:

- SRLT SULTAN — Request Line Test.
- SRCL SULTAN — Request Cleardown of test.
- LETR LEOPARD — Transfer Trouble Report.
- LETA LEOPARD — Transfer Technical Assistance report.
- LRSS LEOPARD — Request Service Status report.
- LRRF LEOPARD — Request Report Form to be renewed.

The Operator Message Switching subsystem examines the Command Code for each message and either transfers the message directly to LEOPARD for processing, or for SRLT, SRCL codes performs the appropriate SULTAN function. The SULTAN test result data is displayed to the operator as either a three character fault code for transfer to LEOPARD, or where operator interpretation of tone type test results is required, as a literal message.

SULTAN OPERATOR COMMUNICATIONS CONTROLLER (OCC) STRUCTURE

The OCC uses similar hardware and operating systems to the TCC. **Fig 4** illustrates the major subsystems in the OCC.

All transactions from the Service Assistance Operators are examined by the Operator Message Switching subsystem and directed either to the LEOPARD system or to the SAC Request subsystem for SULTAN test requests. Incoming messages from LEOPARD are passed directly to the operator's VDU.

For a SULTAN test the SAC Request subsystem obtains a translation on the entered customer's number from the Translation subsystem. The responsible TCC is identified by this process and a communication path set-up via the OCC/TCC Communication subsystem. A more detailed analysis at the TCC determines the robot tester type. Where access to a tone type robot tester, or the operators dedicated network is required, the TCC instructs the OCC to perform the access directly. In these cases the Call Handling subsystem initiates the connection. A VF line to the Operator's headpiece is provided via the Interface hardware. Test results are heard as tones.

For MRTs, the TCC carries out a line test and passes back the results to the OCC, where the SAC Request subsystem analyses them and displays a simplified three letter code to the operator, or a status message.

Operator Message Switching Subsystem

The Operator Message Switching (OPMST) subsystem controls the data circuits between the SAC operator VDU's and the LEOPARD processor. This subsystem directs all incoming messages either to LEOPARD or to the SAC Request subsystem. All LEOPARD transactions are passed in a transparent mode, and all incoming messages from LEOPARD are passed directly to the operator's VDU. SULTAN messages displaying test results or status data are also transmitted to the VDU.

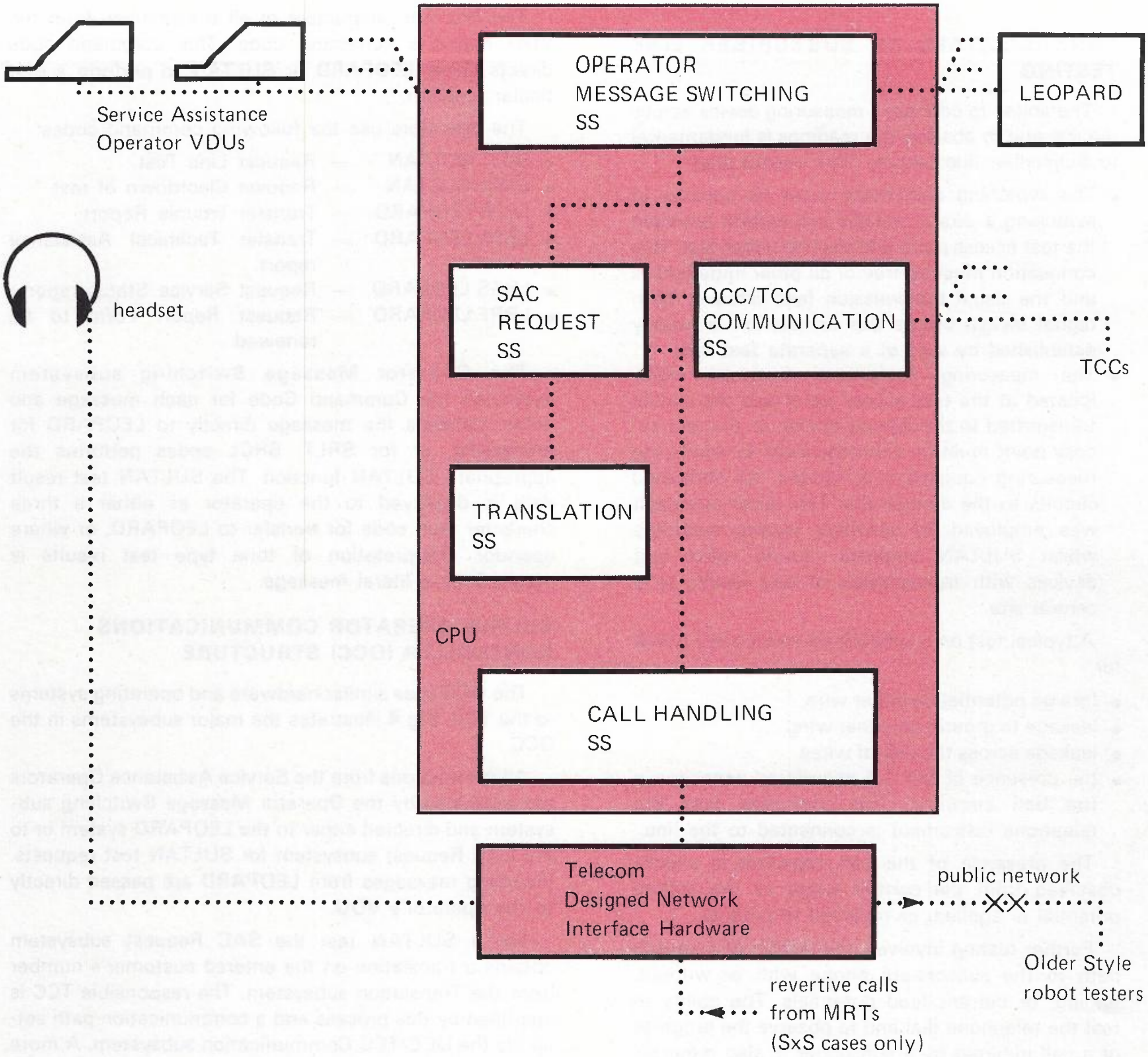


Fig. 4 Major OCC Subsystems

Fig 5 illustrates the components of the Operator Message Switching Subsystem.

SAC Request Subsystem

This subsystem controls the SULTAN line test process for all SAC operator test requests. On receiving a test request it asks for a number translation from the Translation subsystem and then accesses the appropriate TCC. Test results returned to this module are passed on to the operator through the Operator Message Switching subsystem.

Translation Subsystem

At the OCC translation is performed on the first five digits of the national number. (i.e. The O of the STD code and the next four digits). This translation process provides either:

- The number of responsible TCC and data port numbers.
- An indication that the number is to be tested via the older operators Doesn't Answer (DA) test network.
- An indication that test access to the number is unavailable.

Further translation at the TCC allows more detailed resolution of the test access facilities.

Call Handling Subsystem

The Call Handling subsystem in the OCC is similar to that used in the TCC but includes extra software and hardware to allow up to thirty operators to share the ten available hardware channels.

OCC-TCC Data Communication Subsystem

The OCC-TCC Data Communications subsystem allows data to be transferred reliability between the OCC and the TCC.

- A direct data path is provided between each OCC and the TCCs within the OCC's area of responsibility. The

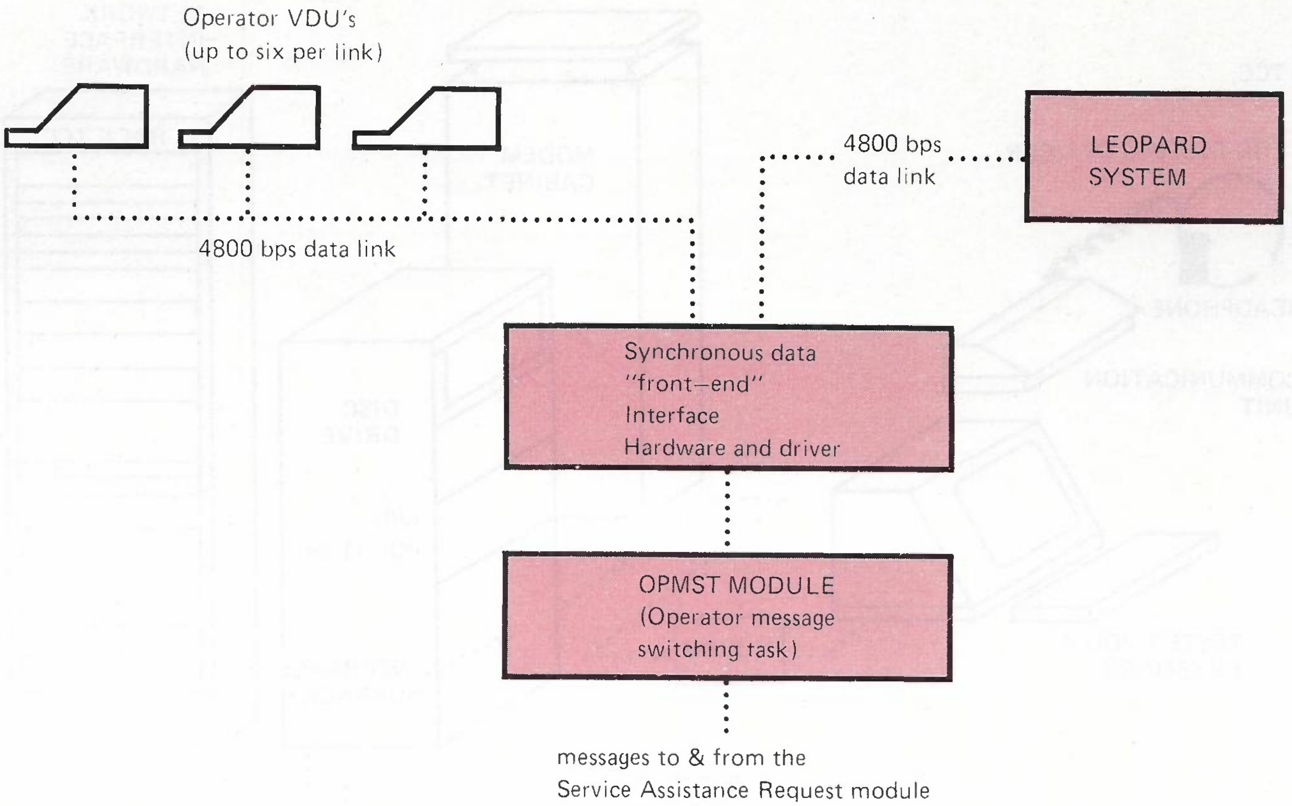


Fig 5. Operator Message Switching Subsystem

resulting "mesh" network is effective in metropolitan installations as TCC and OCC processors are usually co-sited in a small number of locations.

- Duplicated 1200 baud asynchronous circuits are usually provided to each TCC for reliability. However, a single circuit can handle the traffic volumes.

The structure of each message is similar to the MRT protocol; however, both the TCC and OCC may initiate messages. Each message contains a packet address defining the related user channels at both the OCC and TCC. Control of the data circuits is achieved by the use of control messages to "open" and "close" the data link. The OCC/TCC messages involved in a normal test call are shown in **Fig 6.**

SULTAN HARDWARE

Microprocessor Robot Tester

The MRT consists of a card shelf that may accommodate one or two robot tester units. Each MRT consists of eight printed board assemblies (PBAs). Extra PBAs are utilized to provide functions unique to particular exchange types. A separately mounted modem provides the data communications. The MRT interfaces to the exchange switching equipment through similar test interface circuits to those employed by local test desks.

Access to the MRT is either through a dedicated multi-drop 1200 baud asynchronous data network, or by a dial up 300 baud data circuit.

The MRT is also connected to an outgoing exchange line. Where speech transmission is required between the MRT and the TCC, the MRT establishes a ringback call to the TCC via this line.

A more detailed description of the MRT is contained in the accompanying article.

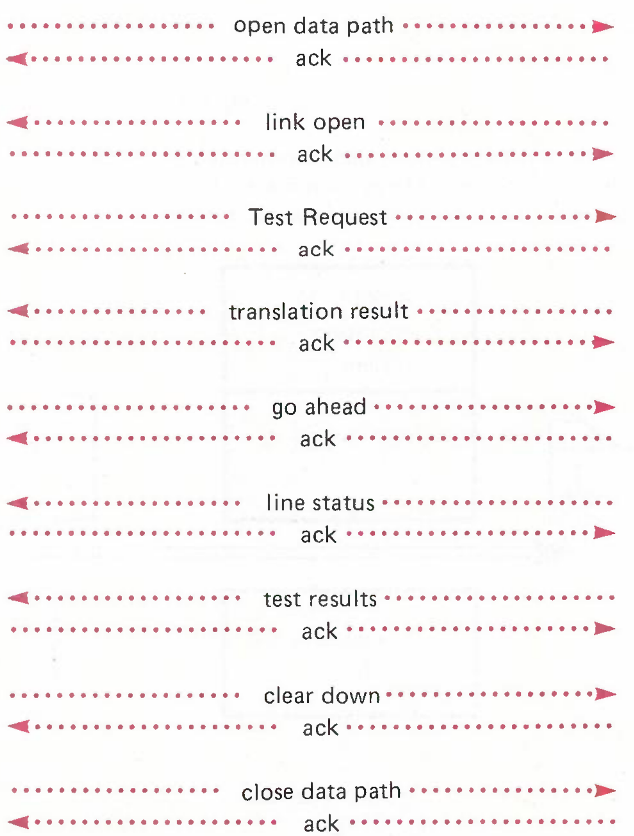


Fig 6. OCC-TCC Data Protocol

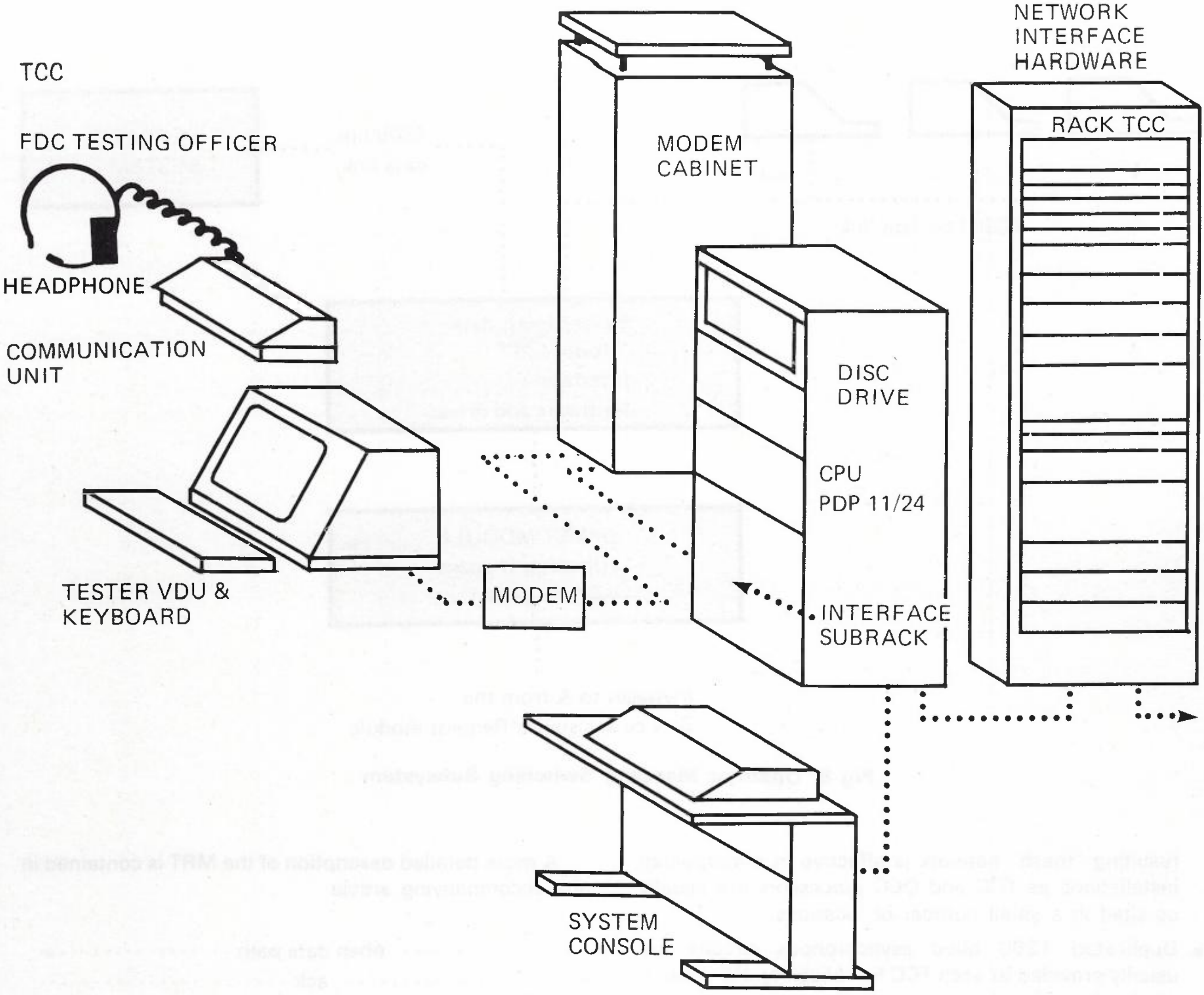


Fig 7. TCC processor, rack, and modem cabinet.

The SULTAN system also incorporates older style tone type robot testers. These robots are used in the smaller crossbar and step by step rural exchanges.

For SAC operator testing, the existing decadic style test network and it's simple pass/fail testers will continue to be utilized until SULTAN is fully implemented. The

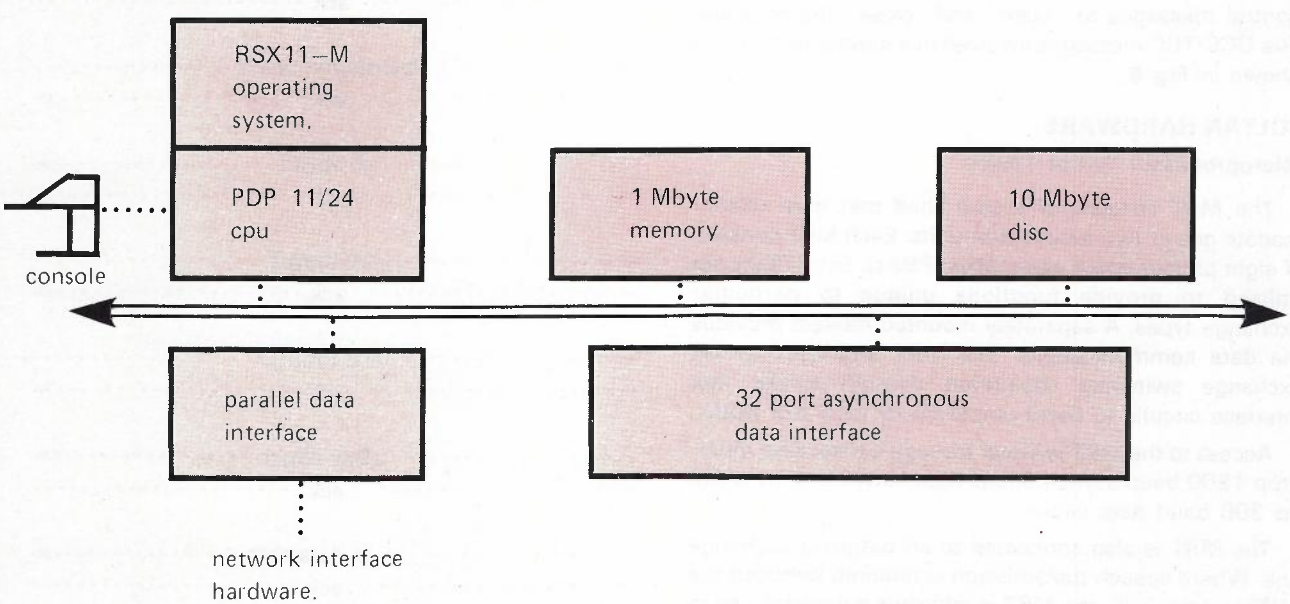


Fig 8. TCC computer configuration.

OCC interworks with this network, older style tone type testers or TCCs as appropriate.

TCC Equipment Configuration

The TCC consists of a Digital Equipment Corporation (DEC) PDP11/24 minicomputer running under the RSX11-M operating system and interconnected with a rack of TELECOM designed interface equipment and a network of data circuits. **Fig 7.** shows a typical TCC configuration whilst **Fig 8.** illustrates the processor configuration.

A TCC can be dimensioned for up to:

- Eight testing officer's VDUs.
- Ten MRT links with up to eight MRTs per link (total of eighty dedicated link MRTs).
- Six sender devices for access to the older style robot testers.
- Eight links from associated OCCs. (May be increased if required).
- An incoming dial up data link. (Used during MRT installation testing and for general maintenance).

The 10 Mbyte disc is a cartridge type and is used for transfer of the operating system, application programs and data to the TCC. The 32 line asynchronous interface supports the data circuits to the Tester VDUs, the MRTs and the OCC-TCC links. The 16 bit parallel interface is used to control the Network interface hardware.

OCC Equipment Configuration

The OCC is similar to the TCC design. Basically the same processor configuration is employed with a second cabinet added to include an extra disc drive and a "sixteen line synchronous data interface." This synchronous interface provides the data communications with the LEOPARD system and the operator VDU terminals. The extra disc drive is included to backup the storage of traffic statistics. **Fig 9.** shows an OCC installation whilst **Fig 10.** illustrates the processor configuration.

An OCC may be dimensioned to support up to:

- Thirty operator VDUs (Five links with up to Six VDUs each).
- Six sender devices for access to the older test equipment.
- Twenty direct data links to dependent TCCs. (This may be increased).
- An incoming dial up data link used for maintenance and support.

Network Interface Hardware

The SULTAN TCC and OCC hardware, which is part of the Call Handling subsystem module, is designed to provide control and access into the public switched telephone network (PSTN), and the older operators dedicated test network.

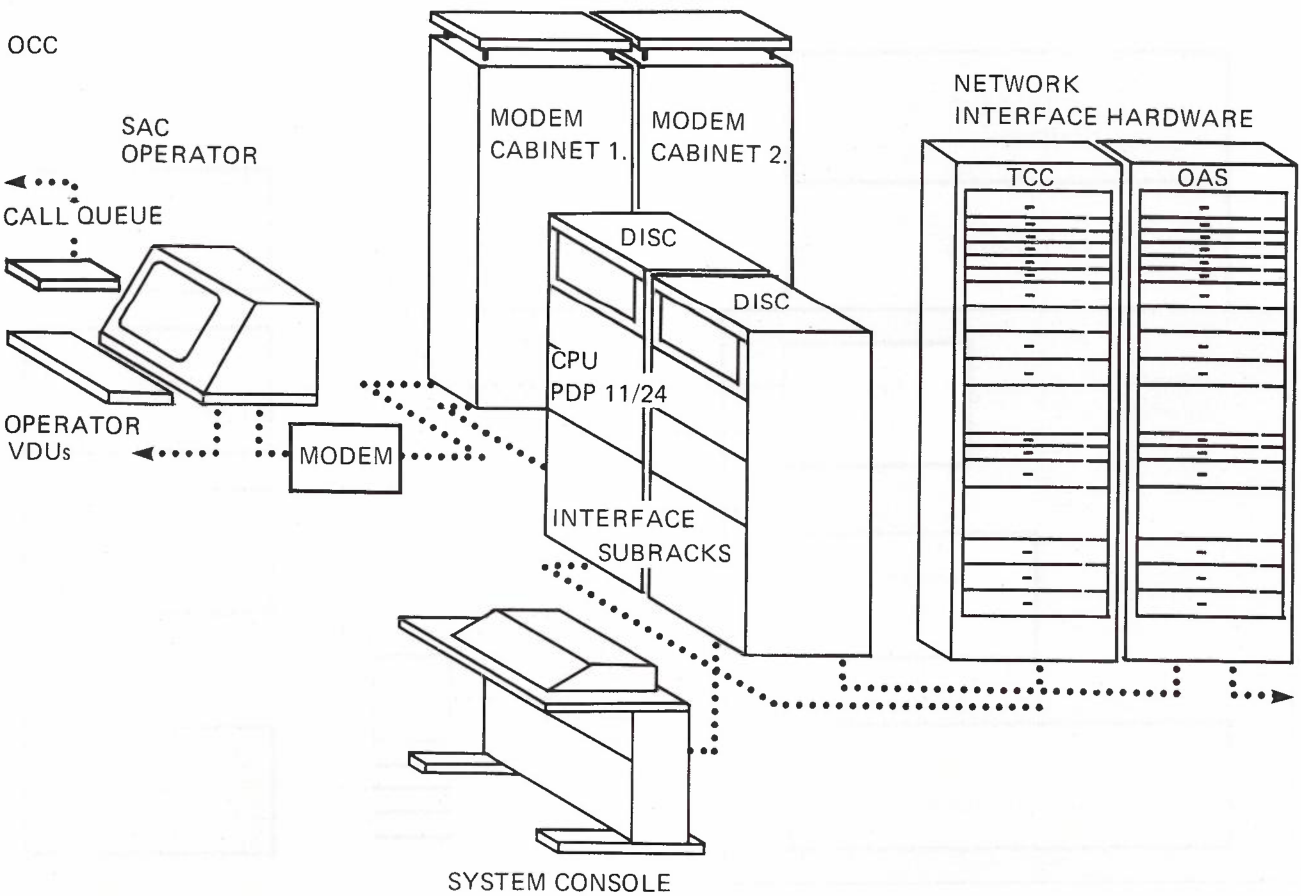


Fig 9. OCC equipment

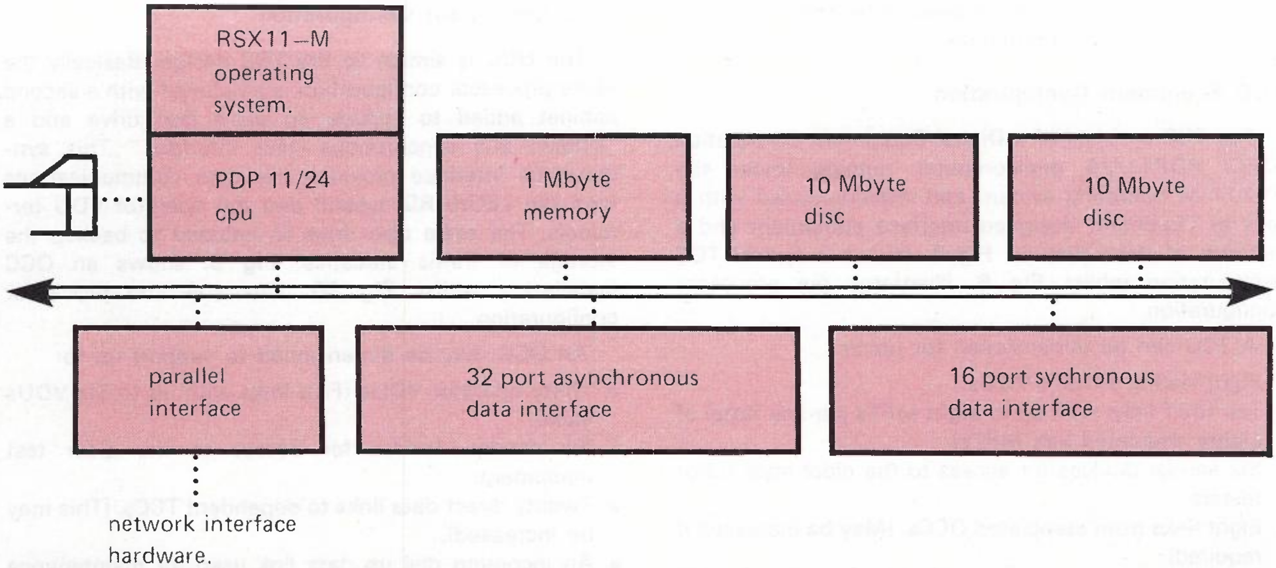


Fig 10. OCC computer configuration.

This hardware, which is used in both the OCC and TCC, consists of a rack of crossbar type relay sets under control of the PDP11 processor. The OCC contains an extra rack that enables 30 operators to share the use of the ten circuit channels provided by the standard rack. **Fig. 11** shows the hardware elements of the Call Handling subsystem.

The Selector stage allows any of the ten interface channels to be connected to an appropriate sender from the pool. Various sender types allow:

- Loop disconnect decadic impulsing.
- Dual Tone Multi Frequency (DTMF or Touchtone) dialling.
- Tone modulated decadic impulse signalling.
- Tone pulse signalling.
- 300 baud full duplex data communication.

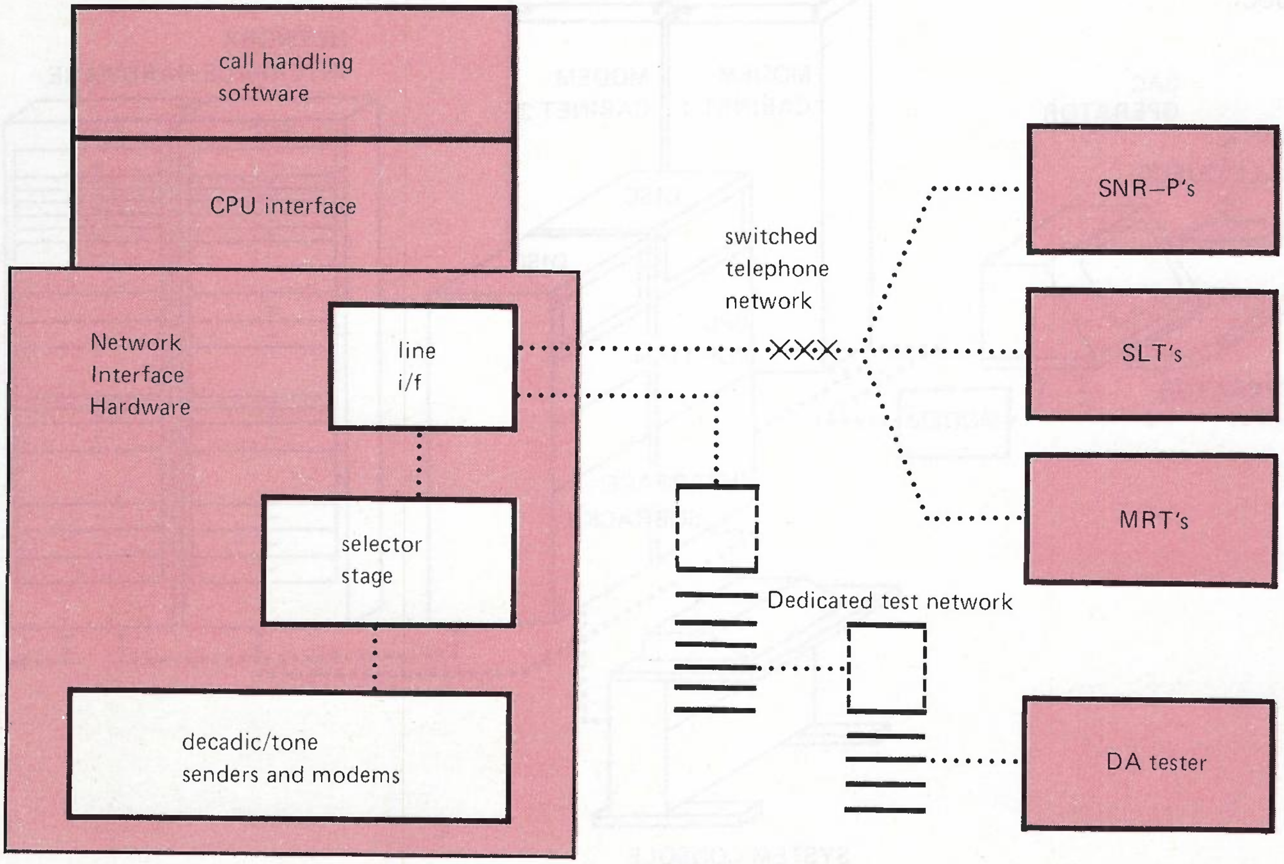


Fig 11. Call Handling Subsystem

CPU Interface

The CPU interface allows the CPU to operate and release relays, via relay drivers, and to test the state of various wires.

The SULTAN hardware allows up to 15 metres of cable between the CPU cabinet and the hardware rack, achieved by using an intermediate signalling voltage of 15 Volt and "contact bounce eliminator" Integrated Circuits. In this way it is not necessary to either bring noisy 50 Volt relay wiring into the CPU cabinet or to bring the sensitive 5 Volt wiring out to the rack. This provides good noise immunity without the need for the more conventional balanced line driver circuits, and the associated doubling of the wire count.

SOFTWARE DESIGN APPROACH AND THE USE OF SDL IN SULTAN

SDL (CCITT System Description Language) has been used in SULTAN both as a system design and coding tool, an as an aid to documentation. To best utilize SDL, some aspects of the formal SDL have either been modified or not employed in the SULTAN application. The pictorial elements denoting the various call state conditions, for example, are not relevant to the SULTAN application and have not been used.

Each program module in SULTAN is specified in terms of dormant wait states, input signal events, and transitional activities. SDL allows these dormant states to be identified and documented along with the various input signals at each state. From the SDL diagrams it is then possible to compile a list itemising:

- Each state.
- The list of possible input signals at each state.
- The list of software routines corresponding to each of these state/signal combinations.

TABLE 2 is an example of a simplified control table for an individual module (Test Desk Request Subsystem) and **Fig. 13** shows the corresponding SDL for one of the states.

STATUS	MESSAGE	Program Subroutine
1 (Idle)	Input characters	Request password
1 (Idle)	Release key	Ignore
2 (Password)	Input characters	Check password
2 (Password)	Release key	Ignore
2 (Password)	Log off key	Return to Idle
3 (Number)	Input characters	Process number
3 (Number)	Release key	Ignore
3 (Number)	Log off key	Return to Idle
4 (Transl'n)	Input characters	Ignore
4 (Transl'n)	Release key	Cleardown
4 (Transl'n)	Log off key	Ignore

TABLE 2. CONTROL TABLE (simplified)

It should be noted that the discipline of SDL allows the designer to deliberately address every possible condition. This methodology eliminates unwelcome 'surprises'.

A typical call through either an OCC or TCC can be broken up into a number of small steps interspersed with waiting delays. In a real time system the processor continues with other available work during these waiting states. Each program in SULTAN consists of three parts:

- The control section.
- The state control table.
- A number of short subroutines for each step.

The actual execution of the program is carried out one subroutine at a time as the call progresses from one waiting state to the next. During waiting states the CPU will perform processing for other calls. The programmer is able to consider each subroutine independently; coding it to accept input information, do the required process, and set up the input conditions for the subsequent state.

Data areas are used to record information specific to a particular user. In the OCC there are thirty such areas, (one per operator VDU); whilst in the TCC eight are used for Tester positions and ten are used for incoming

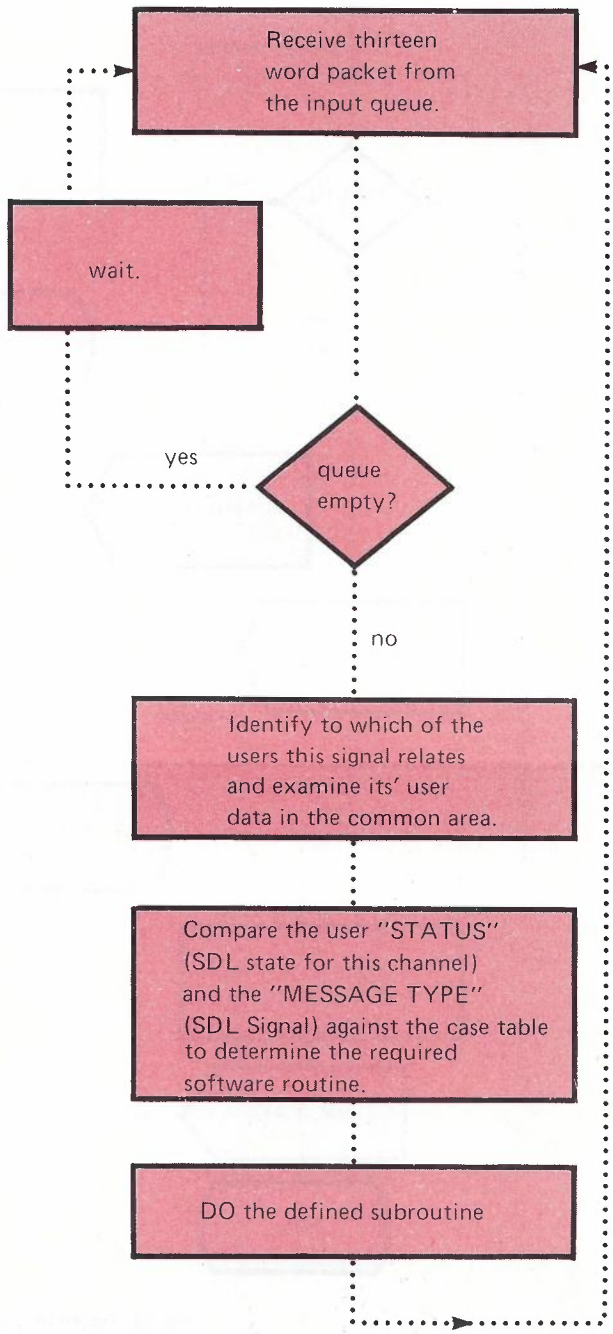


Fig 12. Control sequence used in SULTAN modules

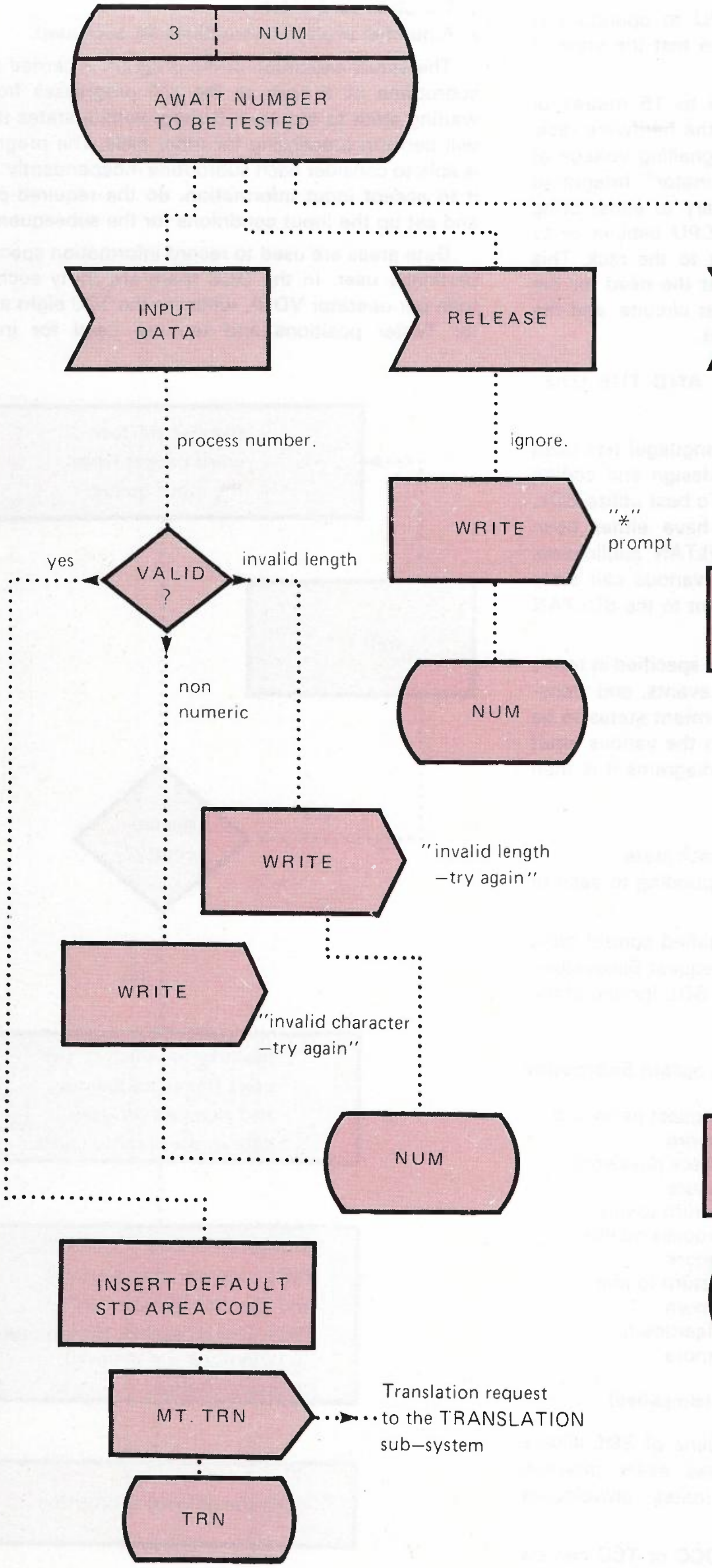


Fig 13. Detailed SDL for "NUM" state

requests from the OCC. Extra data areas are used for man-machine and maintenance functions.

Fig 12. shows the control sequence employed within each program module to determine the process (i.e. sub-routine) required.

INTER MODULE SIGNALS AND COMMON DATA AREAS

For the transfer of data between modules the SULTAN OCC and TCC software makes use of the Send Receive data packets and common data areas. The use of common data areas, whilst seen as a compromise to the integrity of the modularity, allows higher efficiency in transferring data. The common areas also allow the use of powerful debugging tools to monitor the progress of a call at each step. One such debugging tool dynamically displays on a VDU all the data associated with a call.

Common data areas are employed for:

- The translation data.
- The common data associated with each user including the number to be tested, current user STATUS (SDL state), senders, and other hardware employed.
- The Sender hardware control data.
- The status of OCC/TCC and MRT data circuits.

As each signal event occurs within the system various modules are notified by data packets passed from one module to another. These packets are passed by means of a facility within the operating system that can transfer up to thirteen words of data. SULTAN uses two of these words to identify the channel whilst a third defines the message type. The remaining ten words contain parameters specific to each message type.

CONCLUSION

Telecom Australia employs a wide range of exchange equipment which prior to SULTAN provided limited facilities for subscriber line testing. The SULTAN network has been developed to provide an enhanced testing network based on a specially developed MRT, but also employing the older style test robots, and using minicomputers as the controllers for the test access requirements of Service Assistance and Testing Officers. The cutover of TCC and OCC sites commenced in 1983 and on the completion of implementation SULTAN will provide a single standard national system for the testing of subscribers' lines.

Wherever possible the design of SULTAN has applied the concepts of modularity. The hardware has also been designed to allow maximum flexibility for future developments. Through these design techniques, new developments are being incorporated into SULTAN allowing it to evolve along with the changes that are occurring throughout the Telecom network. Current design enhancements to the SULTAN system include the introduction of dial up MRTs, integration with the AXE switching equipment, and adaption for a more distributed environment. (eg. rural areas.)

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NEW RESEARCH HEAD FOR TELECOM

Telecom Australia's new Director of Research is Mr. Harry Wragge. He replaces Mr. Ed Sandbach who retired recently. Announcing the appointment, Telecom's Chief General Manager, Mr. Mel Ward, said that Mr. Wragge was ideally suited for the position because of his depth of experience in telecommunications research both within Australia and overseas. Mr. Ward said that Mr. Wragge was widely experienced in advanced telecommunications and has represented Australia at the International Telecommunication Union and a number of major international telecommunications forums. Mr. Wragge, who had been Assistant Director, Business Development since 1983, is 54.

He began his career as a Cadet Engineer in the then PMG Research Laboratories in 1955, is a Bachelor Electrical Engineering (Melb) and a Master of Engineering Science (Melb). His last position in Telecom's Research Laboratories was as Assistant Director, Customer Systems and Facilities. As Director of Research, Mr. Wragge will be responsible for Telecom's Research and Development program valued this year at $29 million.

Mr. Wragge was the foundation Editor-in-Chief of the Australian Telecommunication Research (ATR) Journal, a sister publication of this Journal.

BOOK REVIEW

ECONOMIC ANALYSIS OF TELECOMMUNICATIONS. Theory and Applications Edited by L. Courville, A. de Fontenay and R. Dobell. North Holland Publishing Coy., 1983

This book has been compiled by the authors using a selection of papers presented to the Conference on Economic Analysis of the Telecommunications Industry in Canada in Montreal in March 1981. It covers a number of the contentious issues in the economic analysis of telecommunications with contributed papers by many respected industry and academic experts in North America. The stated purpose of the conference was to:

"take stock of past economic research into characteristic features of the telecommunications sector in Canada, to draw out the results of primary interest, and to link these to major questions of corporate management or public policy. The goal was to provide a careful appraisal of results to date, and a link to usable policy conclusions."

Basically the book is divided into three parts.

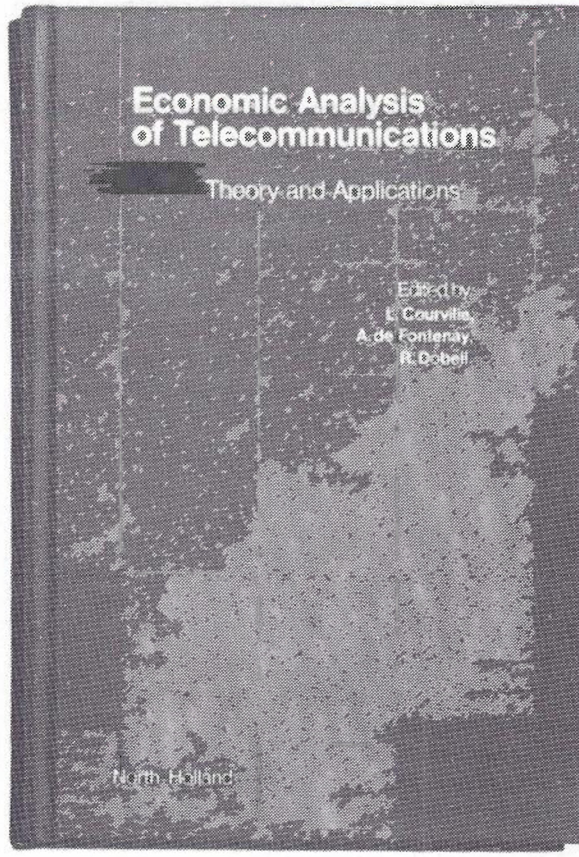
- PART ONE — PRODUCTION ANALYSIS deals with production conditions in the telecommunications sector. It covers statistical analysis of economies of scale and scope, productivity measurements and the use of such indicators by management.
- PART TWO — DEMAND ANALYSIS is devoted to the analysis of demand conditions in the telecommunications sector covering both local measured services and long distance services. It also includes a very useful analysis of different rate structures.
- PART THREE — WELFARE CONSIDERATIONS AND REGULATION explores the welfare implications of various pricing decisions and examines the relationship between regulation and investment decisions.

Econometric studies in the first part are virtually unanimous on the presence of economies of scale in major parts of the telecommunications network. It is perhaps unfortunate that a further paper was not available to draw out the implications of the recognition of economies of scale for economic theory especially in the context of the analysis of the telecommunications industry. Sharkey (1) has done this quite effectively in Chapter 9 of his recent book.

Other papers in the first part centre on the analysis of total factor productivity and the role productivity measures can take as part of the normal financial information systems. The management of all service sector organisations will find the concepts here of significant interest. There applications go further than providing background information; more recent work has shown that total factor productivity can usefully be applied in budgetary control and other areas.

The demand modelling papers cover a number of very interesting issues in this area. In this second part the papers begin to address a wider range of topics though, in some ways, the Australian reader may find the analysis of limited relevance because of the different regulatory and industrial structure environment.

This is even more of a problem in the papers presented in Part Three. However, readers should still be able to see some relevance in the papers in this part and the potential applications of the theories presented in the Australian context.



In a book compiled from papers submitted to a conference there is invevitably some lack of cohesion between sections. This problem appears to surface in later parts of the book where the broad relevance evident in the earlier articles gives way to some more theoretical and specific papers with more limited applications.

"Economic Analysis of Telecommunications" has much to offer a range of potential readers; managers and researchers, product forecasters, corporate planners and modellers, economists and others will find this book of considerable interest.

There is a message from this book. Having observed in this book the depth and breadth of economic research into the telecommunications industry in North America it is in contrast to note that a mere handful of worthwhile academic papers have been written in Australia over the last ten years in this area. This book contains a wealth of information on the potential applications and rewards of more in depth economic analysis of the telecommunications industry and other key service industries.

(1) W. W. Sharkey — "The Theory of Natural Monopoly" Cambridge University Press, 1982

Ray King
Chief Economist
Finance Directorate
Telecom Australia

The SULTAN Microprocessor Controlled Robot Tester

ROBIN M. CHRISFIELD

The SULTAN system (Subscriber Line Test Access Network), greatly depends for its success on the accuracy of the results obtained from the devices which test the customers' lines. This article describes the structure and general design principles of the Microprocessor controlled Robot Tester (MRT), which was developed by Telecom specifically for use by SULTAN.

THE SULTAN MICROPROCESSOR CONTROLLED ROBOT TESTER

The Microprocessor controlled Robot Tester (MRT) provides the interface between SULTAN (Subscribers Line Test Access Network) and the customer's line to be tested. The previous article, "Facilities and Operation of SULTAN — A Computerised Line Test Network for Telephone Lines" describes the general application of SULTAN. An accompanying article, "SULTAN System Description" explains in more detail the actual design and implementation of the SULTAN system.

BACKGROUND

When Fault Dispatch Centres (FDCs) were established, dedicated networks were introduced to provide access from central locations to the lines to be tested. However, the distances involved between the central test positions, and the terminal exchanges, made the test results less meaningful than those provided by the analogue exchange test desk.

Remote testing devices (eg. SNR-P) which are accessed via the Public Switched Telephone Network are also used to test lines from a central location, but the information sent back is limited to pass/fail type results using service tones.

The introduction of SULTAN brought with it the need for a remotely controlled device capable of performing all the functions of the local test desk plus some extra facilities. This device would be situated in the terminal exchange to avoid the inaccuracies introduced by testing over junctions.

Previously, conventional line testing tasks have been performed by connecting a voltmeter, with various calibration circuits, to the line under test, using manually operated keys. To reproduce these facilities, in a remotely controlled device, it was necessary to replace the keys with relays and solid state logic circuitry, and use data techniques for communication between the device and the testing officer.

The availability of microprocessors provided the ideal means of meeting these requirements and led to the design of the MRT. The relays which replace the test desk keys are controlled by the microprocessor, via suitable interface circuitry, and the voltmeter function is realised using an Analogue to Digital (A-D) converter. Communication between the MRT and SULTAN is carried out using data modems over a multi drop data link, with each MRT on the link having its own unique "call sign." Messages which are not prefaced by its own call sign are ignored.

The customer line to be tested by the MRT is connected by test access equipment similar to that used by the exchange test desk.

Because a data link is employed between the MRT and SULTAN an additional voice frequency link has to be established between the MRT and SULTAN to allow the tester to talk to the customer, if required. This link is established via the Public Switched Telephone Network.

MRT STRUCTURE

The MRT is designed to be a "dumb" slave to the SULTAN TCC and only carry out actions as directed. This keeps the controlling software simple, and minimises future changes to the MRT.

The functional structure of the MRT is shown in the block diagram, **(Fig 1.)**.

The structure is made up of the following functional "units":

- A Central Processing Unit which provides overall control of the MRT, the testing functions and setting up of speech connections between the customer and the testing officer.
- Measuring circuitry which measures the electrical characteristics of the line under test.
- Test configuration functions which apply the various circuit combinations to the line under test.
- Exchange interface functions which control the access equipment for connections to the line under test, and the setting up of the revertive call to the testing officer.

MRT FUNCTIONS

The MRT carries out controlled tests on the customer's line and sends the results to SULTAN for processing and display to the test operator. The available tests are based on those provided by the exchange test desk, but have been extended and enhanced to allow the

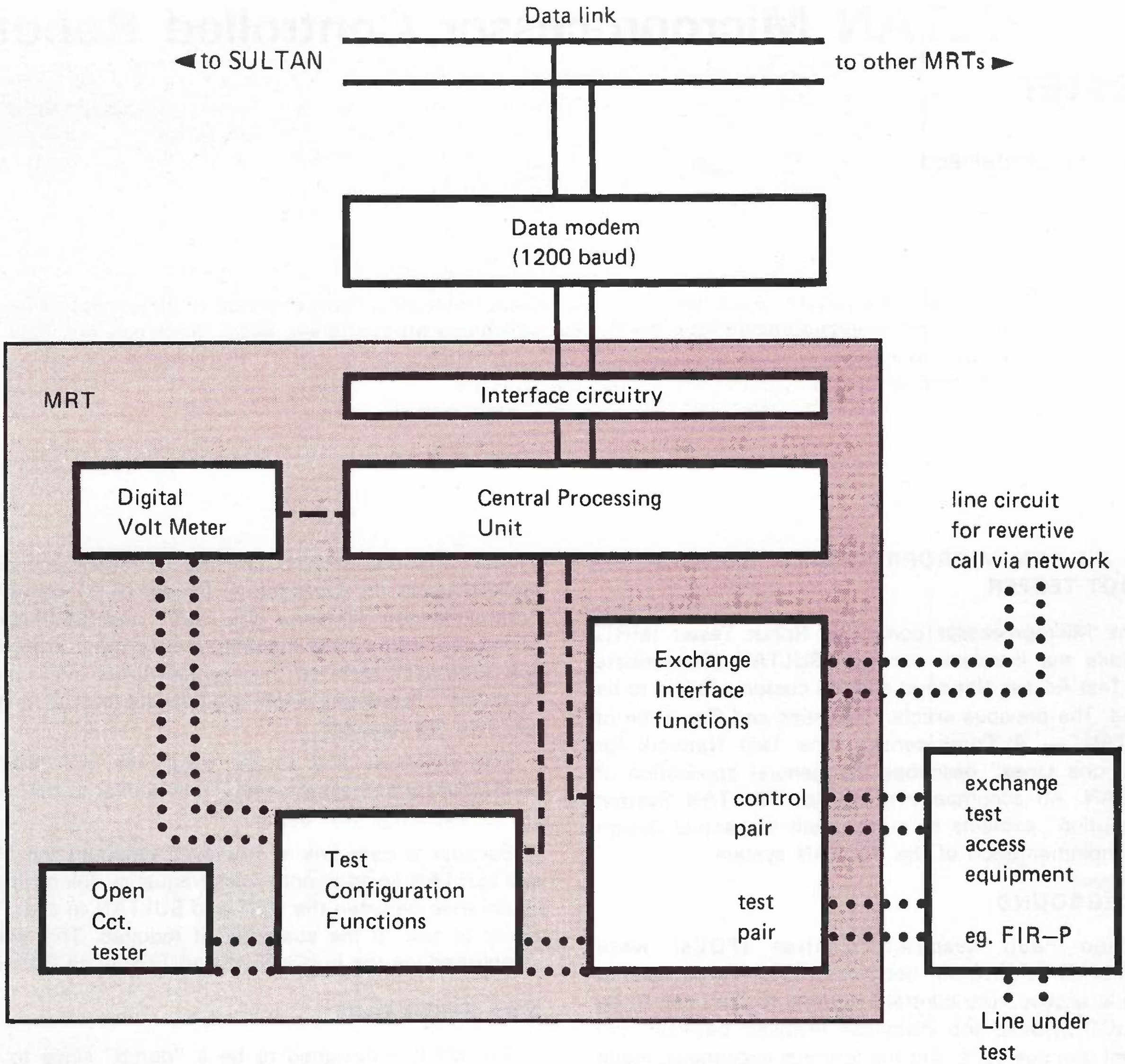
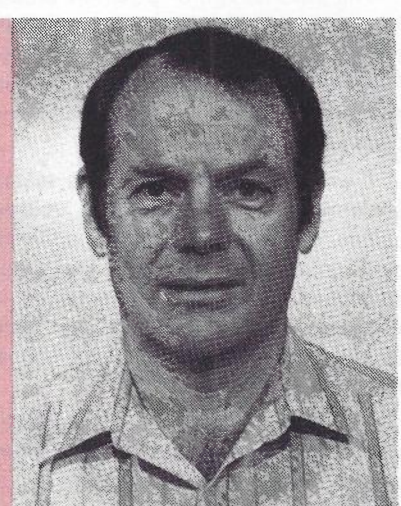


Fig. 1 - The MRT structure

- Unbroken lines indicate the data path between the MRT and SULTAN
- Dot-Dash lines indicate CPU control lines
- Dotted lines indicate metallic connections to the test line

ROBIN CHRISFIELD commenced with the PMG's Department in 1954 as a Technician-in-Training and worked on country and metro exchange installation in Victoria before joining Telecom Headquarters in 1969. He is currently a Senior Technical Officer in Switching Design Branch. He was part of the team which designed and developed the MRT and gratefully acknowledges the assistance of the other team members, David Weinstein (Engineer) and Andrew Morrison (Senior Technical Officer). He is presently involved with the ongoing design and field support aspects of the SULTAN system.



testers to make more effective decisions regarding fault diagnosis.

Many of these tests are done using a Digital Volt Meter (DVM) in the MRT. This is applied in various ways to measure the following electrical conditions of the line:

- DC voltage
- Resistance
- Low scale Resistance
- Insulation Resistance
- Foreign DC voltage
- Foreign AC voltage
- Capacitance

A "package," or combination test, is available which gives a general indication of the overall electrical conditions present on the line and requires a minimum of key strokes by the tester. This is the test performed on an idle line when a Service Assistance Centre operator uses the SULTAN system in response to a customer complaint.

Other tests which do not employ the DVM provide the tester with the means to:

- Verify that applying a loop to the exchange equipment connected to the line gives dial tone, and that opening this loop for a time period equivalent to a dial pulse results in removal of the tone.
- Ring and converse with the customer. The ring current and transmission current may be applied with the polarities of potential reversed for certain types of customer equipment.
- Return control over the exchange equipment to the customer, then monitor the line to check for correct operation or the availability of facilities such as STD and ISD access.
- Monitor a busy line to check for the presence of speech.
- Test that the pulses produced by the customer's dial are within prescribed limits.
- Accurately measure the distance from the MRT to an open circuit condition.

The Digital Volt Meter used for the main testing functions is a two and a half digit device (+/- 0 to 199), calibrated to give the full scale result at 60 volts DC, and clocked to perform conversions at 50 millisecond intervals. The results are converted to ASCII characters and transmitted to SULTAN.

Readings of the exchange battery voltage and the insulation test voltage (nominally 240 volts DC) are taken as the first test when the line to be tested is successfully accessed. SULTAN uses these readings for calibrating the results of the other DVM readings.

An area which causes significant problems when testing customer lines is the determination of whether an open circuit lies within the exchange or between the exchange and the customer's premises. As different skill groups are responsible for exchange equipment, external line plant and customer equipment, incorrect analysis results in double handling of faults.

Within the MRT, "special circuitry" has been developed to provide accurate indication of the open circuit's location. Part of this circuitry is an oscillator, the frequency of which is directly proportional to the capacitance of the line under test. The MRT counts the frequency at which the circuit oscillates and sends the result to SULTAN, where the line capacitance and distance to the point at which the line is open are calculated and displayed to the tester.

During each test the condition of the customer's line needs to be monitored to detect any change in line conditions. Electronic circuitry is used to detect direct current flow in the line under test. The output of this circuit is continually monitored and the state used for the following functions:

- To keep SULTAN informed of the loop condition of the test line
- To disconnect ring current should the line become looped (if ring was previously applied)
- To disconnect the howler when the loop is removed (if the howler was previously applied)
- To measure the pulses from the customer's dial during a dial test

MRT HARDWARE

The MRT is required to provide the test interface for the majority of telephone exchange types used by Telecom. The hardware employed must meet the standard enviromental and reliability requirements and, consequently, it was decided to use standard ARE-11 exchange type hardware. As new exchange types are introduced, evaluations will be carried out to determine the appropriate hardware to be used.

The hardware was structured to group common functions on individual boards to minimise interboard wiring, and to provide greater flexibility to cater for new requirements and changes in component technology. Because the MRT provides the interface between SULTAN and a number of different exchanges types the design is modular with particular interface cards for each exchange type.

The photograph of an MRT shelf **(Fig. 2)** shows the layout of the circuit boards. The main PBAs are:

- The Central Processor (CPU) board, this performs all of the controlling functions.
- The Digital Volt Meter (DVM) board, this performs the analogue to digital conversion, call sign decoding and RS232 interface functions.
- The Measuring board, this calibrates the DVM for the type of reading required and connects it to the line under test.
- The Ring trip board, this performs the "cord circuit" type functions such as applying ring current and transmission battery feed and monitoring the status of the line under test.
- The Impulsing board, this controls and monitors the exchange test access equipment to connect the line to be tested, and establishes the revertive call back to the tester.
- The Miscellaneous board, this contains +12v and -12v power supplies for the RS232 interface and the oscillator used in the open circuit location test.

Additional boards for exchange dependent functions are inserted as required, eg. the selector release board for Step by Step exchanges and the ARK exchange test interface access board.

An example of these cards, the CPU card, is shown in

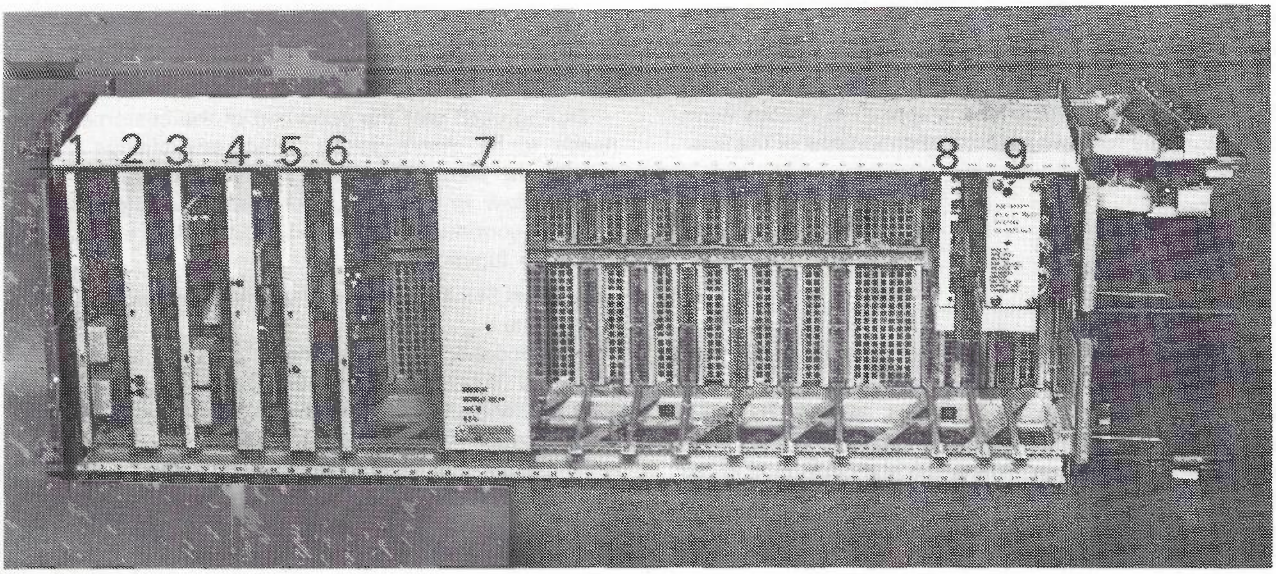


Fig. 2 - The MRT shelf with printed circuit cards mounted

The Card assemblies identified are:

1. Digital Volt Meter (DVM) Board
2. Central Processing Unit (CPU) board
3. Ring Trip board
4. Impulsing board
5. Measuring board
6. Miscellaneous board
7. Selector release board
8. -50v to +5v DC-DC converter
9. 5 volt regulator

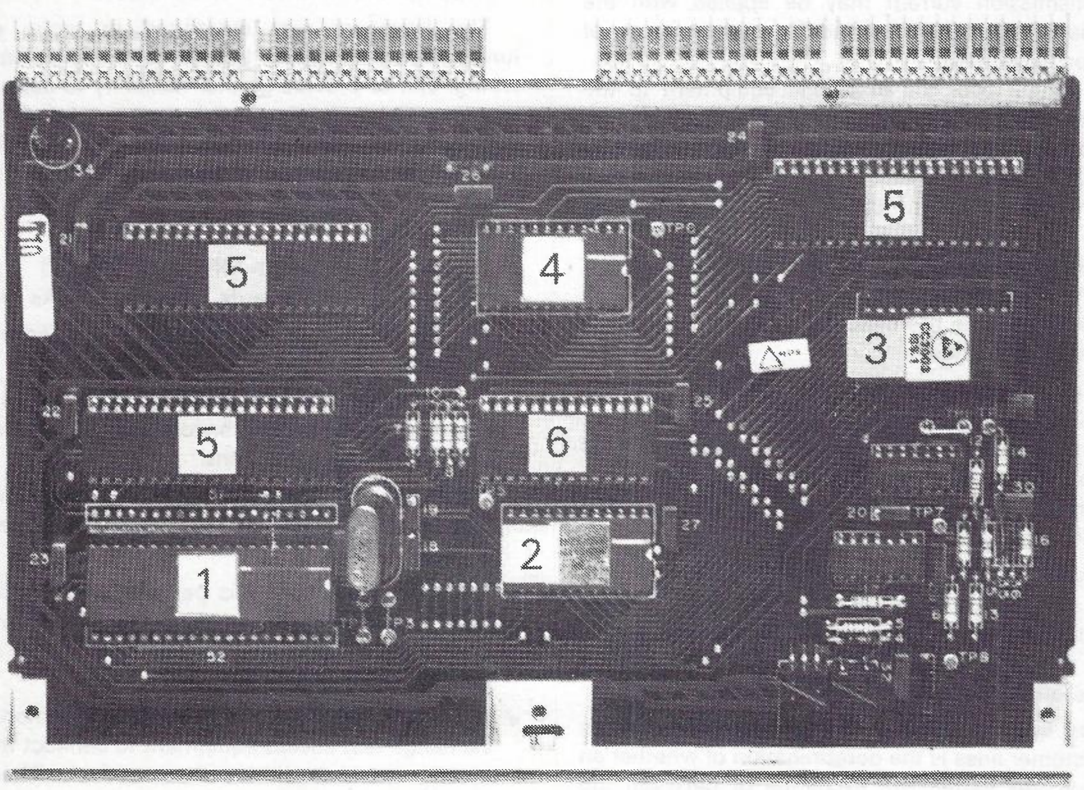


Fig. 3 - The Central Processing Unit circuit card

The main integrated circuit components identified are:

1. The 6902 Microprocessor
2. Random Access Memory (RAM) used to provide data buffers
3. 8 K-byte Programmable Read Only Memory (PROM) contains the control software for the MRT
4. Asynchronous Communications Interface Adapter (ACIA) which, in conjuction with RS232 interface components, provides communication with the SULTAN TCC
5. Peripheral Interface Adapters (PIAs) provide the input and output lines used for the control of the other circuits in the MRT
6. Programmable Timer Module (PTM) provides the interrupts and other timing signals for the MRT

the attached photograph (**Fig. 3**). As Telecom had adopted the Mototola 68XX series as the standard for internal use, a microprocessor (6802) was selected from this series.

MRT SOFTWARE

The MRT software has been structured on a functional basis, and operates in a "Primary Interval" mode where it is controlled by fixed interval interrupts. The main functions or modules are:

- Monitor. Initialises the MRT on start-up and after a reset. Calls the other modules if work is required of them during the current primary interval.
- Receive Data. Processes all data incoming from SULTAN and directs the received messages to the appropriate module for further processing.
- Transmit Data. Formats and transmits all messages from the MRT to SULTAN.
- Call Handling. Establishes the test call to access the line to be tested, and the revertive call to the testing officer or the Service Assistance Centre operator.
- Command Handling. Decodes the commands received from SULTAN and controls the processes required to execute them.
- Meter Reading. Applies the DVM as required by the received commands and prepares the results for transmission to SULTAN.
- Test Line Supervision. Supervises the line under test by means of the loop detect hardware, keeping track of the present "state" of the line, ie. looped or not looped. Disconnects interrupted ring or the howler as appropriate and times the pulses from the customer's dial.

The activation of each software module is controlled by memory flags which are set when a particular function is required. On receipt of the interrupt the Monitor module scans the state flags of all the software modules and activates the appropriate ones. Any timing functions are achieved by a count of the appropriate number of interrupts. When the function has been completed, or when the MRT is reset at completion of testing, the flags are cleared.

Interaction between modules is performed by setting the flag of the module concerned and loading any data that is to be transferred into a memory "buffer".

The receive data and transmit data modules each use a flag controlled by the Asynchronous Communications Interface Adapter (ACIA). These flags become active when the ACIA has just received a character, or is ready to transmit one.

Hardware inputs for detection of conditions such as line busy, idle etc. are scanned by the microprocessor via input ports of Peripheral Interface Adapters (PIAs). Relays are operated and released by setting or resetting output ports of the PIAs, which then turn on and off the relay drivers.

SIGNALLING PROTOCOL

Communication between the MRT and the SULTAN Test Communications Controller (TCC) is done by transmitting ASCII characters at the 1200 baud rate.

Each MRT on a link monitors all transmissions on that link. On receipt of a message start character the next two characters are compared against the MRT identity which is strapped in hardware. If these match, the rest of the message (6-14 characters) is stored for analysis. If the strapped identity is different all subsequent characters are ignored until another message start character is received.

For each received character a number of error checks are carried out. A checksum is calculated for each complete received message. This involves a process of performing an exclusive OR on each character from the first received character following the message start to the end of the actual message text. The result thus obtained is converted to ASII characters and compared with the last two characters before the message end.

When an MRT is in the process of receiving characters after having recognised its own call sign, failure of any of these transmission checks results in the MRT transmitting a negative acknowledge (NCK) message to request a repeat of the message.

For a typical test the following sequence of messages occurs.

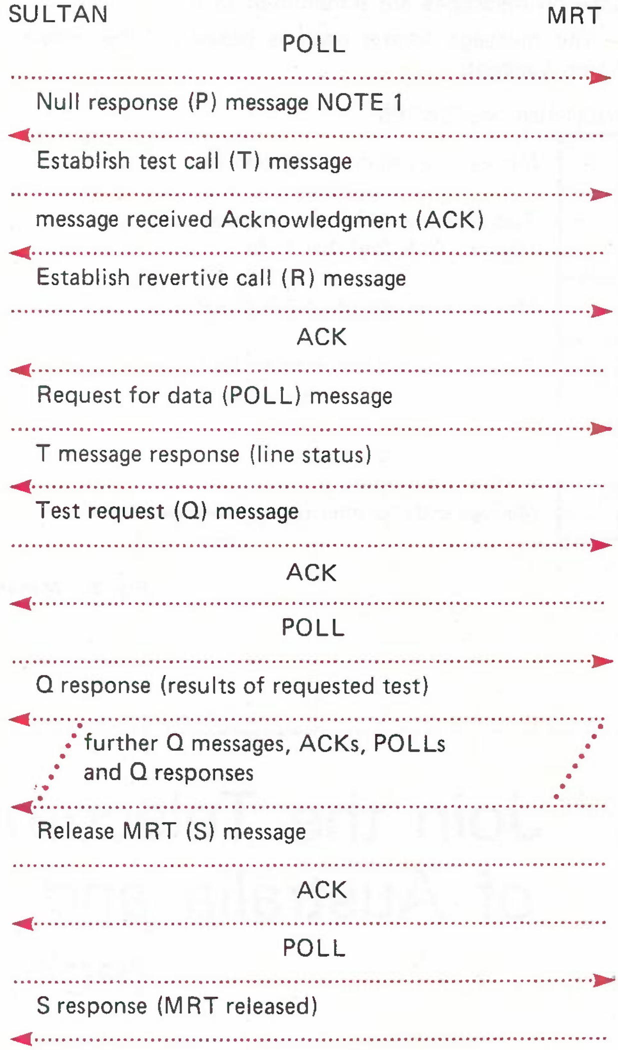


Fig. 4 - Message sequence of a typical line test

The types of message types currently used are:

- Incoming
- Establish Test call (T).
- Establish Revertive call (R).
- Test Command (Q).
- Release MRT (S).
- Poll or request for data (P).
- Negative acknowledge (%).

- Outgoing
- Message received acknowledgment (+).
- Negative acknowledge (%).
- Null response (P).
- Test call response (T).
- Revertive call response (R).
- Command response (Q).
- Release MRT response (S).

NOTES 1. A Null response message is transmitted by the MRT each time a POLL is received and no specific data is ready for transmission.

2. Poll messages are received at approximately the following intervals:

- While the MRT is in use for a line test — every 800mS
- When the MRT is idle between tests — every 26 seconds
- MRT declared faulty by SULTAN — every 3 minutes

3. An MRT may be blocked at the SULTAN site, in which case no messages are transmitted to it.

The message format used is based on the normal frame concept:

CONCLUSION

Microprocessor technology has provided the means to design a comprehensive test instrument, which, coupled to the SULTAN system, gives an accurate, reliable and user friendly tool for Testing Officers. The modularity of both the Software and Hardware aspects of the MRT ensure that future additions or enhancements will be simple to implement.

One variation to the existing design, to be implemented in the near future, will permit accessing of an MRT via the Public Switched Telephone Network. This will extend full SULTAN facilities to remote exchanges eg. small ARK installations, without the need for dedicated data links.

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TELECOM AUSTRALIA Engineering Training Publication — ETP-0912 'Introduction to the SULTAN System', 1983.

INCOMING MESSAGES

OUTGOING MESSAGES

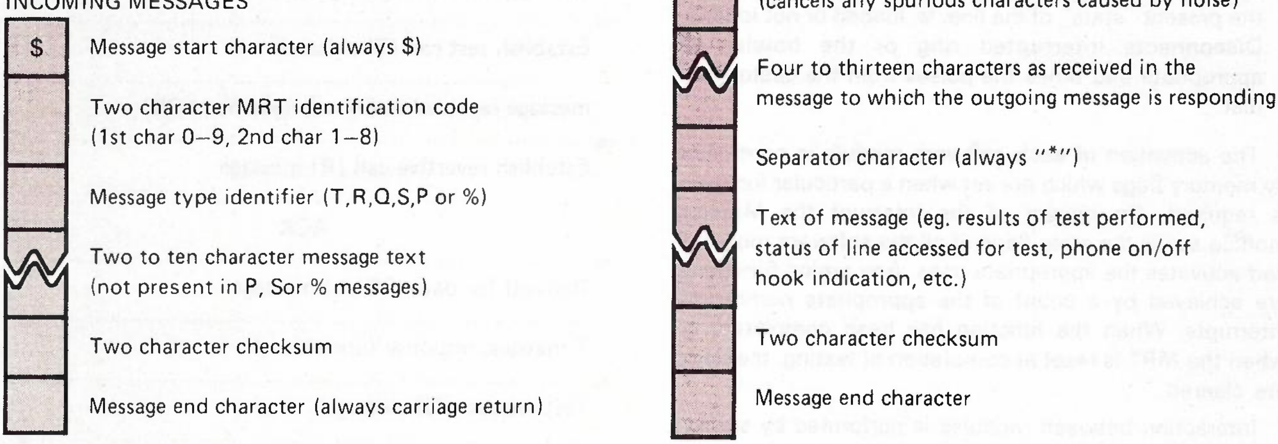

Fig. 5 - Message format

Planning for Change in the Television Industry

L. R. FREE B.Sc., B.E.

This article discusses the topics of technology life cycle, consumer television technology and the social needs for television programme services.

INTRODUCTION

Any attempt to discuss new technologies or the impact of new technologies for the future of society is bedevilled by semantics. People reading this paper will come from differing backgrounds and experience and it is very likely that their respective perceptions and understanding of such terms as satellite broadcasting, Pay-TV and conduit distribution systems will be different. This paper endeavours to clearly define such terms and to present concepts and scenarios from which conclusions might be drawn about new technologies and their future.

BACKGROUND

It will be illustrative to discuss three particular topics, namely technology life cycles, consumer television technology and the social needs for television programme services.

Technology Life Cycles

Every technology has a life cycle, as illustrated in **Fig. 1**, recognizing that it is simplistic to use a single curve to represent the life cycles of different technologies or even a single technology. Nevertheless the curve of Figure 1 is useful for descriptive purposes and several phases can be distinguished.

Phase 1, referred to as birth, covers the period of the discovery of the technology, contemplation of its potential uses and the development of viable prroducts of successful applications.

Phase 2 is the period of rapid growth in the use of the technology and this is the time frame in which new enterprises do well if successful applications of the technology occur.

Phase 3 is when the use of the technology has reached maturity. Its use is accepted as basic to society's way of life.

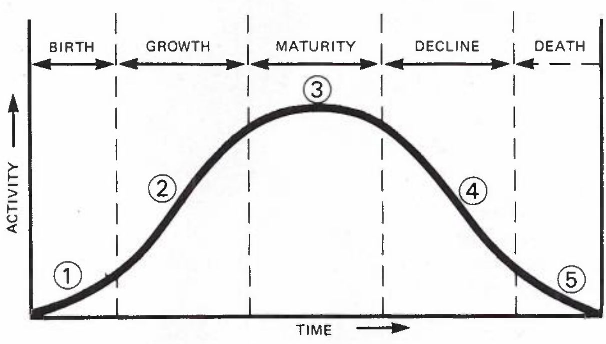

FIGURE 1 PHASES OF TECHNOLOGY

Phase 4 is when the use of particular technology begins to decline due to such causes as a shortage of supply, competition from alternatives, boredom with the status-quo or a change in the habits of people.

Phase 5 is when the technology virtually ceases to be used. For example, the use of steam for engines was essential for the growth of the Industrial Revolution but is now rarely used.

In general the life cycle of any successful technology appears to be rarely less than 50 years but might be muuch longer.

Consumer Television Technology

"Consumer television technology" covers the technologies and services derived from them for the distribution television programmes, as well as the consumer's reception and viewing facilities. New technologies in this area cover a diverse range of possibilities including the development of new technical components such as the solid state charge coupled device (CCD) which is now being introduced as the light sensitive element in TV cameras and for new services such as satellite broadcastings and teletex.

The main question is 'what are the technologies of interest for the next 10 or 15 years?'. For consumer television purposes, the technologies which will be used between now and the year 2000 are already used or known. This in no way means that the television industry will not change but what is required is an assessment of how these known technologies will impact the present situation.

Social Needs for Television Programme Services

The customer is interested in a regular supply of programmes and a substantial organisation is required to create a successful television programme service.

In the real world, there are mass appeal television programme services which can be defined as those which usually attract at least 20% of the potential viewing audiience at peak viewing times. At the other end of the scale, there are specialised television services which are expected to attract at most 1 or 2% of the potential audience. These services are referred to as narrowcasts. Then there are those television programme services which attract audiences between these extremes but as yet, they are not known by any particular descriptor.

There are no more than three mass appeal television programme services in any country around the world. The reason for this is unknown although it might be the equalising effect of competition from other media or its sufficient diversity for most viewers.

Most countries have few if any narrowcasts and where they exist they are either government funded or subsidised by other services. In the intermediate range there are never more than one or two television programme services.

In Australia, there are three mass appeal services, i.e. the commercial networks. The two narrowcast services are the Special Broadcasting Service (SBS) and 'videos' and in-between these extremes there is the Australian Broadcasting Corporation (ABC). In terms of its population, Australia is fortunate to have such diversity of television programme services. In particular we are lucky to have a government funded ABC not only to provide a range of programmes which are non-viable ffor a mass market yet have an appeal way beyond a narrowcast, but also to provide some competition to the commercial stations.

With this general background, the range of distribution media which might be of significance for consumer television purposes during the next 10 or 15 years can be addressed. In order to assess the probabilities, it is useful to classify the possible options as shown in **Fig. 2.** These four categories of radiated, conduited and packaged distribution or public showing cover all practical possibilities for television distribution.

PUBLIC SHOWING

Public showing requires the attendance of customers at a specially provided building usually located in the town, suburb or city centre, or at a strategically situated drive-in. Although cinema is clearly not television, it is included here for completeness, for it is a competitive visual experience.

An electronic cinema is a relatively new concept in which a large screen television projection system is used but so far all attempts have failed commercially due to inferior technical quality. The future hope is that the Japanese inspired high definition television system (HDTV) will give an impetus to this concept within 5 years.

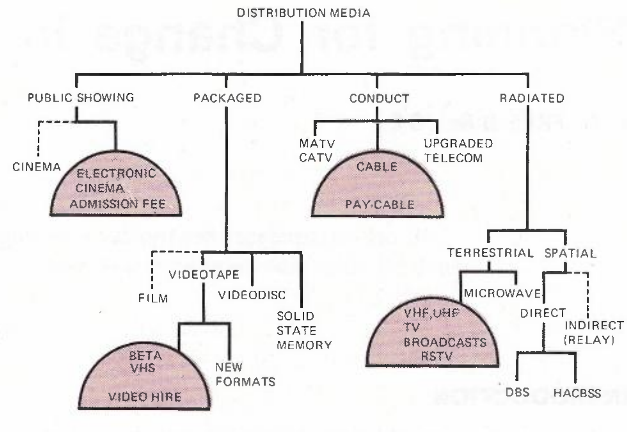

FIGURE 2 RANGE OF DISTRIBUTION MEDIA

PACKAGED DISTRIBUTION

Distribution of packaged media involves the delivery of pre-recorded television for customer use in their homes.

Film

The use of small gauge film for home projection has been practicable for 30 or 40 years. At best, it was marginally successful and has now virtually disappeared compared with 'videos'.

Video-cassette

The growth of the 'video' industry in Australia has been remarkable and it appears that the existing penetration is about 35% and still growing at the rate of 1% per month. If trends can be relied upon, it seems that there will be a penetration of home videocassette recording machines (VCRs) of 60% before the end of 1986.

It is certain that VCRs will have an important role in consumer television for many years to come. VCRs are used currently for two main applications, namely time shifting and for the repplay of leased cassettes. A third use for the VCR of replay of home produced videos is

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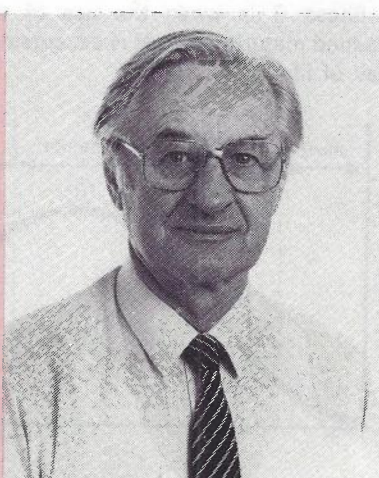
From 1955 to 1977, he was employed by Television Corporation Ltd. (TCN9), Sydney Australia, being the Chief Engineer from 1962-1977.

Since 1977, he has been Executive Vice-President, Research and Engineering, for Publishing and Broadcasting Ltd., which is the holding Company of Television Corporation Ltd. This position has entailed study of a wide range of telecommunication and broadcast communication issues including domestic satellite, CABLE, pay television, and opportunities for private enterprise in telecommunications.



emerging, but it is certain to remain a minority application.

Videodisc

The videodisc is an important technology similar to the well-known audiodisc except that it uses laser optical technology rather than mechanical recording methods. Its advantages compared with the VCR include high digital storage capacity, the highest quality television recording and random access. The videodisc is already successful in commercial and industrial applications. For consumer television its main disadvantage has been the lack of a recording capability. Although a recording capability for a videodisc has been recently announcced, it is doubtful whether the videodisc will become a significant consumer television product unless the VCR unexpectedly fails to upgrade its technical performance, as the worldwide move towards improved television quality on larger screens gathers momentum.

Finally, the increasing storage capability of solid state devices will enable recording of television programmes on a chip. However this is a prospect for the 21st century rather than the next 10 years.

CONDUIT DISTRIBUTION

The next category of distribution media is designated as conduits and it is this area of cable and wired systems which has been greatly confused by semantics. As an illustration, Australia is already cabled by wires running into your house although they are only narrow-band telephone cables. In one attempt to overcome the difficulty the term 'cable television' has been used. This still confused the issue because the requirement could be for carriage of general telecommunication traffic as well as television. A clear perception of the issues can be obtained by consideration of some conduited or wired systems.

MATV and CATV

Master Antenna Television (MATV) is a small wired system within a private estate, invariably intended for television within those premises. Community Antenna Television (CATV) is a small wired system which crosses property boundaries licensed by the Government and intended to provide television service into an area of poor reception. It has been suggested that an aggregation of this multiplicity of small units could constitute a viable system if TV programmes are supplied from a central source and that this is a technological possibility by use of a satellite. However, in Australia, this is a doubtful proposition.

Coaxial Cable

CABLE, in capital letters, is a term which evolved in the United States to describe privately-owned, co-axial cable distribution networks having a tree and branch topology. CABLE had its origins in the mid-fities and initially it offered basic television services to those otherwise unable to receive radiated television broadcast transmissions. CABLE developed only in areas of relatively dense population outside of the main cities, with limited penetration into the less populated areas of the United States. Basic service implies payment is for the connection to the cable system, rather than a fee for the services. All efforts to offer pay-services i.e. payment for programmes on CABLE failed until the mid-seventies, at which time Pay-TV was able to be offered to CABLE operators via satellite on a network or syndicated basis.

Recently CABLE operators had hoped to penetrate cities previously unwired in the belief that Pay-TV would be the ingredient for success but this has not been the case. Further, CABLE operators have offered telecommunication services but there is little record of success. Personally, I believe that the tree and branch topology makes this last objective an impossible commercial venture.

Optical Fibre

There is no doubt that Telecom will upgrade its existing switched telephone network for wideband working. Indeed Telecom will provide a publicly owned, nationwide, optical fibre, switched star connected network employing digital transmission. It will provide for transmission of all known services from slow-speed telex, the telephone and to full motion video or a television. Television will then be practicable on a one-to-one basis — the ultimate narrowcast hopefully at a reasonable cost. Alternatively it could provide a mass distribution medium if that is required and is viable.

However timing is the question and it is unlikely that Telecom will commence their upgrade within the next three or four years. Within the existing capital constraints on Telecom, it will take 40 or 50 years to fully upgrade the national network unless a change of Government priorities accelerates the process.

Nevertheless Telecom is well placed to provide and compete with the provision of privately supplied CABLE systems. It is my opinion that Telecom will provide a wideband wired network suitable for general television distribution but not in this century.

RADIATED DISTRIBUTION

Radiated television services provided terrestrally or by satellite transmission are a most important category.

Terrestial Transmission

Terrestrial transmission using VHF and UHF frequencies is a mature technology but is confronted with the problems of increased operational costs, slow loss of audience as interest wanes and as new services marginally fragment the audience and a restricted growth potential as most people now have access to a television set. Nevertheless the future of the four existing television network services for the next 10 years is assured although there will be some changes. Firstly, the television broadcast industry will move increasingly into actuality programmes and become less dependent on movies as the penetration of VCRs further progresses. Secondly, the Government will probably license a further two UHF television stations in main capital cities within the next three or four years. One of these will be a public broadcast operation for educational, cultural and access programmes. It will be funded by subscriptions or other allocations and be dependent on volunteer labour for many of its operations. The other is likely to be a commercial venture. The impact of these stations within the next 10 years or so will be marginal. However it will increase the diversity of television available and go some way to satisfying the demand for narrowcast television services.

Although there is the technological option to use terrestrial microwave frequencies for television purposes, there is a worldwide reluctance to allocate this spectrum to television, for microwave frequencies are in demand for other services. Its future use in Australia is problematical, but in any case it is unlikely to provide other than marginal television services.

Domestic Satellite

The commencement of domestic satellite services late in 1985 is likely to be for the television industry the single most important happening in Australia during the next decade.

The claim that the Aussat satellites are high-powered and satisfactory for television broadcasting purposes is questionable. The signals received at the earth's surface from the Aussat satellite will be at modest levels due to the relatively large size of Australia.

The Aussat satellites will be perfectly adequate for general telecommunications traffic such as telex, telephone and data for point-to-point services between commercial and industrial organisations. In addition, the existing television stations will use the domestic system for the exchange of programme material as a part of the operational process for preparing their own television service.

On the other hand, satellite technology has the potential capacity to provide a direct broadcast satellite (DBS). Current Government policy does not support the general introduction of DBS into Australia, because of concern about its potential to destroy the existing television broadcasting industry infra-structure. They claim that this infra-structure has been carefully nurtured to meet highly desirable objectives of diversity of services, localism and acceptable levels of ownership. In any case it is impracticable for Australia to have DBS this century, if the criteria is taken to be an earth station of reasonable size ie. less than 1 metre diameter, and of a cost acceptable to consumers ie. less than $500.

However, the Government has recognised that the satellite is the only way to provide television to people in the outback and other underserved areas of Australia. In order to provide one or maybe two services to those disadvantaged Australians, the Government developed the Homestead and Community Broadcast Satellite Service (HACBSS) scheme.

In the case of the ABC as a national broadcaster, ABC HACBSS programmes will be available to persons anywhere in Australia, provided that they purchase a satellite earth terminal estimated to cost about $2000. Applications for a commercial HACBSS designated RCTS (Remote Commercial Television Service) are now being considered. Because commercial television is licensed on a regional basis, the Government has indicated that commercial television use of the satellite and the provision of RCTS shall be constrained to reception only in areas which lie outside the service areas of existing terrestrial licensed commercial television stations. This raises major difficulties of viability, availability of programmes and the creation of an acceptable commercial "outback" television service. Whatever happens it will have minimal impact on the television scene in major cities.

Pay TV

Pay-TV is a term which means different things to different people. My definition of Pay-TV involves the direct payment by a consumer to a supplier of television product. Each one of the technological options shown in Figure 2 can be adapted to provide a Pay-TV service. Pay services around the world have only had limited success and invariably they have become little more than exhibitors of premium movies. Occasionally, sports and culture are offered but their effect is negligible.

In Australia, video hire has grown rapidly and this is having a disastrous impact on the cinemas, whose audiences have sharply reduced. It is suggested that half of the cinemas which existed at the beginning of 1984 will have been closed down by mid-1985.

Pay-TV has an inbuilt element of elitism, in that only those who can afford to and are willing to pay, obtain the service. Video hire has the advantage compared with a radiated or wired distribution service in that the television replay is available at the consumer's convenience. I believe that video hire has largely satisfied the demand for Pay-TV in Australia.

Some years ago the Australian Broadcasting Tribunal recommended the introduction of Radiated Subscription Television (RSTV) but seemed to be more a response to let enthusiasts 'have a go', rather than a rational decision in the public interest for Australians. Whatever, it now seems unlikely that RSTV and other similar forms of Pay-TV will be introduced into Australia.

CONCLUSION

In this paper I have discussed a number of issues which need to be addressed by the planners of the future television industry in Australia.

In particular, I believe issues are:

- the increasing penetration of VCRs in the home and their impact on terrestrial television broadcasting and the cinema.
- that conduited distribution systems will not use coaxial cable but rather optical fibre cable provided by Telecom.
- that new TV licences will be granted but they will have only a marginal impact on the existing broadcasting industry.
- that the first generation Aussat satellites are not completely satisfactory for TV broadcasting purposes but are adequate for TV programme inter-change and general telecommunications use.
- that RSTV will not be introduced into Australia.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THE GOLDEN JUBILEE OF THE JOURNAL: M. Chin, Telecom Journal of Aust. Vol. 35, No. 1, 1985, Page 3.

A history of the Journal, past and present.

TELECOMMUNICATION: S. H. Witt, Telecom Journal of Aust. Vol. 35, No. 1, 1985, Page 7.

A reprint of the first editorial in Journal of June 1935.

DECORATOR TELEPHONES: S. J. Sanders and C. S. Wood, Telecom Journal of Aust. Vol. 35, No. 1, 1985, Page 9.

In addition to the range of modern push button premium and standard telephones already offered to customers, Telecom Australia has introduced telephones with a variety of styles to appeal to many personal tastes in decor.

NEW DATA COMMUNICATION SERVICES & THE DEVELOPMENT OF AUSTPAC: M. J. Harrison, Telecom Journal of Aust. Vol. 35, No. 1, 1985, Page 13.

A national packet switching service (AUSTPAC) was established in Australia in December 1982. This paper briefly reviews the present status of the network and describes a significant new electronic funds transfer application that has been implemented using AUSTPAC. A description is also given of the planned supporting role of the AUSTPAC network in the introduction of new public services such as Videotex, Teletex and Electronic Mail.

PLANS FOR THE INTRODUCTION OF TELETEX IN AUSTRALIA: D. J. Gannon and G. C. Crayford, Telecom Journal of Aust. Vol. 35, No. 1, 1985, Page 21.

This paper outlines plans for Teletex in Australia. It discusses the market potential for Teletex in Australia and the approach taken by Telecom Australia in developing the Teletex service. The paper also discusses the architecture of the proposed system and its relationship to other existing and proposed message handling services.

DEVELOPMENT OF A SOLID STATE "SPEAKING CLOCK": J. P. Colvin, Telecom Journal of Aust. Vol. 35, No. 1, 1985, Page 27.

This article describes the design of a prototype solid state speaking clock.

FORECASTING TELEPHONE TRAFFIC — SOME RECENT DEVELOPMENTS: M. J. Allison, Telecom Journal of Aust. Vol. 35, No. 1, 1985, Page 31.

The complexity and variability of telecommunications traffic pose some interesting forecasting problems. Until recently lack of sufficiently frequent measurements allowed the use of only a few formal statistical methods. New measurement techniques allow the use of more statisical methods in some areas although many aspects of teletraffic forecasting still involve empirical methods. This paper describes some forecasting and quality control techniques used in the Planning and Programming Branch of Telecom's Engineering Department in Victoria. The unusual nature of the forecasting subject is illustrated and some situations are shown where quality control methods can enhance the forecasting process.

SWITCHNET — A GENERALISED CIRCUIT SWITCHED MODELLING TOOL: Y. M. Chin, Telecom Journal of Aust. Vol. 35, No. 1, 1985, Page 41.

SWITCHNET is the development of a widely applicable switched network dimensioning computer system used to assist the network planner in the network planning process. This paper deals with the broad description of the various data and computer modules which in totality provides the planner unfamiliar with computer systems relatively easy means of setting up of network models.

T.Q.C. OR MANAGEMENT FAD? J. Keavney and M. Lyrmont, Telecom Journal of Aust. Vol. 35, No. 1, 1985, Page 49.

"Quality is free. It is not a gift but it is free. What costs money are the inequality things; all the actions that involve not doing jobs right the first time." (Phillip B. Crosby).

THE SULTAN CUSTOMER LINE TEST NETWORK — SYSTEM DESCRIPTION: J. M. McIntyre and D. Belshaw, Telecom Journal of Aust. Vol. 35, No. 1, 1985, Page 53.

SULTAN (Subscribers Line Test Access Network) has been designed and developed by Telecom Australia to provide customer line testing facilities. This system incorporates central minicomputers, and outposted test robots in terminal exchanges.

THE SULTAN MICROPROCESSOR CONTROLLED ROBOT TESTER: R. M. Chrisfield, Telecom Journal of Aust. Vol. 35, No. 1, 1985, Page 67.

The SULTAN system (Subscriber Line Test Access Network), greatly depends for its success on the accuracy of the result obtained from the devices which test the customers' lines. This article describes the structure and general design principles of the Microprocessor controlled Robot Tester (MRT), which was developed by Telecom specifically for use by SULTAN.

PLANNING FOR CHANGE IN THE TELEVISION INDUSTRY: L.R. Free, Telecom Journal of Aust. Vol. 35, No. 1, 1985, Page 73.

This article discusses the topics of technology life cycle, consumer television technology and the social needs for television programme services.

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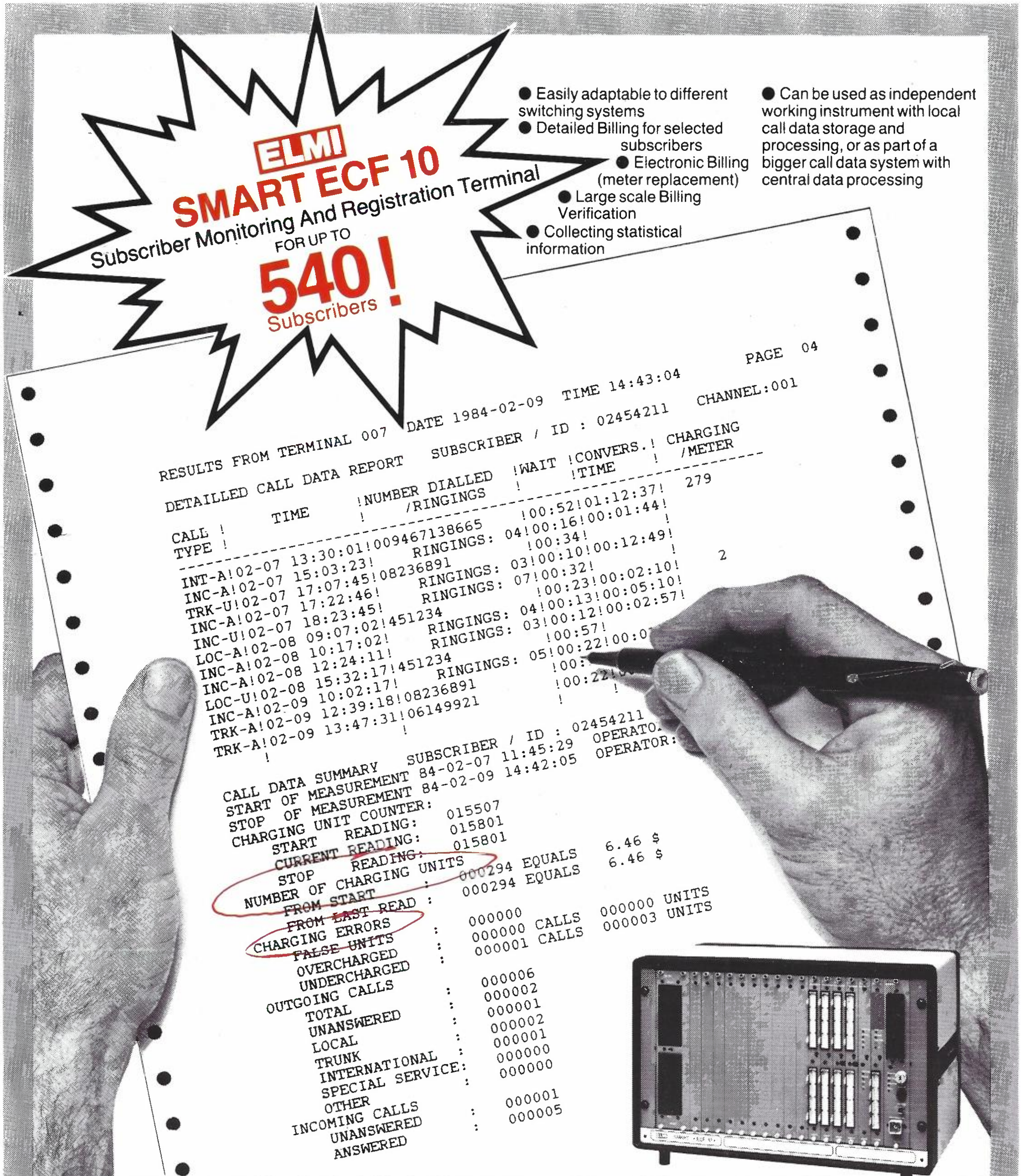
Printed by Standard Commercial Printers, 2 Railway Rd., Cheltenham, 3192.



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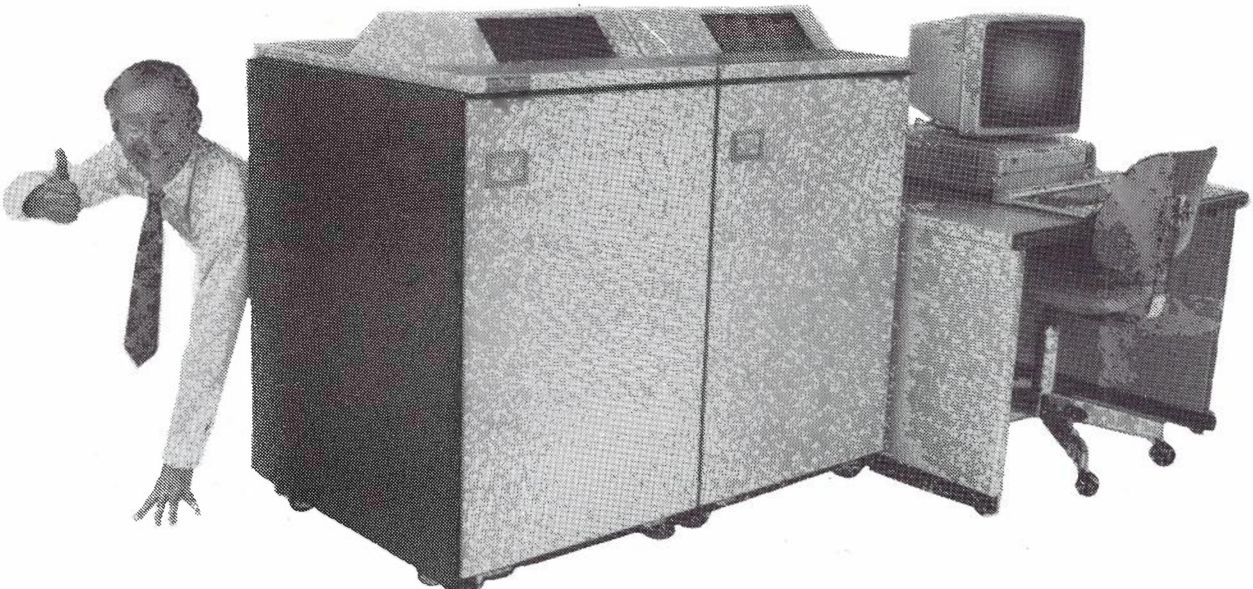

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