Telecom Australia

switching tomorrow

Telecom's new telephone exchange system

Some History

The first telephone exchanges in Australia opened in 1880. The Melbourne exchange served a grand total of 44 customers. All calls were switched manually between customers by telephonists.

In the hundred years since then, the Australian telephone network has grown explosively. Today, there are over 4 million telephone services in operation, and nearly 5 thousand million phone calls are made in Australia every year. It is obvious from these figures that the switching mechanism to handle all of these calls must be extremely sophisticated and up-to-date.

As the number of telephones in Australia has grown, new automatic exchange equipment has been installed at intervals to meet the growing demand.

The first public automatic exchange opened in Geelong, Victoria in 1912, and this historic milestone generated considerable interest in the first use of electro-mechanical step-by-step switching equipment. The next stage, in 1937, was the introduction of '2000-type' step-by-step switching equipment, again based on now well-established, electro-mechanical switching devices. The next really big change was the introduction of the so-called 'cross-bar' switching systems. The first major installation of cross-bar equipment was brought into service in Toowoomba, Queensland, in September 1960 and after nearly twenty years of wide ranging operation cross-bar is now currently being up-dated by the addition of equipment called ARE 11 to bring it into the era of electronic switching.

Introduction of AXE

The next stage, which will allow Australia's telecommunications network to best meet the foreseeable demands, is called AXE.

The AXE system, by the Sweden-based company L M Ericsson, was chosen by Telecom after extensive evaluation of world-wide tenders over a number of years. The new equipment will have considerable advantages for Telecom, and for the telephone users of Australia.

The new equipment has the potential to give the nation's telephone users an increased range of services such as allowing the use of automatic message accounting for international calls, re-direction of calls to a Telecom Operator when the customer is on holiday, diversion of calls to another number, abbreviated dialling and automatic wake-up calls.

These new facilities, however, are almost 'fringe benefits' when the more basic advantages of the system are considered. AXE will improve the reliability of exchange operations and make the detection and correction of faults an easier task; it will simplify the administration of the network and allow its more efficient utilisation; and modernise the charging and billing system for accounts. On top of this, the equipment will be cheaper to buy and install than electro-mechanical equipment, and will take up only about half the space, thus reducing building costs.

The AXE system, in conjunction with the ARE 11 modernisation program, will enable us to make our telecommunications network one of the best in the world, and — importantly, from the customers' viewpoint — will enable us to keep down the costs of telephone services.

The first exchange using the new equipment will be put into service at Endeavour Hills, a suburb of Melbourne, in 1980/81. The equipment is then likely to be progressively installed in other capital cities, and by 1985, there should be about 270,000 lines operating on the new system.

The System

AXE is a fully electronic telephone exchange system. This means that instead of using mechanical devices controlled by electro-magnetic means, control of the system is performed by specialised computers, with instructions stored in their memories. These instructions, or programs, control all switching operations, normal maintenance testing, and access to the system by Visual Display Units, which can be used to enter new instructions or provide readouts of the operational status of the system at any time.

Information on customer categories, traffic routing, and the availability of particular call paths and customer lines in the exchange is also stored in computer memories.

The equipment is based on the extensive use of miniaturised electronic parts and integrated circuits. These are mounted on printed board assemblies which are easy to install and replace.

System Structure

AXE is divided logically into two sub-systems: the switching system, which uses miniature reed relays to connect calls; and the control system, made up of the specialised computers (or processors) and their associated electronic equipment. This control equipment is constructed in modular form, each module performing a particular task.

Rather than being concentrated into one unit, the control functions of the system are distributed out to a number of small processors. This means that if modifications need to be made, for example when an exchange is extended, this can be done easily by altering or adding modules. It also, very importantly, helps to maintain a high standard of reliability.

The more complex tasks are performed by a central processor. Simpler repetitive tasks are delegated to small regional or outposted processors, the number

Fault analysis using a visual display unit and fault trace and repair manual.

of which depends on the size of the exchange.

Security Aspects

Particular attention was given during the design of the new equipment to ensuring that any failures will cause minimum disruption of the service. For this purpose, there are in fact two central processors working simultaneously. Each of these identical units has its own memory and is fully capable of controlling the exchange alone. During normal operation, these two units give exactly the same results. Only in the case of an equipment failure in one half will the results differ. Any such difference is detected by a maintenance unit, which identifies the faulty processor and orders the properly working processor to resume control. All this happens within ten milliseconds.

The immediate detection of equipment failures prevents information from being scrambled, and therefore allows the control of the exchange to continue without interruption. A further advantage is that equipment failures are distinguished from errors in the computer's programs, since the latter do not give a different result between the two units.

Again, all of the regional processors which control the switching system under the control of the central processor are provided in pairs, each of which is capable of handling the full workload of the pair.

All of this ensures high system reliability.

Potential to Meet New Developments

One of the considerations involved in choosing the new system was that Telecom wanted to be sure that it would be capable of being adapted to meet new customer demands and to incorporate new technologies such as digital switching.

In digital switching, signals and speech are broken up into a coded form consisting of pulses or 'bits' of information. This type of system may offer savings in future network costs. AXE is adaptable to this possibility as the switching sub-system has been designed to permit the reed relays, which will initially be installed, to be replaced by digital switching equipment.

Modular Construction

Instead of the racks and relay sets found in existing cross-bar telephone exchanges, the new equipment

will consist basically of modular boxes or 'magazines' in shelves. In this flexible modular system, each magazine contains the electronic circuitry for a particular function. Plug-in cables provide the necessary interconnections between the magazines. This makes the task of installing and inter-cabling the equipment much easier.

Each magazine will have been pre-tested at the factory, which will also speed up the installation task.

The extensive use of modules means that alterations to the system can be handled on a module to module basis, rather than involving the system as a whole.

Operation and Maintenance

The modular organisation and duplication of processing units described also ensures easier maintenance and a high degree of efficiency in operation. In addition, the AXE system is provided with a number of features to improve operation and facilitate maintenance work.

- The performance of the various sub-systems, routes and circuits is automatically monitored by supervisory equipment and programs. An alarm message is directed to the maintenance staff if performance deteriorates to the stage where maintenance is required. Staff then use the Visual Display to obtain information which will enable the fault to be located. This arrangement ensures that staff are not needlessly alerted to minor performance disturbances or temporary faults.
- Certain faults in the central processors can be automatically detected and faulty equipment isolated from the rest of the system.
- In most cases, the alarm message will indicate to the operators the location of the problem so that it can be isolated. At times, however, the staff will need to run traffic tests and use diagnostic programs. A fault trace and repair manual will be provided for this purpose. It will be possible in the majority of faults to isolate the problem down to a particular printed circuit board, which can then simply be replaced.
- The AXE system also allows the exchange to be connected to remote operations centres. Another computer system can be used to control the transmission of information from such centres to a number of AXE exchanges. In this way, for example, a Maintenance Centre some distance from the exchange can be established to diagnose faults and identify items of equipment needing attention. A District Office could obtain records of customer metering details directly from the exchange computer, and this information can also be fed directly into Telecom's billing system. A Business Office could also quickly obtain customer meter readings as for example, when a service is to be temporarily disconnected; or the customer's category marking could be altered if requested. Safeguards are built into the system to avoid errors during such procedures, and to control access from such centres.
- Another advantage of AXE is that each customer's line has an equipment number which is associated in the computer memory with the phone number as shown in the directory. The equipment number for a particular phone number can be altered to another phone number by typing in a command on a Visual Display Unit. No re-jumpering or physical alterations need to be made to connections for such a change. This means that there can be a high exchange occupancy, as cancelled services can be immediately re-used by changing the phone number associated with that customer's line in the computer's memory. This facility also makes it possible to re-balance the traffic load in the exchange by changing the equipment numbers associated with particular phone numbers.
- Improved PBX facilities will be provided. It will no longer be necessary to reserve special groups of lines for PBX facilities — these lines could be allocated freely over all the available terminations in the exchange.

Overview of AXE Switching

As explained earlier, AXE is sub-divided into a switching system and a control system. The switching system connects calls to other local customers and to the rest of the telephone network under the control of computer programs contained in central and regional processors which make up the control system.

The switching system is further divided into three main sub-systems: subscriber switching, group switching, and trunk and signalling.

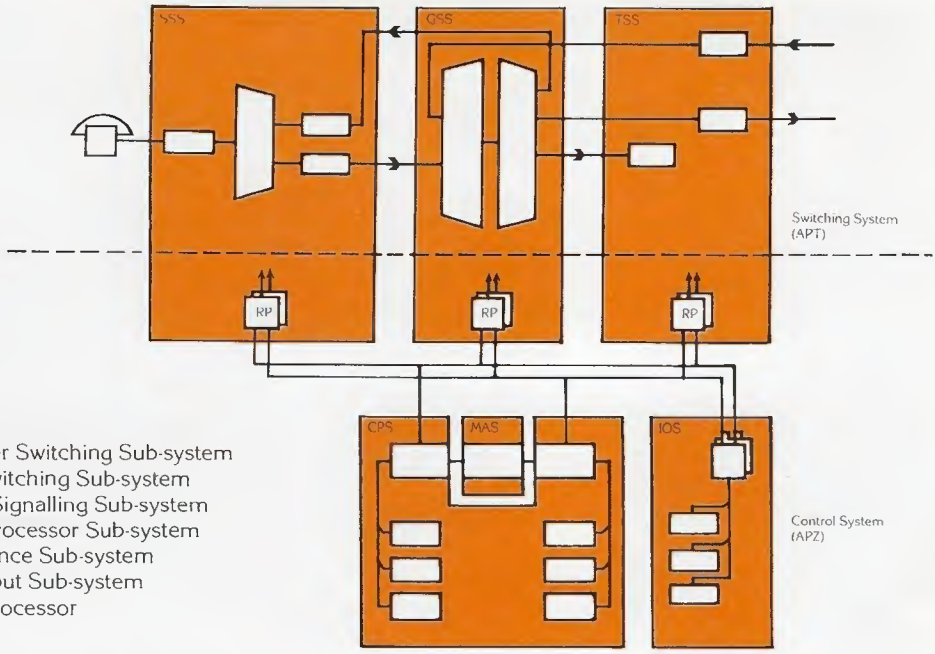
The subscriber switching sub-system takes care of the operations most directly related to the customer: detecting that the customer wants to make a new call; sending appropriate tone signals to the customer; providing electrical current to operate his telephone and so on. In addition, the sub-system contains a reed relay switching network to connect the call to the group switching sub-system.

The group switching sub-system distributes calls from incoming to outgoing points by means of a six-stage reed relay network, which provides two-wire conducting paths between inlets and outlets. This network may be replaced in future by a digital switching network.

The trunk and signalling sub-system includes the code senders, code receivers and junction circuits used to exchange signals with other exchanges.

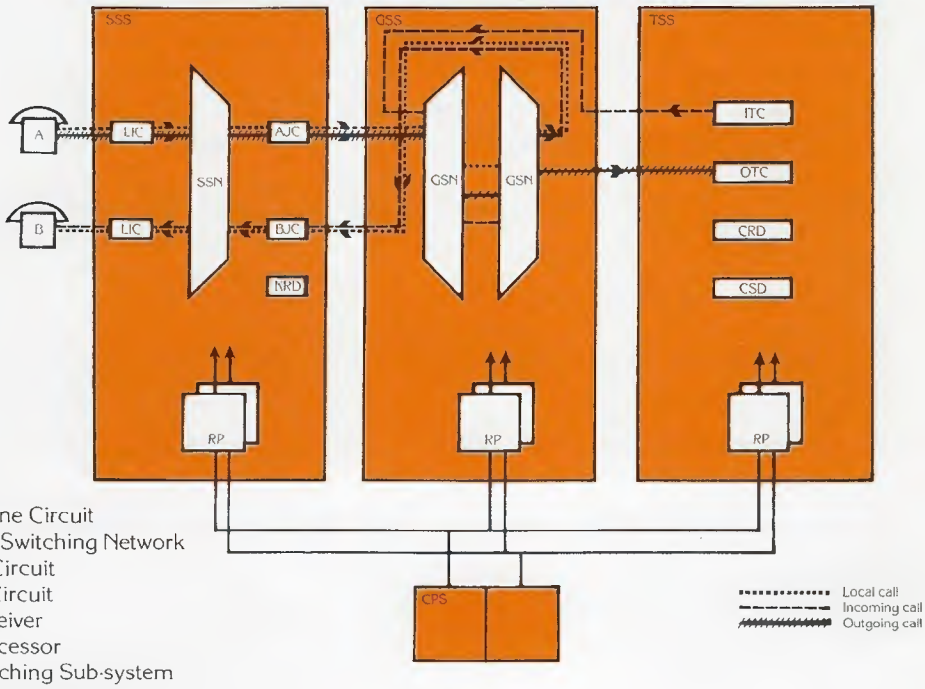
Free paths for calls in the switching network are found by the central processor, but regional processors perform switch operations, line scanning, digit reception and other routine functions.

Figure 1: Simplified block diagram of the AXE system

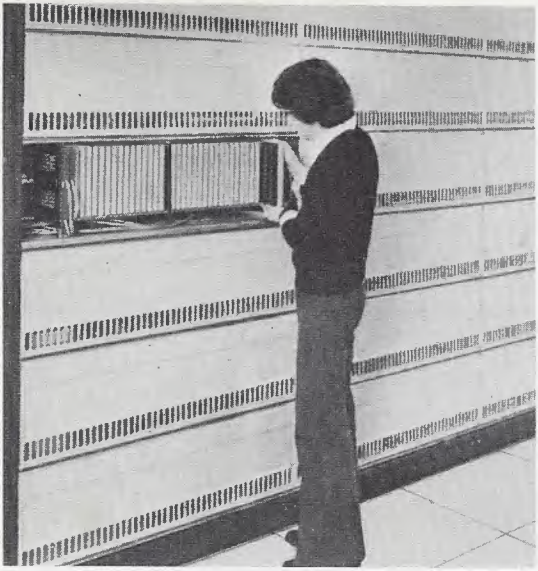


LEGEND
SSS — Subscriber Switching Sub-system
GSS — Group Switching Sub-system
TSS — Trunk & Signalling Sub-system
CPS — Central Processor Sub-system
MAS — Maintenance Sub-system
IOS — Input Output Sub-system
RP — Regional Processor

Figure 2: Progress of a call through AXE equipment



LEGEND
LIC — Customer Line Circuit
SSN — Subscriber Switching Network
AJC — A Junctor Circuit
BJC — B Junctor Circuit
KRD — Keyset Receiver
RP — Regional Processor
GSS — Group Switching Sub-system
GSN — Group Switching Network
ITC — Incoming Trunk Circuit
CPS — Central Processor Sub-system
OTC — Outgoing Trunk Circuit
CRD — Code Receiver
CSD — Sender



Printed board replacement following fault analysis.

AXE Control System

The control system is divided into the central processor sub-system; the maintenance sub-system; and the input/output sub-system. Control is also distributed through the regional processors.

The division of the central processor into two identical halves, and the monitoring of the performance of these halves by the maintenance unit have been described earlier.

The input/output sub-system handles the devices, such as teleprinters and Visual Display Units, used by staff to operate and maintain both the control system and the switching system.

Routine control functions are assigned to small, rapid regional processors, each of which handles a number of modules of the switching system and is mounted together with these.

Progress of a Call Through an AXE Exchange

Consider a telephone call from Customer A, connected to an AXE exchange, to Customer B, connected to the same exchange.

Each customer has his own individual line circuit in the exchange, which senses the condition of the wire loop formed by the customer's line and telephone set.

When Customer A lifts the handset, a switch is closed and current flows in the loop causing a voltage drop in the line circuit in the exchange. This is detected by a regional processor.

The customer is then connected to an idle A-junctor circuit through the reed relay network. As soon as the connection is made, dial tone is sent to the customer to indicate that dialling may start. The A-junctor circuit also provides electrical current to the customer's telephone.

The exception to this procedure is if the customer has a push-button rather than a rotary dial telephone. In this case, the tone is returned by a special keyset receiver.

As soon as dial tone is sent, a regional processor starts scanning the line 200 times a second to detect dialling pulses. These pulses are counted and the values of the digits are transferred one by one to the central processor.

This number, that of Customer B, is then analysed to determine whether it has any special category marking, say for re-direction of the call to another number or use of the 'do-not-disturb' facility. Customer B's line is then tested and if it is free, a path is set up from the A-junctor circuit through the group switching network to a free B-junctor circuit.

The B-junctor circuit supervises Customer B's telephone, rings the bells in the telephone and provides electrical current. When Customer B answers, the ring is cut off, and the two customers can converse. Charging for the call is determined by the central processor and recorded against Customer A's meter.

Calls between exchanges are handled in a similar manner, but the central processor determines from the digits dialled that it is necessary to connect a call to another exchange. It is then routed through an outgoing trunk circuit rather than through a B-junctor circuit. While the call is being set up, an additional path is established through the group switching network to a code sending device for signalling between the AXE exchange and the distant exchange.

A call coming in from another exchange arrives at the group switching network from an incoming trunk circuit and a code receiving device interprets the signals from the other exchange. The connection of this device is made through the group switching network.

The call is terminated when Customer A replaces his handset. The path is then broken and all participating devices and the paths through the switching networks are released to make them available for other calls.

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Issued by the HQ Information & Publicity Office, 1979