# COMMUNICATIONS: THE ELECTRONIC EXPLOSION IN HARNESS

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Ladies and Gentlemen,

I count it a privilege to present this 1984 lecture in commemoration of the late Ralph Slade. Unfortunately, I did not have the pleasure of meeting Mr. Slade in person, but from reading about him it is obvious that he was a man with true pioneering spirit and a vision regarding the tremendous potential of electronics, coupled with a determination to develop a strong professional and industrial base in New Zealand. The only claim 1 have to some association with Mr. Slade would stem from the fact that he started work as a Post Office cadet in Dunedin, which I also did, and whilst in Dunedin I worked under a Post Office Engineer who was one of Mr. Slade's peers in early radio pioneering activities - in fact, this particular Post Office Engineer was for many years credited with holding the world record for radio communication, he worked a Russian ice-breaker in the North Sea using a spark transmitter, and the records show that for his effort he was fined five shillings by the Post Office for his abuse of the radio spectrum. Mr. Slade was both an innovator and a practitioner in the field of electronics, and throughout his life he was involved in many of the latest electronic developments and applications. However, although he was undoubtedly farsighted regarding the future I think even he could not have predicted the changes that have occurred in the 20 years or so since his death. In this short space of time, the development of electronic technology has increased dramatically until it can now only be described as a continuing explosion. Whereas technology was once the limiting factor in the services and products that could be provided, we are now virtually in the position where ideas and money are the only limiting factors, and the challenge of today is to determine the applications of available technology which mankind needs and desires and is able to afford.

The communications industry is one of the most important leaders in electronic technology applications, and this is understandable because it is at the centre of information services. The world in our generation is undergoing a structural and social change on a scale that has never before been experienced. Earlier changes saw a move from agriculture to industry in what we know as the "Industrial Revolution", but the move today is virtually another revolution into an information society. Countries throughout the world now recognise that their development is linked to knowledge, and that the acquisition and flow of information is crucial to their progress. This social and political recognition means that huge resources are being directed into the development of information services, thus stimulating technical development and innovation particularly in the field of electronic communications, which has witnessed a dramatic and continually increasing rate of change.

I want to focus on some of the more significant communication developments which illustrate the current situation and point to possible future directions. In this regard, the main thrust of communication development is stemming from simultaneous advancements in four specific sectors:

- Chip Technology
- Digitisation
- Fibre Optics
- Space Technology

## CHIP TECHNOLOGY

Over the past three decades, advances in semi-conductor and chip technology have been on an unprecedented scale. Starting with the invention of the transistor in the late 1940's, solid state technology rapidly developed into integrated circuits from the 1950s, firstly with what is called small-scale integration, followed by medium-scale, large-scale and now very large-scale integration. Since the advent of integrated circuits, the number of electronic components that can be placed on a single chip of silicon has about doubled each year, so that today one chip can contain more than a million tiny devices, enabling an ever-increasing range of functions of the size and unit cost of earlier technologies. Power requirements for these chips have also been progressively reduced, so that the sophisticated technology can now be widely distributed, and if necessary used quite inefficiently, and still be economic.

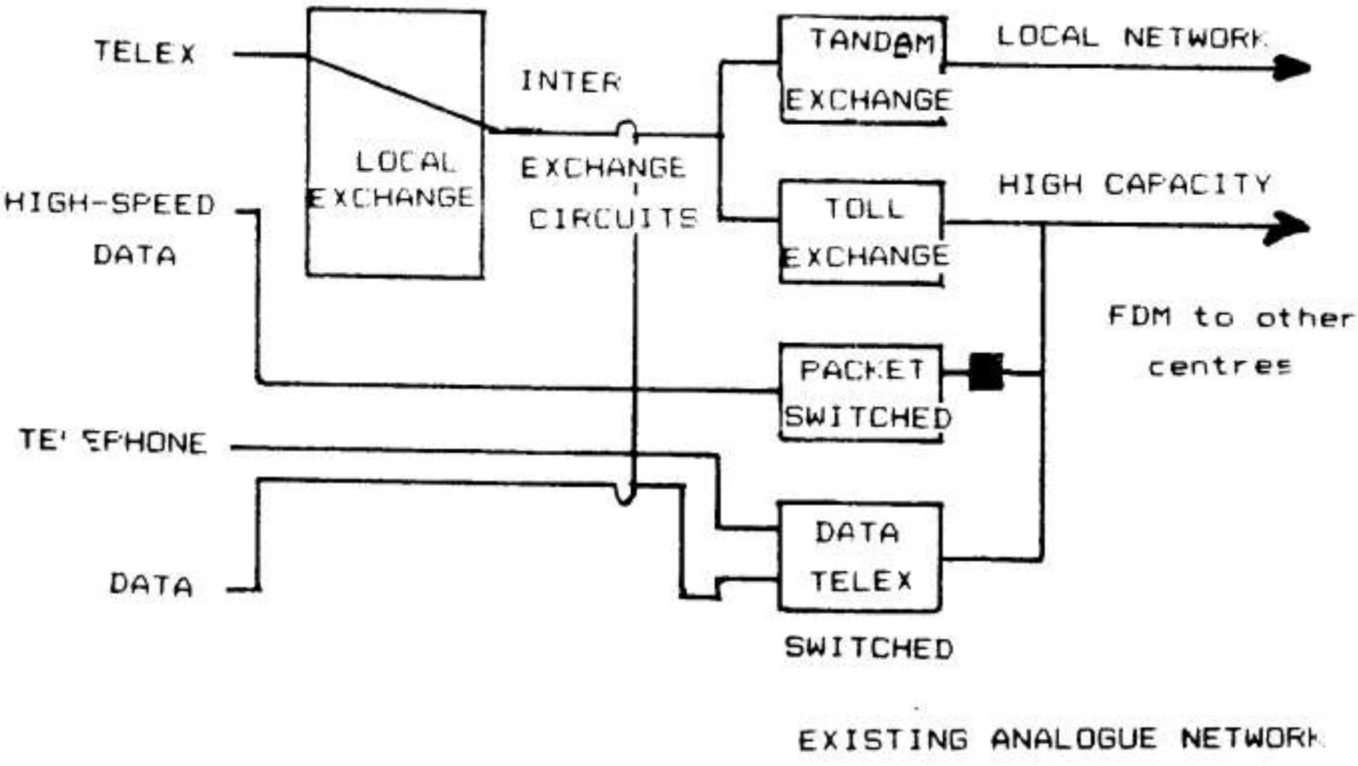
Widely visible examples of modern chip applications would be in digital watches and hand-held calculators, in which functions have progressively increased, while size has decreased to an extent only limited by the dimensions of the physical boxes, keys and displays that are necessary for practical human use. However, the same relative scale of change has also occurred throughout the communications industry. Typical examples can be found in the telephone switching sphere. A modern electronic switch with stored program control could be expected to occupy only about 10°Io of the space required for an equivalent wired logic electro-mechanical exchange. A similar comparison would apply to a PABX. Also as the intelligence of the electronic telephone exchange is vested in its centralised software, expansion or changes of function can be performed without the need for complex and expensive hardware modifications. This gives an electronic exchange a tremendous flexibility for progressive updating to provide for new developments in operation and services.
Spectacular advances have also occurred in other areas of switching as well as in the areas of transmission, signalling and radio, where chip technology has enabled rapid developments in design, accompanied by smaller space, lower unit cost, more flexibility, faster operation and better control.

Developments in chip technology have already opened up new horizons in communication applications, and there is no end in sight to further development and micro-miniaturisation which will have profound effects on the lives of every human being.

## DIGITISATION

Until quite recently virtually all telecommunication networks have used "analogue" transmission, in which the amplitude or frequency of the electrical signals varies continuously in harmony with the acoustic or electrical source oscillations. This has suited telephone services because voice signals are analogue at their source. Local reticulation, exchange systems, transmission paths and multiplexing arrangements have been designed and implemented to a nominal 4 kHz channel bandwidth, which is regarded as the international standard for voice communication.

In contrast to voice signals, telegraph and data type services employ "digital" signals comprising simple "on's" and "off's" or "1's" and "O's", and these signals have needed to be transformed into suitable format for end-to-end transmission over existing analogue network paths. (Figure1).




Although a method of digitising speech has been known for about 40 years, it has only become economical on a large scale with the development of modern chip technology. The technique used is known as pulse code modulation (or PCM), which involves the periodic sampling of the analogue waveform, and in coding each sample into an 8-bit word which is then assigned a time slot on a common highway.

The most commonly used international standard is for a 32 time slot system providing 30 speech channels plus two channels for signalling and synchronisation at a sampling rate of 64 kbit/sec. This bit speed corresponds to a bandwidth of 4 kHz in an analogue network. The encoded signal is transmitted as a series of pulses which are very insensitive to noise on the transmission path, and can be regenerated as often as necessary. In this way, the accumulation of distortion and noise typical of traditional analogue transmission systems is almost eliminated.

Digital switching systems have also recently been developed on an economic basis using modern chip technology. These systems, when used in conjunction with digital transmission systems, enable voice signals once converted into digital format to be transported throughout the network without the need for intermediate digital/analogue conversions. The signals thus transmitted can then be reproduced in high quality at the receiving end.

The digitisation of communication systems has also been influenced over the last few years by developments in computers, which operate inherently in digital format. These developments have brought the technology of communications and computers onto a common path, such that the future progress in both industries is closely linked, and also matches society's growing requirements in regard to information. Computers provide the means for information to be stored and processed, and communications provide the means for retrieval and transmission to a desired destination. Communication systems must, therefore, enable man to talk to computers and computers to talk to each other, as well as providing for the traditional man-to-man communication. This has accelerated the move away from well known analogue techniques in communications to digital operation.

In New Zealand digital transmission systems have been used for some years to link stored program controlled electronic exchanges, and digital stored program control for electronic exchanges are now being installed as standard. Digital PABXs have been introduced, as well as digital trunk-line bearer systems to carry long distance traffic. A packet switching network has also recently been established, providing a highly efficient, reliable and flexible method of transmitting data between computers, between computers and terminals and between data communication terminals at lowest possible cost.

Most data communication consists of short bursts of data with intervening spaces which are often of longer duration than the actual data bursts. Packet switching takes advantage of this characteristic by inter-leaving bursts of data from many different users to make maximum use of a shared data communication network. This inter-leaving is achieved by assembling the bursts of data into "packets", each containing address and control information as well as "message information.

## FIBRE OPTICS

The third area of spectacular development concerns communication by light. It has been known for a long time that the higher the frequency, or shorter the wave-length, of an electro-magnetic radiation, the more information it can carry. Typical broadcast radio waves are measured in hundreds of metres, microwaves have wave-lengths of less than half a metre, and light has wave-lengths of about a ten millionth of a metre. So theoretically large amounts of information can be carried over a beam of light, but this has required the parallel development of both suitable optical sources and receivers as well as the development of a transmission medium to "pipe" the light wave.

Initial breakthrough occurred with the invention of the laser, and particularly the development of a solid state version with high stability and reliability characteristics. The laser, which emits very intense, non-spreading light of uniform wave-length, has provided the stimulus to develop a transparent transmission medium, and this has led to the production of thin fibres of very pure glass having a variable refractive index over their cross-section, such that all light waves launched at one end are contained within the fibre and arrive simultaneously at the distant end. Most fibres are formed by a chemical vapour deposition (CVD) process, whereby many layers of vapour materials are progressively oxidised on to the inside wall of a silica tube, which is then collapsed to form a solid fibre preform. The actual fibre is then drawn from the preform. Glass purity is such that a block many kilometres thick would pass light as readily as a window pane. The fibre is flexible and provided there are no kinks is quite strong. It is coated with plastic and incorporated into a cable for practical use. Attenuation characterics of optical fibres have been progressively reduced, to a current level of less than 0.5 dB per kilometre at wave-lengths of around 1.3 um - i.e. just within the infrared range.

Early fibres were drawn to about 1/10 mm in overall diameter (core + silica cladding), and using non-polarised light waves ("mult-mode") could support transmission speeds up to 140 Mbit/sec, equivalent to 1920 digital voice channels, over distances of 20-25 kilometres without intermediate regeneration. However, most current high capacity fibres have a much smaller core diameter and are designed to use polarised light waves ("mono-made") Using present technology such fibres can support transmission speeds of 565 Mbit/sec, equivalent to about 8000 voice channels, up to 100 kilometres without regeneration.

Apart from their channel capacity and repeater spacing advantages as a transmission medium, optical fibres have other important advantages over metallic conductors, including immunity from induced interference, negligible crosstalk problems, system security, ease of handling, abundance of source material and growing cost -effectiveness.

Optical fibre network applications will, therefore, increase firstly in high capacity inter-exchange links and special problem areas such as power sub-stations, oil refineries, railway electrification, etc., and later in the local reticulation areas for cable television, subscriber data services, control telemetry, etc. New Zealand's first use of optical fibres in the telecommunication network was in a 140 Mbit/sec multi-mode cable installed between Wellington and Lower Hutt, a distance of 15 kilometres without regeneration. A cable of entirely non-metallic construction has also been installed for telecommunication services to the New Plymouth power station, where high earth potential differences can occur under certain power fault conditions. Many further applications are currently being planned for both short distance and long-distance routes.

Development of the opto-electronic devices needed to make optical transmission a reality at the steadily increasing bandwidths has proceeded alongside the actual fibre development. Lasers and fight emitting diodes have been used for optical transmitters, and avalanche photodiodes for receivers, with all these devices being progressively developed to handle single-mode operation, higher speeds, longer wave lengths (up to 1.55 um) and greater distances. The higher speeds possible with opto-electronics are leading to the development of optical switching devices and integrated optical transmission/switching networks, which represent a further quantum leap in communication technology. These developments, together with the necessary jointing and terminating equipment, test instrumentation and operational surveillance facilities have established a new industry within the electronic communication field.

## SPACE TECHNOLOGY

Space technology has enabled payloads to be launched by rocket or space shuttle and positioned very accurately above the earth, and this has provided obvious possibilities for communications. Communication satellites launched into a circular orbit some 36,000 kilometres above the equator hover above the one spot, moving around their orbit at the same speed that the earth rotates. Such an orbit is known as geostationery, and from this height each satellite can "see" about one-third of the earth's surface. Thus a series of satellites positioned over the Atlantic, Pacific and Indian Oceans used in conjunction with appropriate earth stations and terrestrial links, can provide world-wide broadband communication coverage.

Many satellites are already in orbit, and systems have been established to cater for general international communications (telephony, telex, data, facsimile, television), maritime use, domestic services, etc.

Early communication satellites had a comparatively low circuit capacity, and operated globally over the whole of their earth "footprint". They received the signals beamed in their direction by earth stations within their coverage zone, amplified the signals greatly, and then retransmitted them at different frequencies. Resulting from developments in radio polarisation and modulation techniques, together with higher speed, lower power and smaller size electronic componentry and more sophisticated antenna systems, present day satellites have much higher circuit capacities and are able to reuse frequency ranges several times, concentrating beams on different parts of their earth footprint that cover high traffic areas. For the future, it is likely that satellites will be able to switch digital signals from one beam to another and, via inter-satellite links, from one satellite to another.

The continuing developments in satellite technology, and also the more economical launching techniques available by means of modern rockets and space shuttles, are progressively reducing satellite circuit and channel costs and making satellites a viable alternative for more communication service applications. Looking further ahead, space platforms will enable even greater expansion of power, capacity and facilities for all forms of space communication.

Satellites presently have a continuous life of about seven years, and ongoing development is taking place. About half of New Zealand's international communications traffic is carried by means of satellite, via our earth station at Warkworth and the INTELSAT satellite over the Pacific. A second earth station antenna has recently been commissioned to cater for increasing circuit and service requirements - this antenna has been designed to work to the latest design INTELSAT V satellite which will be positioned over the Pacific in 1985, and will have capacity for 12,000 voice circuits and two television channels.

## NETWORK DEVELOPMENTS

So far I have outlined the four basic developments in chip technology, digitsation, fibre optics and space technology that are revolutionising communications. As actual applications tend to occur initially within the communication network, their effects do not always become immediately obvious to the user. However, network developments and enhancements have now been such that new communication services are rapidly emerging into public use. Whereas for many years the services available to the public largely consisted of ordinary telephone service plus a limited range of data services and equipment, this scene has dramatically changed over the last few years, and the rate of change is increasing rapidly.

The combined effect of digital public exchanges, digital PABXs, digital microwave systems, optical fibre cables and PCM transmission systems is that telephony in New Zealand is already well on the way towards an "integrated digital network" (IDN), with all-digital communication between end exchanges, and the telephone network is also becoming increasingly compatible with the requirements of non-voice services. (Figure 2). In addition, for non-voice services discrete telex and packet switching networks have already been established, with limited inter-connection between them and with the telephony network.

Longer term network development is to integrate all voice and non-voice services oil to a common digital network right out to customers' premises. This network will be known as the "integrated services digital network" (1SDN). In effect, ISDN will then provide a common "digital pipe" between end users, which can be used for transporting a wide variety of information including data, telephone calls and even television pictures. (Figure 3).

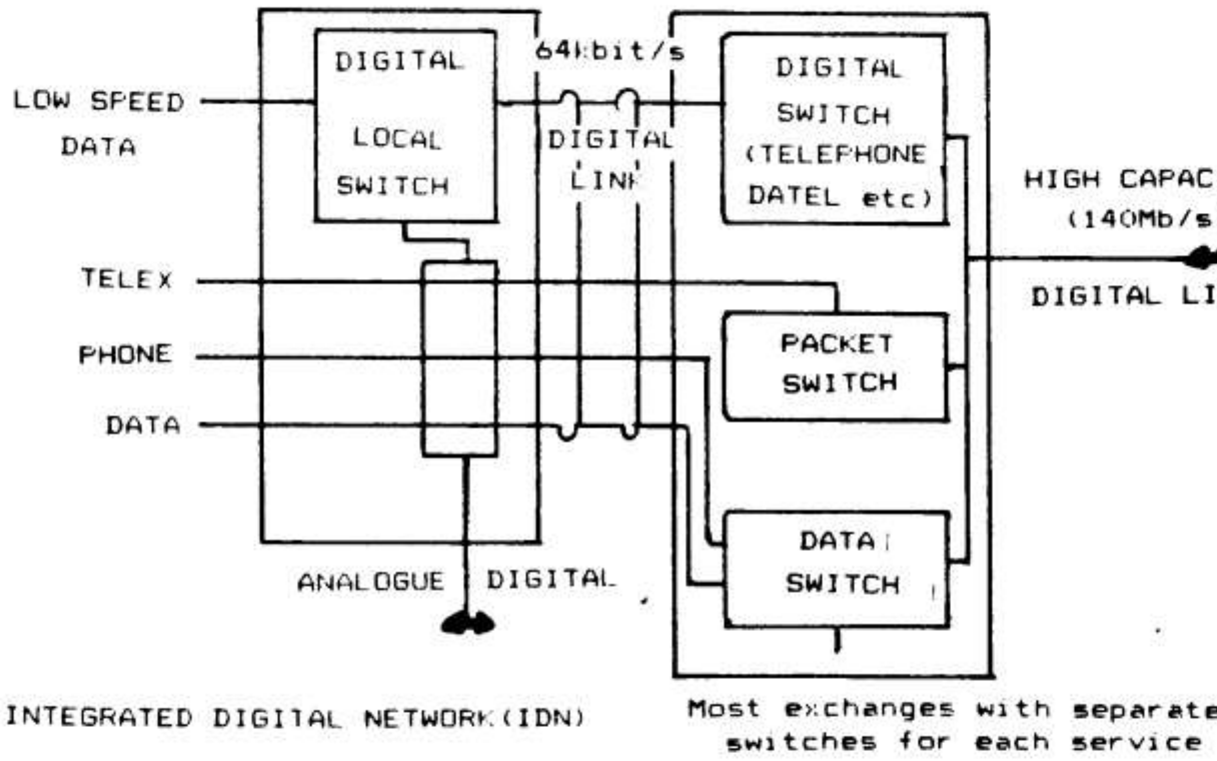



Fig. 2

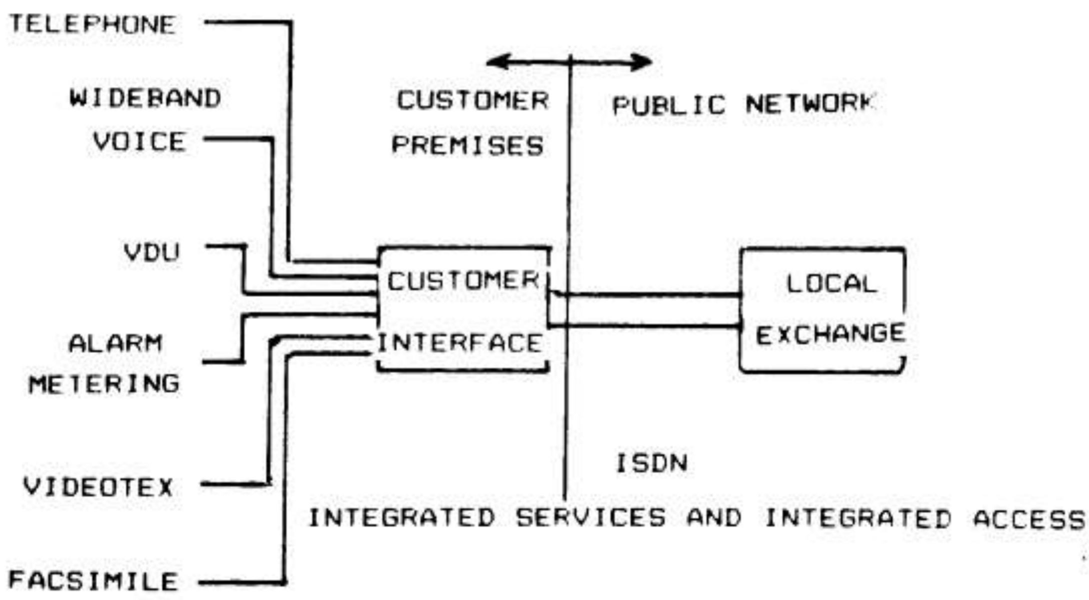



Fig. 3

The rapid increase in the requirements of businesses for storage, processing, retrieval and transmission of vast amounts of information, plus the variety of services used within a single business, has stimulated development of integrated office systems which can handle commercially and economically both voice and non-voice services. As well as providing for voice telephony, such systems will have the flexibility to provide for "work stations" to handle any desired combination of data, text, image and video services, enable easy access to computers and facilitate integrated access to any desired computer/ communication services either within the business or via the public network. Where warranted by business size and range of inter-communicating requirements, a specially designed "local area network" (LAN) may be established, to which the computers, terminals, work stations, etc., belonging to the business are connected. The LAN will facilitate fast and easy internal access and allow high speed information transfer and processing.

## CUSTOMER SERVICES

From a user perspective, the advancing electronic technologies have opened up an increasing range of services and products. Many of these are already available or are being planned, whilst others are still in the future.

The most visible universally used item will continue to be the telephone, but in future the range of instruments will be much greater and will cater for individual requirements. Colours and shapes will vary over a wide spectrum, and the adoption of fully electronic internal technology will make available many options - e.g., memory dialling, last number recall, loud-speaking facility, cordless operation, built-in calculator, clock and radio. Coupled with facilities now being incorporated into electronic exchanges, telephone users will also be able to enjoy additional services such as "call waiting", "wake-up", "do not disturb" and so on.

Electronic technology has also stimulated the development of a new type of mobile telephone system which can be integrated as part of the normal telephone service. This system uses a honeycomb arrangement of radio transmitter/receiver "cells" controlled by a centralised computer which tracks each wandering telephone and passes it from cell to cell to maintain optimum transmission quality and interconnection with the fixed telephone network. With this arrangement, the various services available to a fixed telephone user are also available to a mobile customer. The mobile instrument is suitable for use in car, batch, boat or even hand-held, and can be used anywhere within the radio coverage area of a cell. The technology is new and sophisticated, it has recently been introduced or is currently being developed in some overseas countries, and it is now being planned for New Zealand.

The cellular mobile telephone system together with an enhanced mobile dispatch service and national telepaging service, will provide effectively for the various requirements in mobile communications.

Other telephony based services are also emerging, and perhaps one of the most useful in the immediate future will be teleconferencing. Initial developments of this service are likely to concentrate on audio-conferencing with co-ordinated graphics under full user control. With these arrangements a wide variety of business, social and educational requirements can be met. For special purposes, video-conferencing will also be available, although this is likely to develop more slowly because of its greater transmission bandwidth and studio requirements, and hence its much greater cost compared with audio-conferencing.

Two new services which are currently receiving much attention throughout the world and have the potential for wide public use are videotex and electronic funds transfer. Videotex is a service that enables a telephone subscriber with a suitable terminal to call a variety of databases through the switched telephone network. (Figure 4). Access and information retrieval arrangements are "user friendly" and both text and graphic displays are possible on a television type screen. The service is thus suitable for a wide variety of applications and no special knowledge or training is required for terminal operation. Travel, industry, farming and veterinary services are all early users of the new system, which is likely to expand progressively into both specialist and domestic areas.

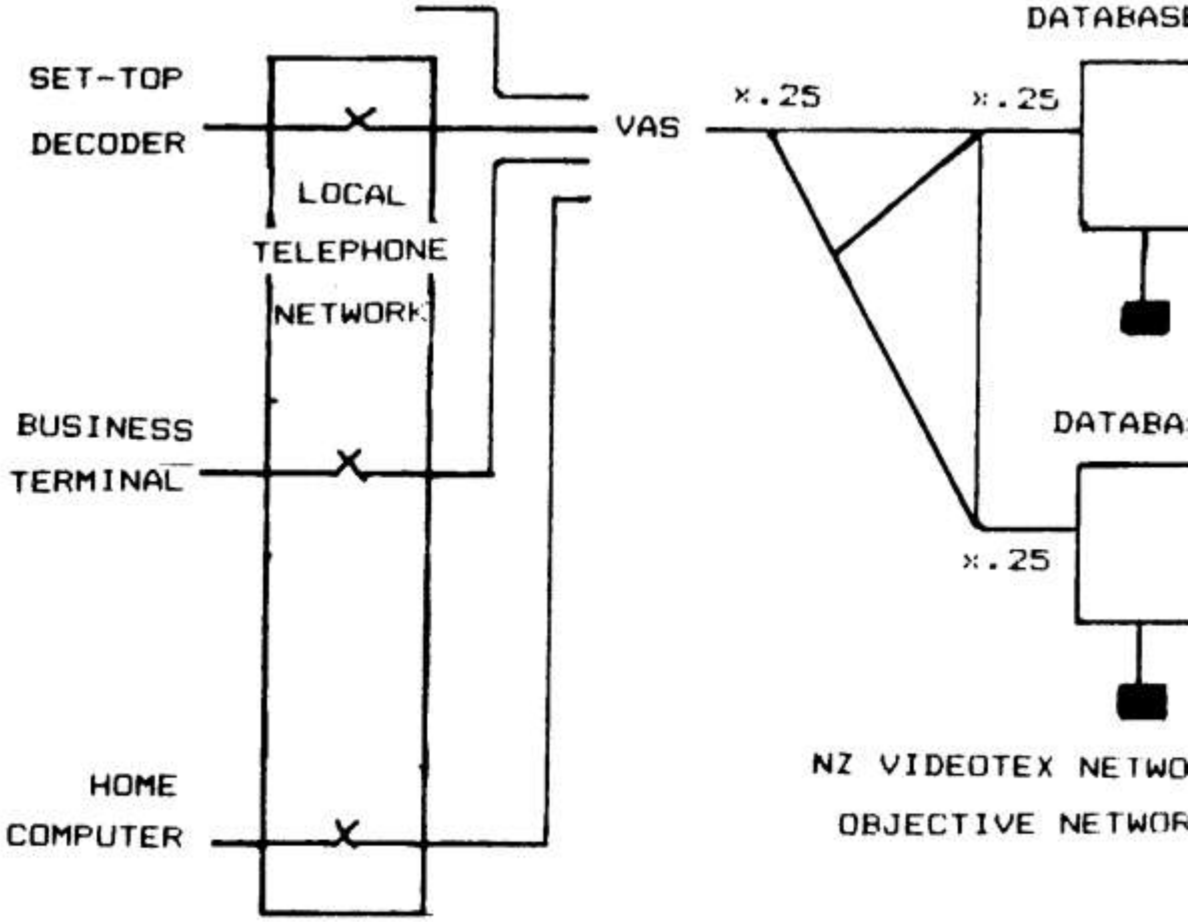

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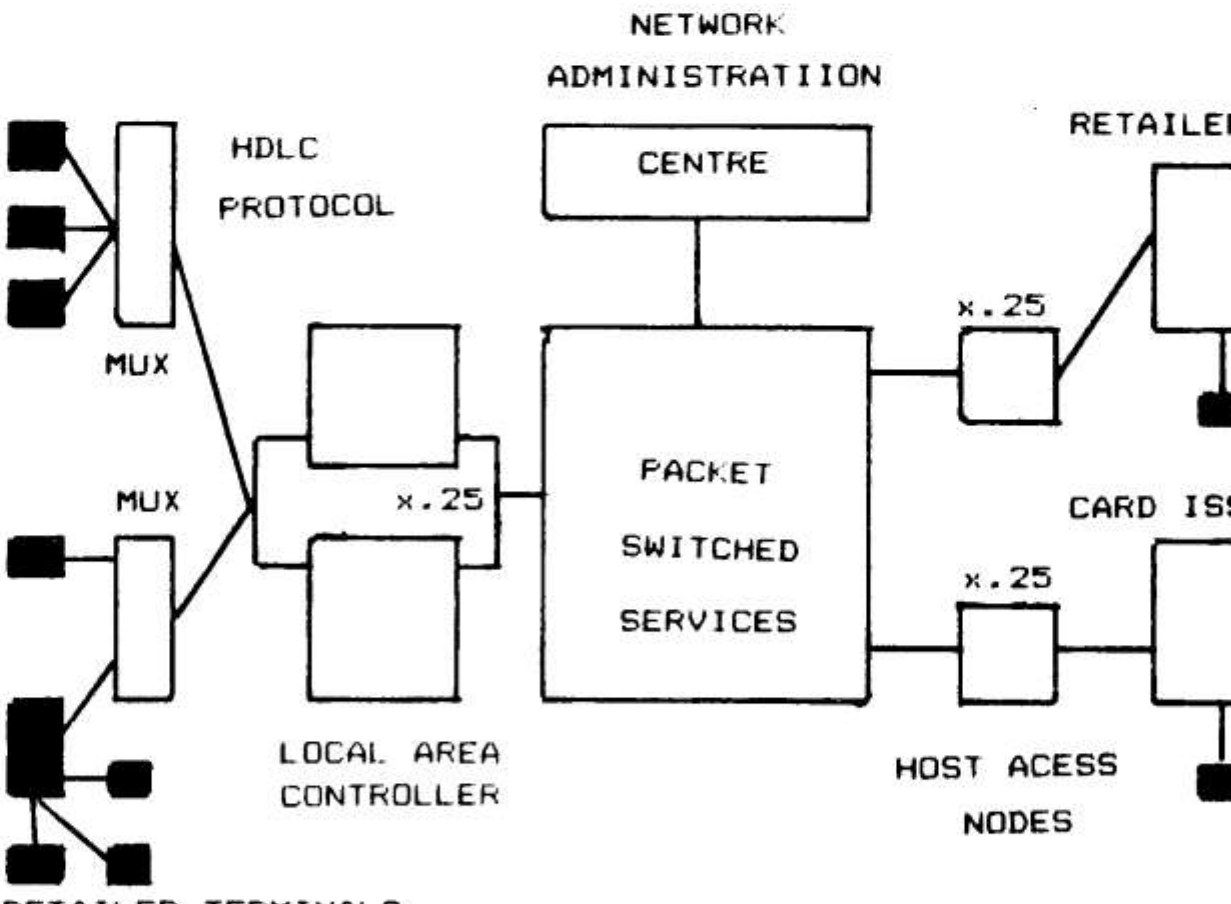
Fig. 4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Electronic funds transfer involves the use of point-of-sale terminals at stores and other retail outlets. This system enables automatic debit and credit transfers for purchases by customers with a debit or credit card. The POS terminals connect over the public switched telephone network and/or the packet switched network with both the retailer's bank and the card issuing organisation so that all accounting action involved in a transaction is completed at the time of purchase. (Figure 5).

The advent of new videotex and electronic funds transfer type technologies, together with the increased network capabilities to transport both broadband and data type information right out to customers' premises, open up even more possibilities. For business customers communication and computer systems will become more convenient and provide a greater range of facilities, with integration of voice, data and processing capabilities to meet the needs of the office of the future. There will be a growing use of intercommunicating word processors. Electronic credit card verification will be possible by means of special telephones at retail outlets. For the domestic user it will be possible to undertake banking, shopping, messaging, reservations, education, conferencing and so on from the home. Alarm and control telemetry, multi-channel television and other service enhancements will also be possible over the telecommunication network. These possibilities are examples only, as actual provision of services will depend on the public demand for business and domestic purposes, and the economics of introducing them. However, network design will ensure that total communication requirements are able to be satisfied as these needs emerge. (Figure 6).
Some new services which become possible with advancing technologies also have significant social implications, and relevant community issues will therefore need to be taken into account as part of the planning for their introduction.

## CONCLUSION

I would like to conclude by restating the simple observation I made during my introduction, to illustrate the change that has marked communications. Up till quite recently the application of communication concepts was constrained by the available technology. In our time those constraints have virtually disappeared, electronic technology has advanced so far that practical applications are now largely limited only by the human and financial resources required for their conceptual, system and programme development.

A comparison with the automobile industry provides us with a useful perspective as to what is actually happening - if the motor car had developed as rapidly as the electronics being applied in communications, a Rolls Royce would now cost about $1.75, it would use .0003 litres of petrol per 100 kilometres (about 1 million miles to the gallon), and develop as much power as the ocean liner QE11. Unfortunately there would be a problem - it would be only the size of a pin head!

We are in the midst of an electronic explosion. The communication industry is in the forefront of harnessing this explosion mid applying new electronic technologies for the benefit of mankind. 1 am happy to say that New Zealand also is right up front in applying these developments to meet both present and future requirements for our community. And this brings me back to the reason for this lecture, which is to commemorate the late Ralph Slade. Although Mr. Slade may not have been able to predict the actual changes that have taken place and will continue to occur, his vision is being realised and his pioneering spirit lives on in the industry he did so much to establish in this country.