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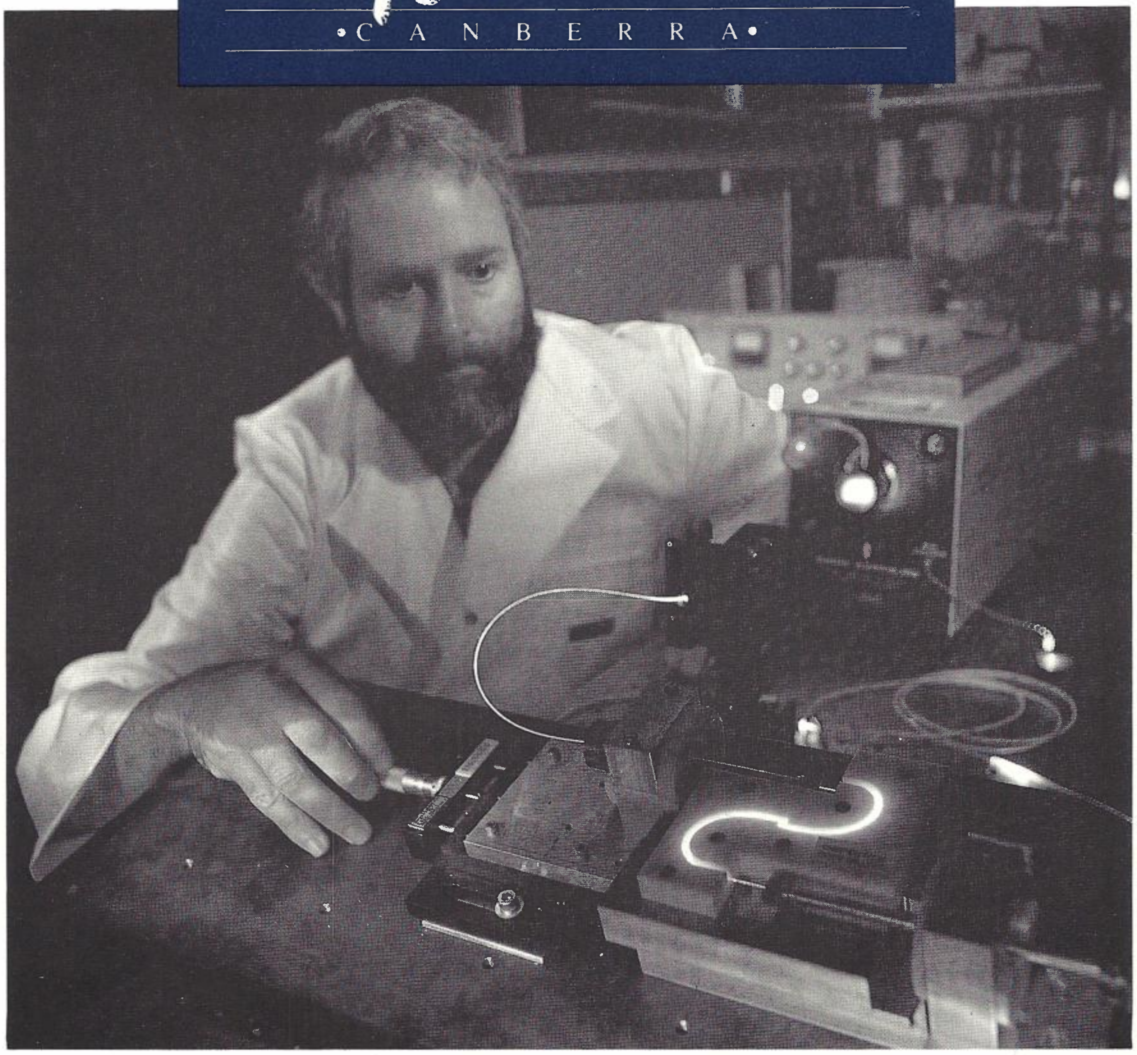


This magazine contains information about exciting research projects and recent scientific breakthroughs made at the Telstra Research Laboratories.

At Telstra we do our own research. Our customers benefit from leading edge technologies developed right here in Australia. At the Telstra Research Laboratories our professional staff undertake research projects to bring the future of telecommunications technology to our customers.

Telstra is proud to be a major sponsor of the Australian Science Festival.

Telstra

Research Laboratories

Switching

Switching to the Future

It is widely expected that in the future, there will be a significant increase in the number of telecommunications services available to business and domestic consumers. Work at Telecom Research Laboratories (TRL) is underpinning this expectation, and preparing the way for the further introduction of broadband services in Australia.

The telecommunications services of the future will integrate voice, video and data transmission on the same network. To achieve this, new switching technology is needed, and Asynchronous Transfer Mode (ATM) is viewed by many as the appropriate technology.

ATM is an integrating technology which allows diverse services to be switched through the same network and with the same transmission equipment. It can operate over optical fibre, coaxial cable and existing copper cables, and it has a much higher performance than existing circuit and packet switching techniques. The big advantage of ATM is that it offers bandwidth which is fully scaleable, or "bandwidth on demand". It is flexible enough to allow changes in bandwidth allocations to be easily made, both during a call and between one call and the next.

This makes the technology "future proof". New services developed using ATM can use any bandwidth for a voice, data or video service. This is important as network operators cannot guess what bandwidth will be necessary for future services.

Even for existing services, ATM's flexibility is important. For example, as video coding technology improves there will be a reduction in the transmission capacity required for a particular service. With ATM, there is no fixed channel capacity, so Telecom can improve existing services and implement new services without reprovisioning the network.

Many of the new services which are anticipated with the telecommunications technology of the future come under the banner of Broad band-ISDN, and ATM has been developed as the switching technique for this technology. However, ATM is already being used for other services, at lower transmission speeds than those defined for B-ISDN.

Despite the almost universal agreement that ATM will be the switching technology of the future, it is also agreed that currently, very little is known about the economics of ATM and the cost of installing it into the established network. ATM will be introduced more quickly if customers demand the services for which ATM is best suited, that is interactive multi-media services. But given those services do not exist at the moment, it is difficult to predict the consumer demand for them.

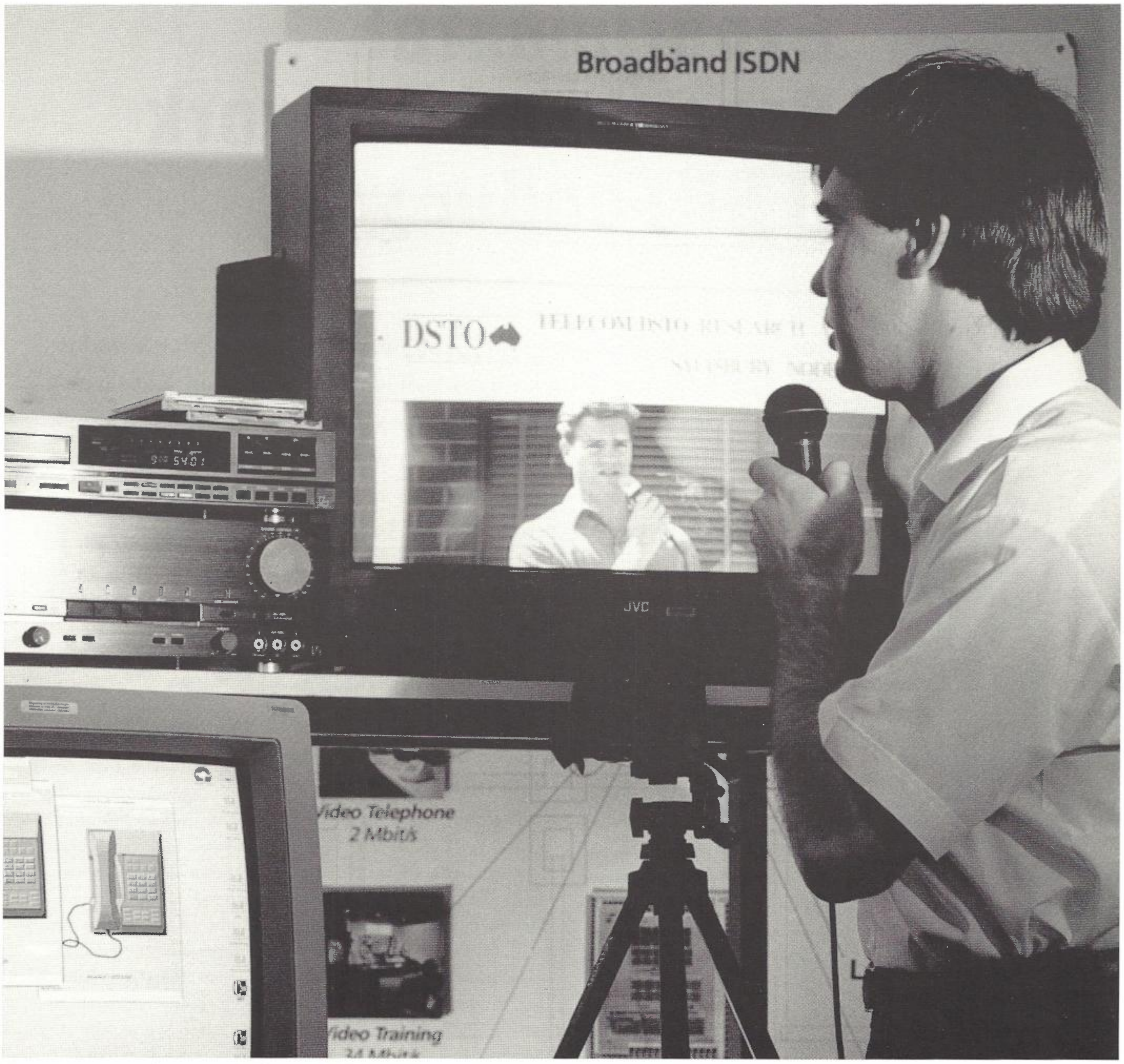
To help get the answers to some of these questions, TRL has worked with the Defence Science and Technology Organisation (DSTO) in Adelaide to establish a research ATM network.

The network was commissioned in November 1993. Garry Heinze of the Switching Section at TRL said the research ATM network is allowing researchers to test new services and what it takes to implement them.

"It also allows us to determine the cost effectiveness of replacing existing switching with the new generation ATM switches. This has the potential to simplify the overall network architecture and reduce operating costs.

"In the mean time, we have the research ATM network to test the theoretical models we have developed. It is important to test whether the ATM network behaves as predicted before we can recommend what can be done and how it can be more widely implemented." Garry Heinze said.

"There are many question which need answers at this stage. The different services have different bandwidth requirements. For example, voice requires a low bandwidth, which is constantly used. High speed data requires a lot larger bandwidth, but it only uses the capacity in



Videoconferencing on the research ATM network. A TRL researcher in Melbourne talking to a colleague at the DSTO in Adelaide.

bursts, while video requires a constant high bandwidth. We have to develop protocols which determine call admission, that is, does the network have enough capacity to fit in this call? There are some quite complex calculations to be made about the types of services and their characteristics, and how they can be connected into the network in the most effective and cost efficient way, and with appropriate attention to providing an acceptable quality of service for all customers.

"Also, the network needs to have controls on customer's traffic so they only use the amount of bandwidth requested. If customers want more bandwidth than is available, or if some network overload condition occurs, then some means of congestion control has to be established." Garry Heinze said.

Apart from testing the theoretical models and the economics of ATM switching, the research ATM network also provides TRL with the opportunity to demonstrate the technology to corporate customers.

How ATM Works

ATM is a fast packet switching technique which uses fixed length packets called cells, to carry digital information. The cell length of 53 bytes is divided into 48 bytes of user information or the payload, and five bytes of header information, which allows the cell to be directed (that is switched) through the network to the required destination.

In contrast to ISDN, where a call or service has a fixed capacity, an ATM network can in principle accept calls at any rate appropriate to the service. The network capacity is shared amongst the callers or services as they require it, rather than in a fixed and predetermined manner. This is what gives it the capacity for bandwidth on demand. ■

Experimental Broadband Network (EBN) under way

Advanced broadband communication services will play a major role in the future of businesses worldwide. Telecom Research Laboratories (TRL) has conducted extensive research and work on standards for broadband services, and is now planning an Experimental Broadband Network. This means Australia will be amongst the first countries to have broadband services.

Broadband services will encompass a wide range of voice, data and video information services which will be smoothly integrated through the broadband network. The services will range from standard products to highly personalised services developed by individuals. At this stage the debate about which will be the key broadband services continues. The technology is still in the early stages of development and development and considerable further research into broadband service issues is being undertaken.

So not only does the technology have to be fully developed, services and products have to be developed as well.

To progress this development, TRL will establish an experimental broadband network this year. The focus of EBN will be to provide a platform for cooperative development to take advantage of Asynchronous Transfer Mode (ATM) capabilities.

The overall aim of the EBN is to develop new telecommunications services and products in the Australian environment.

EBN will be developed in two stages.

The intial stage

The first stage over two years will establish ATM switches with 15 to 20 ports in Brisbane, Sydney, Canberra and Melbourne. The network will initially support semi-permanent connections, moving to the support of switch services as soon as possible. Synchronous Digital Hierarchy and other current transmission technologies will be used to carry the ATM cells.

The second stage

Stage two of EBN development is planned for mid-1996. It will have additional network features and capabilities, the exact nature of which will depend on developments in stage one, and on market requirements and demand.

EBN Researcher Brian Kelly believes it is important to keep an open mind about what services are developed.

> **The higher bandwidth networks will let customers ask new questions, such as " What image quality do we need?" rather than "What image quality can we get?"**

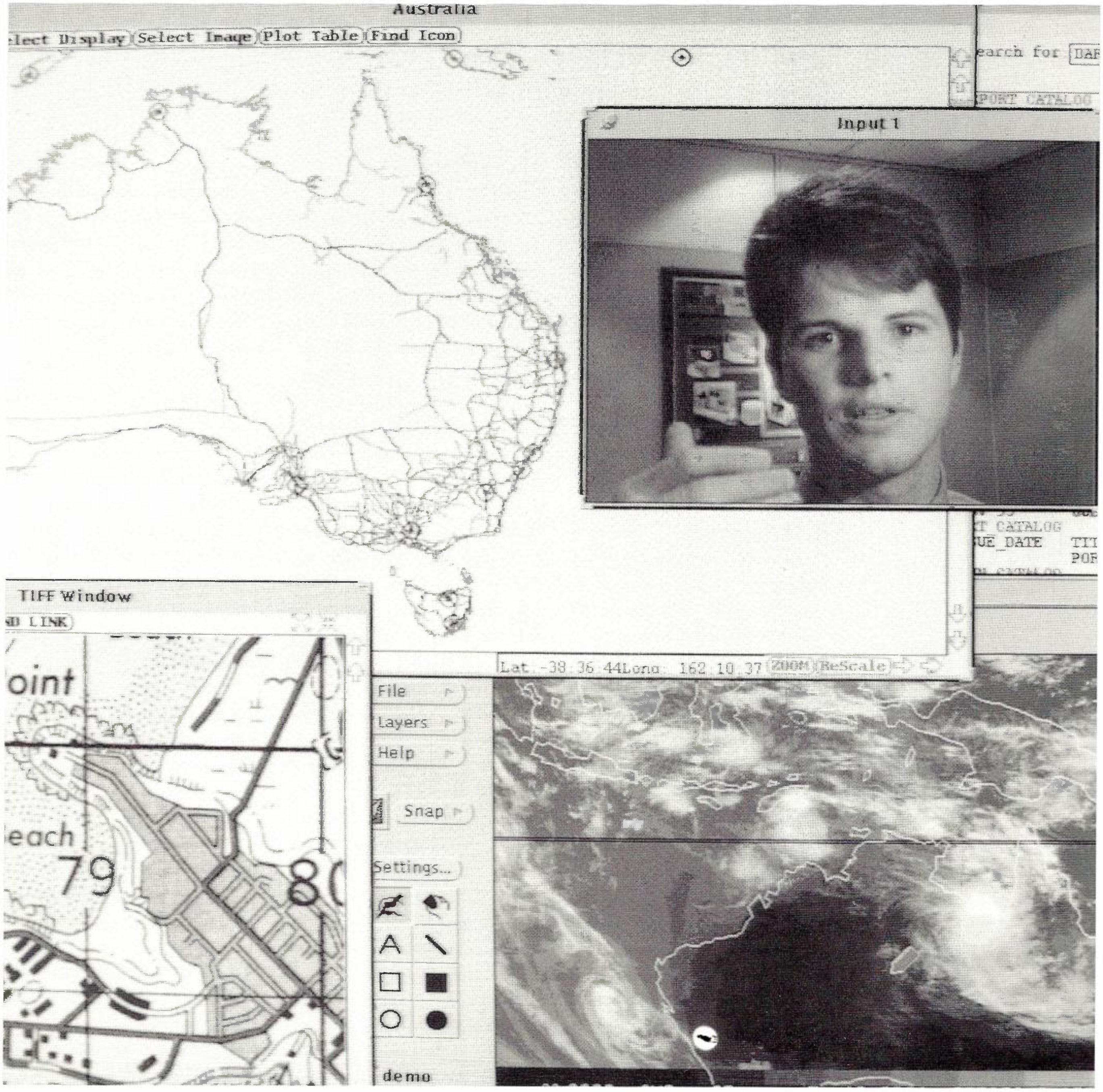
EBN

"There is no certainty about what broadband applications will meet the strongest demand. However, there is already evidence of a growing demand for specific applications in a wide range of businesses in the finance, media, publishing, entertainment, retailing, health care, manufacturing and transport sectors.

"Advanced broadband communications will change the environment in which business will operate. For example, the higher bandwidth networks will let customers ask new questions, such as " What image quality is required?" rather than "What image quality can we get?"

"However, there is no one application associated with ATM which would by itself guarantee the introduction of ATM. ATM will be introduced to meet service demand when several different applications and market sectors reach a critical mass. Just where and when this will happen is still uncertain. Meanwhile, the EBN should give us some answers to reduce the uncertainty about the introduction of ATM. It will continue Telecom's learning process with this technology and provide opportunity for the cooperative development of applications in an ATM environment." Brian Kelly said. ■

A multitude of services will be possible on a broadband network.



Pay TV

Pay TV now on Copper

In Australia, it appears the telecommunications future lies with optical fibre, given the pace at which this thin thread of glass is being installed. Conversely, it appears that the existing copper wire network is yesterday technology and is due for the scrap heap. However, a new technology which is being developed at Telecom Research Laboratories (TRL), will see the copper network being used to deliver Pay TV and a range of other video services. This will exploit the capacity of the copper wire access network far beyond what was ever thought possible.

Pay TV is currently a hot topic in Australia, but there is a lot of confusion about the technology which will deliver Pay TV. To add to this confusion, there is now another possible Pay TV delivery system, Asymmetric Digital Subscriber Line or ADSL.

ADSL was originally developed at Bellcore in the United States in the late 1980ís.

It supports high speed data transport over the existing telephone copper pairs, so it can be used as part of an overall video delivery system.

Manager of Integrated Communication Services at TRL, Phil Sykes, said that ADSL technology represents the intersection of advanced line coding techniques and the availability of low cost digital signal processor technology.

"ADSL is being positioned as one of a number of access network technologies which will deliver visual and multi media services to the mass market. While no-one knows exactly what these services will be, it is widely expected they will require a large bandwidth and interactive capability.

"The major advantage of ADSL is that the copper network from the exchange to the house already exists. This means customers could easily be connected to pay TV and video services without digging up the streets to lay new cable. Also, the current national optical fibre infrastructure has the capacity to deliver large amounts of information from the service providers to the exchanges. ADSL technology will complete the link between the exchange and the customer.

"If we were to lay optical fibre to all homes, it would cost billions of dollars and take a significant amount of time to complete. Even the roll-out of optical fibre/coaxial cable, which has already started, will take a considerable amount of time. ADSL has the potential to make interactive services available earlier than they could otherwise be achieved.

Phil Sykes said ADSL video delivery is far more complex than a cable TV network.

"This is because the video has to be switched in the network, and that requires considerable expenditure on switching equipment. With cable, all the TV and video channels are delivered to the customerís set top unit. The customer simply selects the desired channel.

"However, ADSL represents the beginning of a new era in technology in the home which will have many and varied consequences. It will stimulate and bring forward interactive video applications. People will get a taste of interactive services and this will be important to help stimulate market demand for such services.

"Implicit in ADSL is a fundamental shift in who has the power to control services. With current free to air TV, the power is with the broadcasters, as they determine what is viewed and when. In reality, the customers of the broadcast TV channel are the advertisers, not the person at home watching television. With Pay TV and multi-media services, the power and control shifts to the person with the remote control unit at home."

The ADSL Demonstration System and Field Pilot

TRL is well advanced with its work on ADSL video based delivery systems. A demonstration system, which has been supplied by AWA Australia at a cost of $1.5 million, is now fully operational. The system consists of a real time video encoder, a video server, wideband switching, ADSL and TVs with digital set-top units.

Phil Sykes said this demonstration system allows TRL to show Telecom's customers, particularly the service providers, the performance and applications that can be supported by interactive video delivery systems.

However, the demonstration unit represents only part of the research work.

"ADSL access network technology is one thing, but having a fully operational service is another. There are questions of how to activate the service, how to charge and bill for the service, how to manage the transmission, and what service and customer support systems are required."

To help answer these questions, an ADSL field pilot has been established.

Telecom has invested $15 million with NEC to establish the field pilot. It will be centred on Melbourne, and about 300 consumers will access the services provided.

The pilot will support 10 live video channels and up to 50 channels for video on demand and other retrieval services. It will test ideas which have already been developed with the TRL demonstration system, and it will allow content providers to work with Telecom to prototype applications.

Content providers will eventually include video distributors, entertainment houses, computer software distributors, banks, retail outlets, government departments and educational institutions.

Pay-TV on ADSL can be quickly connected and it is suited to areas of low density housing.

The Future of ADSL

However, Phil Sykes said that the introduction of ADSL is not a foregone conclusion.

"The existing network is optimised to switch voice traffic. For Telecom to deliver interactive video services to the mass market, a considerable investment in broadband switching equipment will be required. Initially, Telecom will use the capabilities of it's Synchronous Digital Hierarchy (SDH) transmission network to transport and switch video streams, and the network will gradually evolve to broadband switching.

"However, ADSL does offer a lot of flexibility in the deployment of video and information services. The roll out can match demand, which makes it more economical than optical fibre, where a whole street would have to be laid with fibre, even if there was only one customer. This makes ADSL suited to low uptake and low density housing areas, and it can be deployed very quickly to meet market demand."

How Video is Delivered with ADSL

Starting at the home, a set-top unit and standard television set are required. The set-top unit will be about the size of a standard telephone answering machine and it will decode the digital video signals. The standard telephone line will be terminated at an ADSL box attached to the house. This box will split the service into telephone and television streams so there is no interference if the telephone is being used while a video is being screened. The unit will be powered with 240 volts, but in the case of a power failure, power will be maintained to the telephone service.

At the local exchange, another ADSL unit terminates the customer's line and splits the telephone and video signals. At this point, telephony and video will not be integrated, but in the future, it is anticipated that Asynchronous Transfer Mode will be the means of switching, and that will integrate all services (telephony, data and video), no matter what its source.

The next element of digital video is the information itself. Video information will be encoded, compressed and stored in digital media servers. From there, the video will be accessed by customers through the Telecom delivery network.

Customers will interact with the set top unit and entertainment service via a hand held remote control device. The video quality will meet currently accepted broadcast quality expectations.

"What needs to happen now is to develop the market and the business that the ADSL technology will support." Phil Sykes concluded. ■

Self-healing Networks

Self-Healing, Survivable Networks

We are rapidly reaching the stage where telecommunications services are as essential as electricity, water and gas. Indeed, many people claim telecommunications have already reached that stage. Many companies and businesses would be severely disrupted if there was a major breakdown in the telephone network. Network management research at Telecom Research Laboratories (TRL) will ensure that the future network can be robust and will have the capacity to heal itself if a problem does arise.

Maintaining a reliable service is an important feature telecommunications companies can offer customers. As the information superhighway develops, it will be possible to transfer huge amounts of data all around the world and there will be economies of scale in using the high bandwidth available with optical fibre.

However, there is a downside to this scenario. The operation of many businesses will be relying on a single optical fibre about the diameter of a human hair. If this fibre is cut or disabled in some way, there could be major disruptions and a huge amount of information and many customers could be affected.

To prevent this from happening, researchers have investigated ways in which the network can heal itself in the event of a breakdown, so that despite cable damage or equipment failure, the network survives.

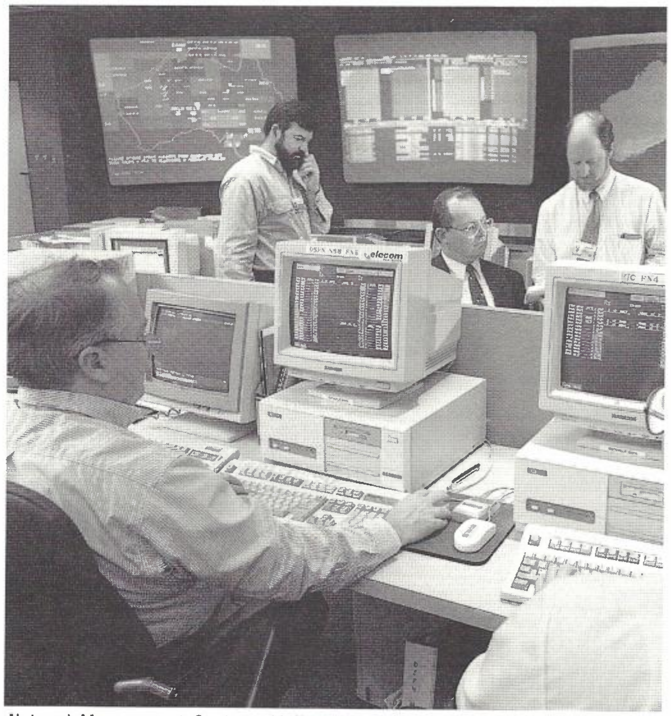
Dr Meir Herzberg and his Network Management team at TRL have determined there are three conditions necessary for a telecommunications network to be self-healing.

Physical Route Diversity

If there is only one optical fibre connection between two points and it fails, there is no alternative way to make a connection. For a network to be self healing, it needs to have more than one connection path between any two points.

Pre-placement of Protection Capacity

By having more than one pathway between two points, excess capacity can be introduced into the network. Network planners call this redundancy, and they plan it into the network design. If there is no redundancy there is no protection capacity. If the line is exactly duplicated, you have 100 percent redundancy. However, 100 percent redundancy is expensive, so the trick is to find a more effective way which balances between an adequate amount of redundancy and cost.



Network Management Centre —Melbourne.

Functional Control

If a disruption occurs, there needs to be some mechanism which recognises the problem and takes restoration actions to cope with the failure.

TRL Contribution

"With these three factors in mind, we devised a scheme to optimise the assignment of protection capacity. We have developed a computer program, the heart of which is an off-the-shelf mathematical package," Dr Herzberg said.

The problem of assigning effective and economic alternative linkages becomes very complicated as the number of nodes, or points to connect, increases. Very large networks, such as the telephone network in Australia, need lengthy computations to determine optimal assignment of protective resources.

Again, the researchers had to consider three factors:

- The system had to protect against all types of failures, from a single link failure - where a back-hoe has cut the cable, to a multi-link failure or a failure of a transmission node, which can be very complicated.
- Transmission systems are modular, that is, if extra transmission capacity is required, then an additional whole unit of transmission equipment is needed. There is no such thing as a half transmission unit. This is a complicating factor when it comes to devising an economic self-healing system.
- In a large network, there would be many choices of alternative routes for the recovery of transmission between two nodes, and even with current computing power, this could be time consuming and cause confusion in the network. The simple but very effective solution to this problem was to introduce a "hop limit", that is, a limit on the number of nodes or hubs the re-routed transmission goes through.

"By imposing this hop limit, we dramatically simplified the problem the network management system has in deciding which route to take in a large network. The hop limit creates short and most efficient routes for the self-healing process."

"The scheme developed is state of the art. We believe we have an algorithm which will be attractive to many telecommunications carriers around the world," Dr Herzberg said.

The management software package can be used in two main areas of Telecom. One is in the planning of the networks. Redundancy will be designed into the network to be efficient and effective. And it might be used in the network management centres to assist in the management of problems should they occur.

An international patent has been applied for on the prototype program.

ATM and Self-Healing

The idea of self-healing and survivable networks is particularly suitable for Asynchronous Transfer Mode (ATM) networks.

At each node in an ATM network, there are virtual path identifiers, which identify to which pathway the packets (cells) of information should be directed.

It is possible to include virtual path identifiers for back-up purposes. So in an ATM network, the back-up virtual path identifiers will be set up in advance, but will only become "alive" under failure conditions. Such an arrangement seems powerful as back-up virtual paths are not consuming protection capacity under normal circumstances. ■

Healesville Line Depot staff (L to R Colin Kobiolke, Paul O'Brien, Ross Vanes) repair Telecom cable damage by a Back Hoe.

Failure and AT&T

In 1989 in the United States, the largest telephone company AT&T suffered a major collapse of the network. Their long distance network was dead for about seven hours.

The company feared a loss of customers after the event, but incredibly, the opposite happened. AT&T gained customers.

What happened was that with the breakdown, companies realised just how important telecommunications had become, and that failure was possible. It appears that the assessment of the situation was that you needed to be with a reliable company, which was more likely to be a bigger one, and a company with the capacity to fix problems quickly. AT&T had a good reputation in this area. The breakdown highlighted their reliability, and businesses chose to transfer to that company. ■

Broadband ISDN

Broadband ISDN — the coming Revolution

The potential for change in telecommunications technology is so great and all encompassing, it almost defies the imagination. Researchers at the Telecom Research Laboratories are at the forefront of work to bring about these changes, to ensure that Australia can capitalise on the benefits of the new technology.

Throughout history, revolutions have been the turning points for major changes in society. With hindsight, many revolutions were predictable. Most were not predicted.

However, the next revolution is both predictable and predicted. It will be totally non-violent, and many people will never recognise it as a revolution because it will become so much a normal part of life.

The revolution is the integration of audio, video, print, data and graphical information, so a person may use all these sources of information simultaneously at a computer terminal in the office or home.

The technical capacity and potential of this union will only be limited by imagination and people's capacity to change.

Telecom Research Laboratories already has Australia at the leading edge of world developments and application of this new technology to meet the future communication needs of people in their business and personal activities.

The researchers at TRL have a name for this revolution. They call it Broadband ISDN. ISDN stands for Integrated Services Digital Network. The broadband part, as its name implies, is the widening of the bandwidth available for communication such that video and high definition television can be integrated with voice and data communication.

This new communication system will be extremely powerful, it will be visual (video phones and dial a video for home entertainment), it will be intelligent, and it will be personalised and feel very natural.

A lot of what is written and spoken about Broadband ISDN is surprisingly non-technical. It is surprising because the systems that support this coming revolution are state of the art technology. It is pushing the bounds of what is possible to almost the limits of imagination.

Part of the reason the talk is relatively non-technical is that much of the technology has been around for some years. Broadband ISDN depends on the incredible capacity of optical fibres to carry information in a digital form, and optical fibres were developed in the 1970s. It depends on switching systems and devices that were developed in the mid 1980s. And it depends on all the current, separate, communication technologies such as data transfer, audio, video and image systems.

Possibly the main reason the talk is non-technical is because the engineers have asked just what do people want of their communications systems for their business and domestic lives. Much of the discussion and development of Broadband ISDN is how to make the system "user friendly".

However, Broadband ISDN will not just be user friendly, it will be natural. The communication systems will be visual, intelligent and highly personalised. It will deliver communications exactly as people want, no matter how personalised that communication may be.

This aspect of the development is vital given the access people will have to other people, to information and to information processing systems.

ISDN is already operating in Australia. In fact through the efforts of TRL and Telecom, Australia was the first country in the world to have a nationwide ISDN service.

ISDN provides many new services to customers such as itemised telephone accounts, calling-customer identification, third party billing and credit card calls.

Broadband ISDN will be a quantum leap forward from ISDN. From the mid 1990s, offices and the way in which people work will be transformed. The new technology will become cheaper as time goes on and the equipment will be available to smaller and smaller businesses, until early in the next decade, the equipment prices will become cheap enough for domestic use. A parallel development will be the replacing of standard telephone cables with optical fibres.

Broadband ISDN and Business

Business communication will see far reaching and rapid changes during the next six to eight years as the Broadband ISDN revolution takes hold.

By integrating audio, video, data and graphic communication services, transmitted through optical fibre, a whole new world of personalised office communication will be opened up.

Videoconferencing will be done from the personal computer terminal at a desk. And you won't have to be at your own desk. You will be able to quickly and easily personalise any terminal to handle the communication you want.

Instead of walking down the corridor to seek or check information with the resident expert, through your computer terminal you will be able to scan the subject area for written information and contact people who can help you, even if they are on the other side of the world.

When writing up reports or developing plans with colleagues in other states or even other countries, you will set up a video conference on your PC terminal and develop the report, or plan together using electronic pens or other editing procedures. The changes will be instantaneously transmitted to all participants.

The level of access to people, information and information processing, and the speed with which the access will be achieved means a whole new work environment will develop with the introduction of B-ISDN.

There have been many studies of business communication activities and the consensus is that the following features are required by customers:

- personalisation and flexibility to reflect the changing communication needs of the customer
- integration of conferencing and other office tools
- a capacity to provide a multi-media working environment
- a multi-point working environment for conferencing and collaborative work
- greater use of visual communications

The key to developing the integrated service is a new concept for information transfer through a networks. The information transfer system is the Asynchronous Transfer Mode or ATM. This allows high performance public networks to be developed, which can handle all types of visual, data and audio services.

The new possibilities have given rise to three new terms in the communications language. The words are multipoint, multiparty and multimedia.

Multipoint

A normal telephone conversation involves point to point connections. Multipoint facilities are available at the moment with such things as a phone conference call, but the technology uses a set of point to point connections to establish a point to multipoint communication. The asynchronous transfer mode (ATM) transport system makes it possible to connect one source simultaneously to multiple destinations.

Multimedia

B-ISDN has the capacity to transport different information types or media. These include audio, video and data media. However, not only will B-ISDN transport the different types, it will integrate the different media so they are all available simultaneously.

Multiparty

A flexible conference and collaborative working arrangement between many parties will be a feature of B-ISDN. The intelligence and control of the system will be such that parties will be able to enter or leave the call at any time without any disruption to the multiparty call.

This multifunction aspect of B-ISDN is illustrated below.

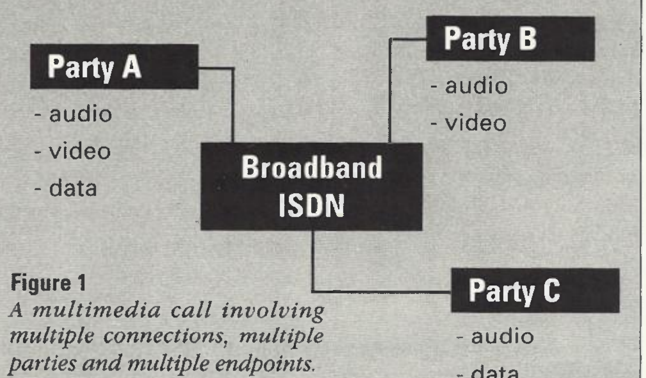


Figure 1
A multimedia call involving multiple connections, multiple parties and multiple endpoints.

Timetable for Broadband ISDN

1994 A limited integrated service will be available; the equipment will be in place to achieve local area networking.

Initial International standards for Broadband-ISDN will be in place.

1996 International standards for a fully featured Broadband ISDN will be completed. There will be public networking multi-media, voice, visual, data.

1998 Equipment for the fully featured B-ISDN service will be commercially available. Fully featured services will be installed by large companies, with smaller ones following as the cost of equipment reduces.

2000-2005 Optical fibres will be installed into the domestic network. High definition TV (HDTV) and multi-media equipment will be cost-effective for domestic use.

Other Implications

There are two sure things about B-ISDN; the technology will be developed, and the capacity of the technology will deliver the type of services people want in their business and personal lives.

What is in no way certain is what etiquette people will develop for using such things as video phones and videoconferencing, what legal implications will arise from the introduction of such powerful communications technology, and the capacity of the legal profession to develop reasonable techniques to deal with issues such as copyright and privacy.

The other uncertainty is how many people will take advantage of all the possibilities B-ISDN will provide.

People will be able to access "electronic books", view "electronic exhibitions" of works of art and museums, and partake in tele-education.

For example, with B-ISDN, it will be possible to simultaneously distribute a single lecture to many sites. A classroom atmosphere could be created in the home through the ability of the students to ask questions and be in visual contact with the lecturer through their computer terminal.

The potential for this type of teaching is enormous. Specialised courses that only attract a relatively few people in each centre could be easily offered on a regional, state or even national basis through the teleconferencing simultaneous lecture facility.

Again, it seems people's imagination will be the limiting factor in how this technology could be used.

International Leadership Role for Australia

One measure of Australia's place in the development of ISDN and Broadband ISDN is the fact that Australia has chaired the international committee that is developing the world wide standards for this future technology.

Broadband ISDN will be a world wide system, with the ability to access any information anywhere, and combine it with other audio, visual and data systems, and that means a lot of effort has to go into creating standards acceptable to all countries.

Also, the manufacturers of Broadband ISDN equipment need to know technical standards so they can develop a range of suitable equipment. Once the international standards are set (by 1996), it will take about two years for the manufacturers to gear up to full scale production of the new equipment. ■

Photonics

Photonics — communicating at the Speed of Light

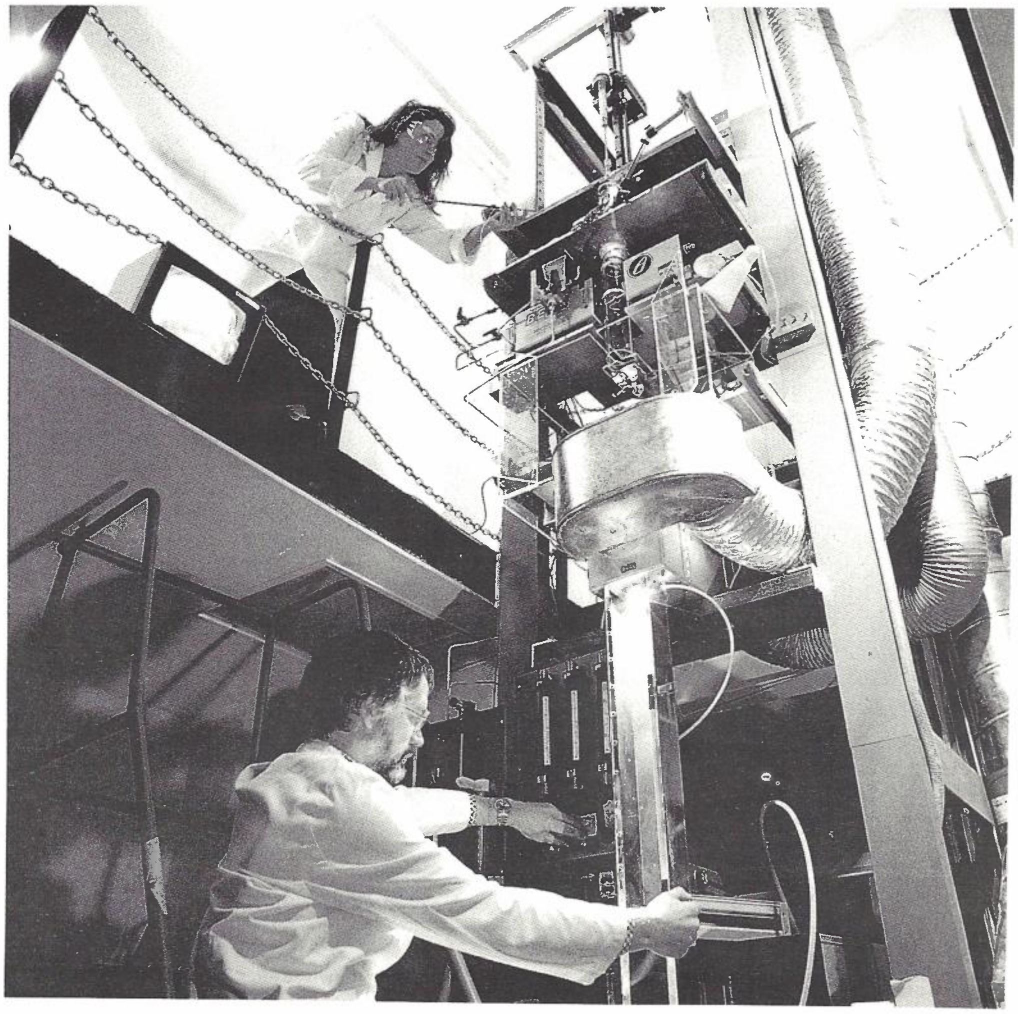
Australia is moving towards light wave communication as optical fibres replace copper cables to carry telecommunications traffic. Telecom Research Laboratories are developing expertise so that the country can communicate at the speed of light.

Optical fibres have a tremendous capacity to carry information in the form of light signals. This has spawned a whole new area of research and development in a field called photonics, which is the use of the fundamental particles of light - photons - to transmit, store and manipulate information. Photonics uses light instead of electrons, on which electronics is based. Photonic technology has triggered a global communication revolution which is now vital for modern economies.

Australia is well placed to take part in this telecommunications revolution, thanks to Telecom developing and installing an optical fibre network throughout the country, and OTC installing undersea optical fibre links.

However, while the optical fibre network is developing at a fast rate, and despite the incredible advances which have been made in optical fibre technology, there are still some major hurdles to overcome to take full advantage of optical fibre.

Researchers Lisa Powell and David Coulson prepare TRL's optical fibre drawing tower for operation.



As well as having great capacity, optical fibres carry data at great speed, but when transmitted over long distances, signals need to be boosted at between 50 to 100 kilometre intervals. Currently, to boost a signal in an optical fibre, the optical (light) signal has to be converted back to an electronic signal, boosted, and then converted back to the optical signal to be shunted along the fibre.

These opto-electrical repeater stations are complex and expensive, so scientists have been investigating ways of eliminating or at least reducing the number of opto-electrical junctions in a network.

Optical Fibre Amplifiers

Scientists in the United States discovered in the mid-seventies that optical fibres made from silica glass and impregnated with traces of a rare-earth element can amplify light signals when the rare-earth element is energised by another light source. The energising light has a slightly different wavelength from the light carrying the signal.

This research is vitally important for Australian telecommunications given the great distances over which optical fibre links are laid. Amplifiers are also needed to compensate for losses when a signal is divided many times over a network, as would occur with the distribution of Pay TV services. Amplifiers are now becoming commercially available for the lowest loss operating region of the optical fibre, and it is planned to install them on the long inter-capital trunk routes.

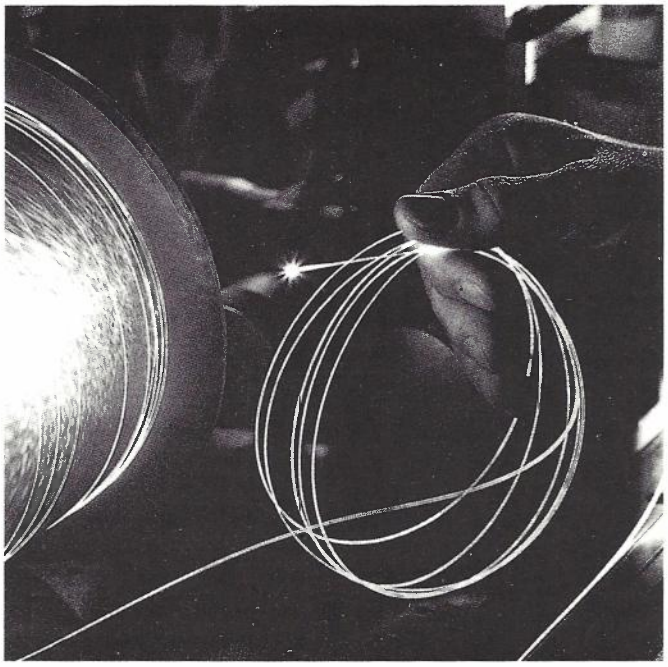
However, amplifiers are not yet available for what is the most reliable and the highest speed operating region of the optical fibre. Telecom Research Laboratories (TRL) have one of just five groups of scientists world-wide working on a range of fluoride-rare earth doped fibre amplifiers, which matches the high speed operating region of the optical fibre installed in the Australian network.

Photonic vs Electronics

Because photonics and electronics achieve a similar end result in the area of telecommunications, there is a tendency to compare the two technologies. However, it is lightwave communication which is going to take telecommunications to the next level of development and into the 21st century. The whole concept of Broadband ISDN (see Future Focus 1), will depend on the capacity and speed of photonics. It will allow the function of telephones, facsimiles, computers and television to be integrated, and from which will come many new services such as video conferencing from your office computer, access to huge data files and banks for data retrieval, no matter where in the world the information is stored, and eventually, for the home user, direct access to video libraries for home entertainment.

Apart from capacity, there are other major differences between photonics and electronics. Photons do not have an electrical charges like electrons. There is little interaction between photons, and between photons and the transparent conduits, to the extent that one light signal can be transmitted through another light signal with no distortion. This means many light signals can easily be sent long distances through an optical fibre. The big disadvantage is that because there is little interaction between photons and they are highly transparent, it is more difficult to switch and control the lightwave information packets in a telecommunications network.

Control is required for two main purposes. One is to boost signals through long lengths of fibre (that is, over distances of thousands of kilometres) and the other is to switch signals to different destinations. Both these areas are subject to world leading research at TRL.



Optical Switches

As has been mentioned, the outstanding feature of photonics is the huge capacity of optical fibres to carry messages.

Because the speed of transmission is fast, the components of the network have to perform at similar speeds, otherwise full advantage cannot be taken of the system.

A simple analogy can be made with cars and traffic lights. If traffic lights respond slowly to traffic conditions, the movement of traffic is slow. If the lights respond quickly, then the traffic can flow more quickly.

In photonics though, the scientists talk about almost incomprehensible speeds. For example, Dr Garth Price, manager of photonics research at TRL, says that information is transmitted in packets at a speed of 10^{10} bits a second, that is, 10 thousand million bits of information a second.

"So the system is not slowed down by the switching device, the switch has to operate at least at $1/10^{10}$ of a second, and we want switches which operate at $1/10^{12}$ of a second. Not only do we want the speed, we want the switch to operate with very little energy.

"We are also looking at the possibility of keeping the normal silicon chip and using optical interconnections. This could overcome the bottleneck that occurs where within a computer chip, there can be one million gates, but only several hundred 'legs' for the information to move into and out of the chip. There is another factor of the physical distance between the chips on a board and the distance between boards in a computer. All these factors slow down the job the device is designed for.

"Because information moves so fast, there is a need for better communication between chips. In theory, light transmission of information would be faster than electrons and there would be no cross talk, that is, non-interfering communication channels.

(Continued overleaf)

Photonics —communicating at the Speed of Light

Another big advantage of photonic switching is that the chips can be stacked one on top of the other, and using the third dimension allows for better use of space in telecom-munication equipment and computers."

TRL has already patented a number of switches the researchers have perfected. The details of the switches themselves and how they attach to the silicon chips is quite fantastic. Each switch consist of 80 to 100 different layers of semi-conductor material with each layer being 1/10 of a micron thick. The switch is grown on a crystal in a complex machine at TRL and each layer is precise to the level of a few atoms thickness. The devise is then lifted from the crystal, and placed on silicon, with which it forms a natural bond. By putting a small electric voltage across the switch, the switch (or mirror) turns off and on very quickly, so when a light source is directed to the switch a signal is created and directed to another destination.

▲ Optical Fibre researcher Chris Byrne investigates the properties of new optical fibre technology.

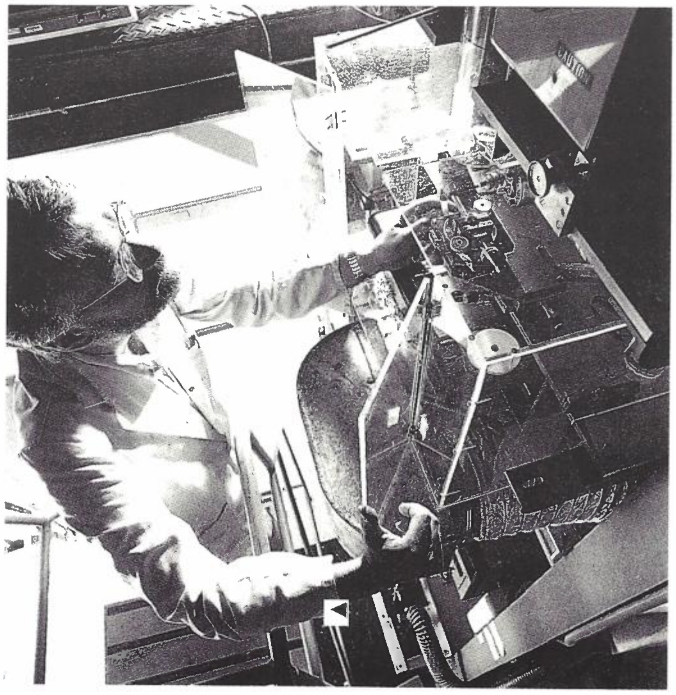
Opto-Electronic Devices

Another part of the photonics research at TRL deals with the technology of getting optical fibre to the customer, the user of telecommunication services. This research is complicated by not having a clear idea of what services will be required by people, and in many cases, people will not know what services they want or are useful to them until the services are available. Even within the research community, there is a range of opinions on which way the research should be directed.

To Jim Thompson, the technical constraints, while significant, are almost the easy part of the equation.

"At the moment, many of the opto-electronic components are Rolls Royce jobs, highly over specified for what is required in the commercial telecommunications network, and therefore very expensive. What is needed is a network design which uses standard devices, which are simple, cheap and easy to manufacture.

"One of the innovative devices we are looking at is a hetero-junction bipolar photo transistor, and despite the



◀ Researcher David Coulson operating TRL's optical fibre drawing tower.

name, it has great possibility to be integrated in opto-electronic devices. The device is a transistor which detects light. It operates over a wide band width, it is more efficient and cheaper to produce than the currently used diodes and it is readily incorporated into devices."

Other photonics research at TRL includes working on optical wave guides, or devices which terminate or connect fibres to opto-electronic devices. It is a measure of the status of photonics that while the possible benefits and advances from photonics are widely recognised, researchers are still trying to perfect devices to perform some of the most fundamental tasks required in a network. All this work at TRL is placing Australia in a box seat to take up innovations from all around the world and to introduce them into the Australian telecommunications network for the benefit of business and of all Australians.

Commercial Opportunities

The future prospects for commercialisation of photonic technology are huge, given the great range of possible applications photonics will have. However, even now, there are significant commercial opportunities, and these are in the areas of the production of optical fibre and cable; amplifiers and detectors based on semiconductor technology switches; and other devices needed to manipulate photons in an optical fibre network.

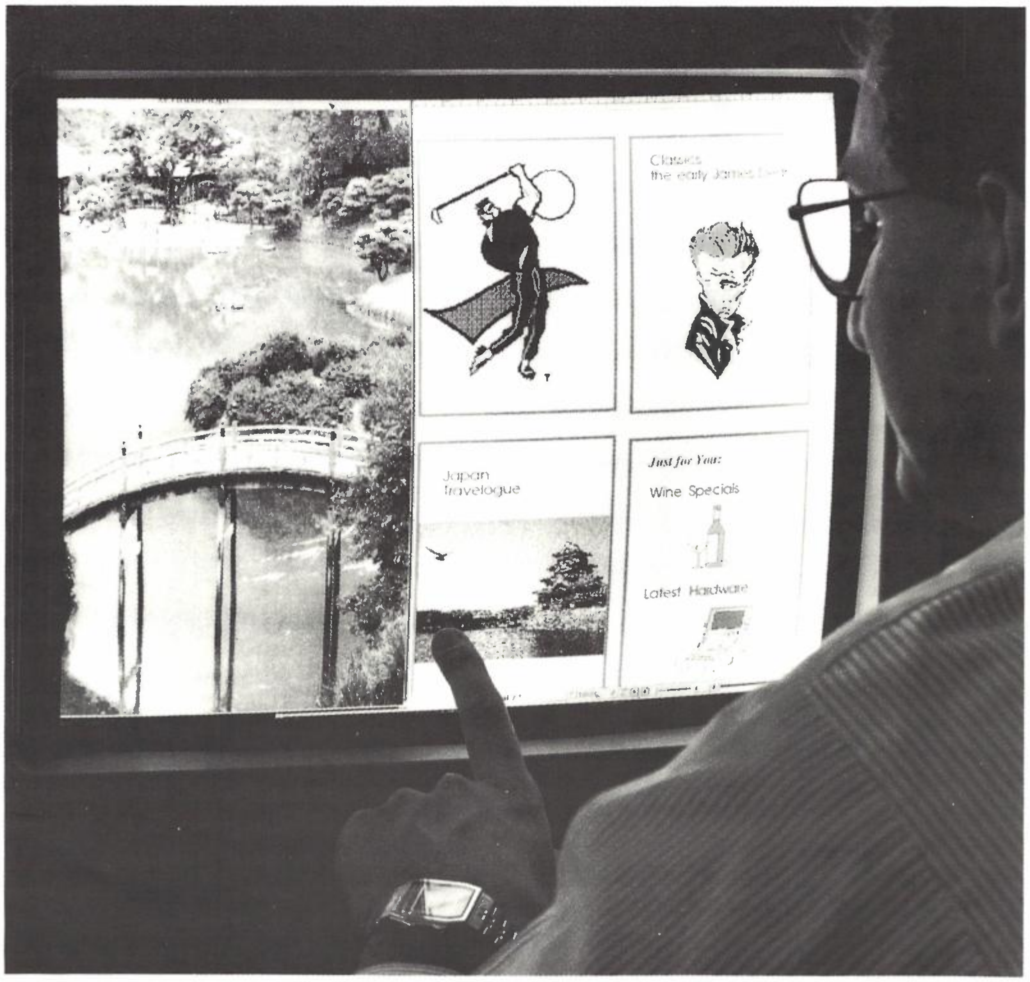
TRL's expertise and experience, along with the work which will be performed at the Australian Photonics Cooperative Research Centre will help underpin these commercial developments. ■

High Tech yet more Personal

With increasing access to information through the linking of computer and telecommunication technologies, people are increasingly faced with greater choice in the services and information available to them. Telecom Research Laboratories (TRL) is looking at how to use high technology to create a more personal way of choosing what is on offer.

Imagine sitting down one evening to watch some entertainment on television, and you have complete freedom to choose either a program or a video. However, in the new age of optical fibre and computer linked telecommunications, you have 500 television stations to choose from, as well as a choice of all the movies ever made. You could dial up a movie to run at any time which suits you. How would you make the choice of which program or movie to watch? The choice is overwhelming.

The question arises because the reality of having unlimited access to movies via the telecommunications network (through optical fibre) is getting closer. In fact, that could be a reality within a few years. Along with the access to the movies, you may also have



Dr Andrew Jennings tests the latest call-up entertainment and travel information program.

access to up to 500 channels of television.

So how do you know what is on and if you want to watch it? Written directories of videos or television programs would be large and difficult to use, and for most people, most of the information would not be required.

Its in this area of choice that a computer model can help. Apart from the computer holding all the information about what is on or available, it is possible to model what people are interested in, and that could help people make a program choice.

Dr Andrew Jennings, Manager of Artificial Intelligence Systems in the Customer Services and Systems section of TRL, has found that a customised guide is very useful for choosing entertainment.

"If you are after information for a school or work project, you will put a lot of effort into getting a range of relevant information. However, with entertainment, we do not want to spend a lot of time making a choice. Future networks will offer an incredible range of choices, so if we model the users interests, we can reduce the amount of information required to make a choice."

"Say for example I like action movies. With a movie adviser, into which my movie preferences have been entered, a list of maybe five action movies which I have not seen would be presented to me for consideration. The personalisation of the movie adviser service means there is a record of every movie I have seen. It also has information on my second and third choice areas of movies. All this can help to create choice without a lot of effort."

Andrew said there are some obvious aspects which need to be addressed.

"One is the system has to be flexible, so that while I generally like action movies, I may have heard from colleagues about a movie which is completely outside the range of my normal viewing, and I still want to have easy access to it. The other vital aspect is privacy. Without privacy, advertisers and retailers would be constantly annoying the consumer, based on the preferences they have for their entertainment."

"Another service we have trialed is a personalised news service. This type of service would take a large number of news articles and deliver them on screen according to the interest of the reader. It would record the history of readership, based on the articles a person reads and rejects, and construct a model of preferences. Over time, the words which appear most often would guide the selection of new articles." Andrew said.

"The trials show that such a service could be useful, and could reduce the "information overload" involved. However, we found it is important to allow flexibility of use through a good user interface."

"In both the movie adviser and the personalised news service, the model would be based on an artificial intelligence program. It would record and learn about your preferences every time it is used. There are a number of practical questions to be answered before this idea is useful when on-line movies become available, but at this stage we believe the adviser system will be an integral part of personalised home entertainment." Andrew said. ■

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