

# AXE hardware evolution

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The AXE system is the most widely deployed switching system in the world. It is used in public telephony-oriented applications of every type, including traditional fixed network applications in local, transit, international and combined networks. AXE is also deployed for all major mobile standards – analogue as well as digital. AXE is very strong in intelligent networks and other real-time database applications. Recent designs also enable data communication capabilities to be added to the system.

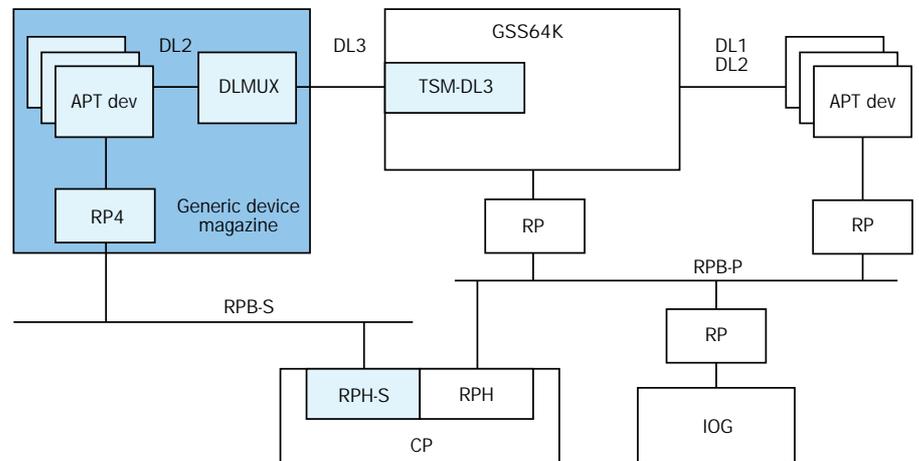
From its inception, the AXE system was designed to accommodate continuous change. Throughout the years, new applications have been introduced, its array of functions has grown, and its hardware has been steadily updated.

The authors describe how the latest advances in hardware technology have been brought into the system, thereby dramatically improving such characteristics as floor space, power consumption, system handling, and cost of ownership. As always, backwards compatibility has been maintained to the greatest possible extent, in order to protect previous investments in AXE.

The hardware used in the AXE system has been updated continuously. Initially, all telephony-related hardware in AXE was analogue. Over the years, almost all hardware has been redesigned to take advantage of the formidable advances in electronics. This has been a continuous, ongoing process. Digitalisation was gradually introduced in the early 1980s, followed by application-specific integrated circuits (ASIC) in the mid-1980s. A major breakthrough came in 1986<sup>1</sup>. In the late 1980s and early 1990s, the evolution continued in small steps. A few original products have remained, however. Today, these last remaining products are being replaced. At the same time, almost all other hardware products that make up the basic AXE system are being rationalised.

## AXE evolution

### Extensions



## AXE evolution

### New deliveries

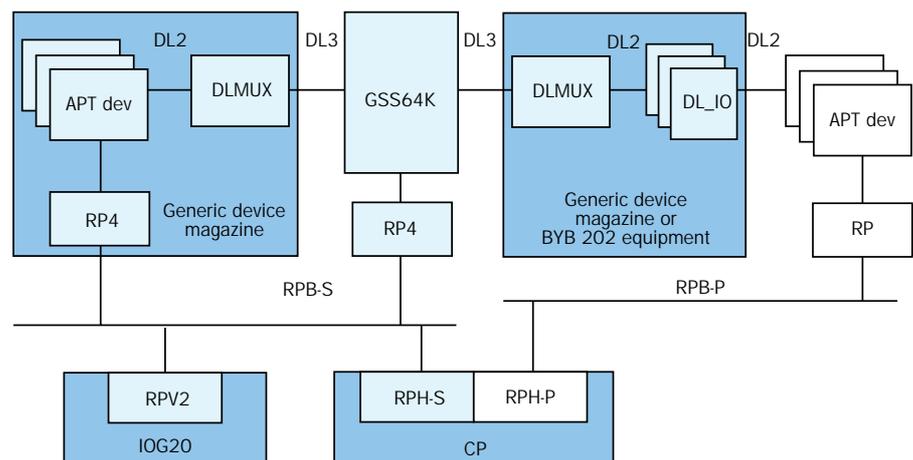


Figure 1  
The figures show how the new interfaces are used for extensions and new deliveries.

## Architecture

As the AXE system continues to evolve, system designers ensure that the very solid and proven system architecture is maintained. The fundamental principle of a central processor (CP) that controls regional processors (RP), which in turn control hardware services, has proved to be superior. Strict interfaces ensure that different system components can be developed independently. To ensure non-stop operation, all vital traffic and operation and maintenance (O&M) system products are built in duplicated structures.

In order to fully exploit the advantages of modern electronics, some fundamental system hardware interfaces are now being improved and extended. It goes without saying that compatibility is maintained in AXE.

Traditionally, a parallel bus, or a regional processor bus (RPB), has been used for communication between the central and regional processors. Now, however, in order to increase capacity (data transfer rate) and

to decrease the need for interface hardware, a serial bus is being introduced alongside the existing RPB (Figure 1). The new RPB permits single-board regional processors to be housed in the same subrack as the devices they control, thus minimising hardware and cable interconnections between hardware devices.

In earlier generations of AXE, an extension module (EM) bus and cables were used to connect regional processors to application hardware (extension modules). In the new hardware design, however, most regional processors are located in the same subrack as the extension modules they control. By locating the regional processors in this way, designers have all but eliminated the EM bus, except in the backplane. The new location makes it much easier for operators to install and extend equipment.

The traditional AXE interface (called the digital link 2, DL2) between the group switch (GS) and its connected devices was at the 2 Mbit/s primary multiplexing pulse code modulation (PCM) level.

Now, a new high-speed interface is being

### Box A Abbreviations

ALI	Alarm interface	EM	Extension module	MW	Megaword
ANSI	American National Standards Institute	EMB	Extension module bus	O&M	Operation and maintenance
ASIC	Application-specific integrated circuit	EMC	Electromagnetic compatibility	PCM	Pulse code modulation
AST-DR-V3	Announcement service terminal version 3	EMI	Electromagnetic interference	PDC	Pacific digital cellular
ATM	Asynchronous transfer mode	ETC5	Exchange terminal circuit generation 5	PROM	Programmable read-only memory
BGA	Ball grid array	ETSI	European Telecommunications Standards Institute	PSTN	Public switched telephone network
BM	Building module (1 BM=40.64 mm)	FSK	Frequency shift keying	RAM	Random access memory
BSC	Base station controller	GDM	Generic device magazine (sub-rack)	RMS	Remote measurement subsystem
CANS	Code answer	GS	Group switch	ROM	Read-only memory
CCD	Conference call device	GSM	Global system for mobile communication	RP	Regional processor
CMOS	Complementary metal-oxide semiconductor	GSS	Group switch subsystem	RP4	Regional processor generation 4
CP	Central processor	HLR	Home location register	RPB	Regional processor bus
CSFSK	Code sender for FSK tones	IN	Intelligent network	RPD	Regional processor device
CSK	Code sender for DTMF tones	I/O	Input/output	RPG	Regional processor with group switch interface
CSR	Code sender/receiver	IOG11	I/O system 11	RPV	Regional processor connected to VME
D-AMPS	Digital AMPS	IOG20	I/O system 20	SCP	Service control point
DL2	Digital link interface 2	IP	Internet protocol	SCSI	Small computer system interface
DL3	Digital link interface 3	ISDN	Integrated services digital network	SNT	Switching network terminal
DSP	Digital signal processor	ITU-T	International Telecommunication Union - Telecommunications Standardization Sector	SPM	Space switch module
DTMF	Dual-tone multifrequency	IWU	Interworking unit	STC	Signalling terminal central
EO	64 kbit/s digital link	KRD	Keypad receiver device	STM	Synchronous transfer mode
E1	2 Mbit/s digital link	LED	Light-emitting diode	STP	Signalling transfer point
ECP 303	Echo canceller in pool generation 3	LUM	Line unit module	T1	1.5 Mbit/s digital link
ECP 404	Echo canceller in pool generation 4	MSC	Mobile switching centre	TCD	Trunk continuity check device
		MTBF	Mean time between failures	TSM	Time switch module
				TSM-1	155 Mbit/s time switch module
				VME	Versa Module Eurocard

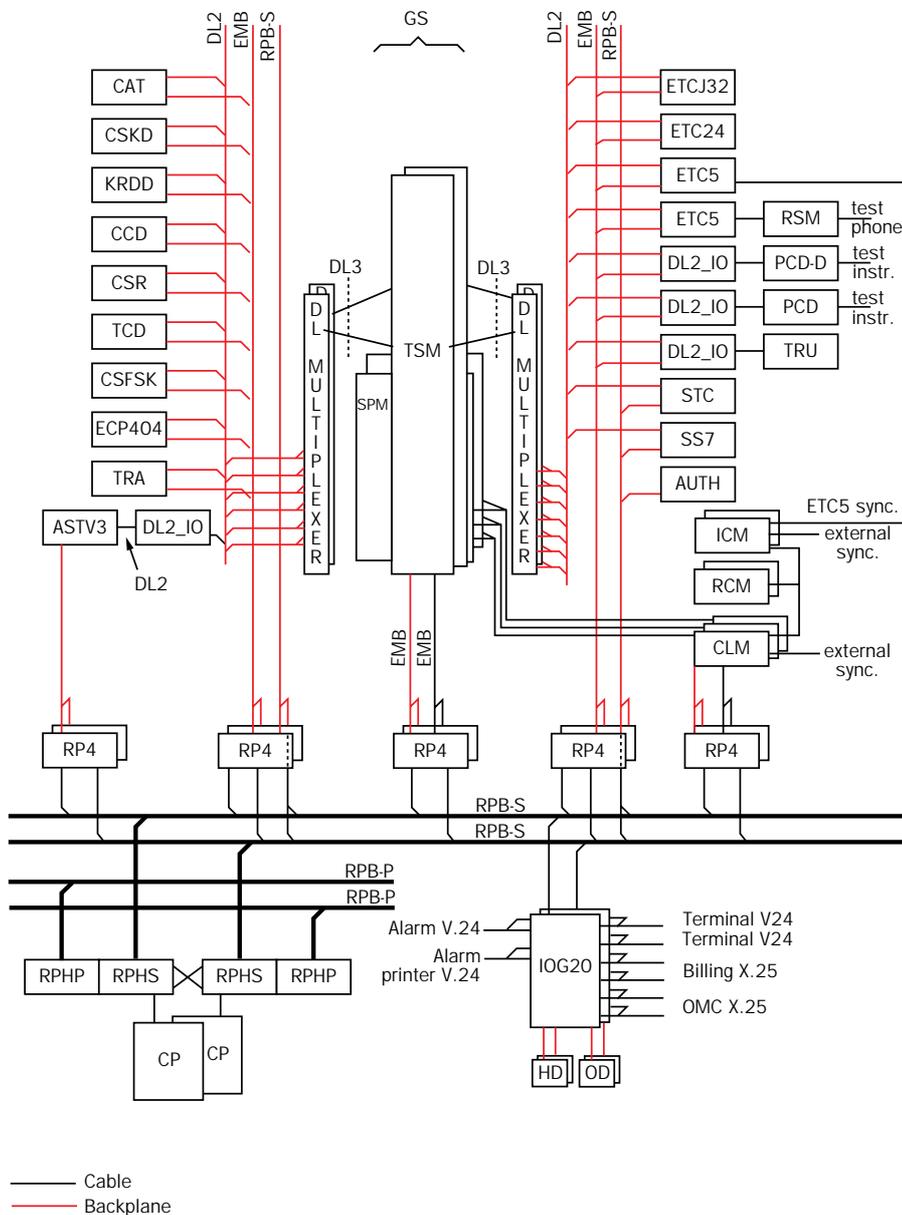


Figure 2  
AXE hardware architecture using new hardware.

introduced at the third level in the basic PCM hierarchy. The interface, which is called DL3 (digital link 3), works at the 32 Mbit/s level (overhead excluded).

The introduction of the DL3 interface dramatically decreases group switch and device hardware. Equally important, it removes massive amounts of internal system cabling. The DL2 interface has been retained to ensure compatibility.

Each DL3 interface contains 16 multiplexed DL2 interfaces. In fact, the DL2s run in the backplane of the new device subracks, which means that only one sixteenth of the cabling is needed between the group switch and the devices that are connected to it.

## Basic technology

In general, designers taking part in the AXE hardware evolution programme have used ASICs, high-performance microprocessors, digital signal processors (DSP) and faster interfaces to improve AXE hardware. ASICs were chosen where volumes of circuits are very high or where performance is critical. Commercial microprocessors, which are becoming commonplace for more and more applications, have also been integrated into the hardware. These changes allow designers to integrate commercial operating systems and software – especially at the regional processor level.

Also, inasmuch as the processing capacity of regional processors has kept pace with developments in general-purpose processor technology, the new AXE hardware requires fewer processors than were used before. This was another important factor in reducing the size of the exchange.

The most common type of processor in AXE systems today is the digital signal processor. DSPs, which are used in many kinds of application, are flexible platforms that may easily be programmed to provide new functions. Moreover, software at the DSP level may be sourced from other manufacturers, which allows designers to introduce new functionality with shorter time to market.

Today almost all AXE hardware uses a 3.3 V power supply. This change and the use of submicron technology (0.25-0.5 µm) have reduced power consumption to levels far below that of previous hardware generations.

## Equipment practice

Owing to the introduction of high-speed interfaces and tougher requirements for electromagnetic compatibility (EMC), AXE hardware designers constructed a new equipment practice, called the BYB 501<sup>2</sup>. The BYB 501 has excellent EMC characteristics and fulfils Class B requirements with good margin. Compared with the BYB 202, whose cabinet shields against electromagnetic interference (EMI), the new equipment practice provides shielding at the subrack level. Note: the standard on which the BYB 501 is based uses the term subrack. However, in AXE terminology, the word magazine is often used.

The equipment practice supports multi-point and single-point earthing. The multi-

point earthing concept will be used in all new AXE deliveries. The equipment practice also supports several different sizes of board and cabinet. However, for use with AXE, two main board sizes are used: 115 x 175 mm, and 265 x 175 mm. The standard dimensions of the cabinet are as follows:

Height: 1800 mm

Width: 600 mm

Depth : 400 mm

Normally, no backplane cabling is needed on the subracks. Consequently, the cabinets may be placed back-to-back, giving the exchange a very small footprint and allowing a flexible cabinet arrangement against walls. The cabinets will also be delivered fully equipped, their hardware tested and cabled at the factory – a feature that greatly reduces installation time and other time-to-customer-related activities.

## Group switch

The group switch<sup>3</sup> has been the subject of far-reaching rationalisation. For example, a configuration for 65,536 group switch ports is now contained in two cabinets (Figure 3). What is more, the new group switch consumes 95% less power than its predecessor. Nevertheless, the basic structure of the switch – that is, the time-space-time (T-S-T) switching architecture, the time switch, the space switch, the clock module, and system concepts such as the switching network terminal maintenance (SNT) and DL2 hardware interface – has been maintained, which facilitates hardware and software design and preserves compatibility.

In improving the group switch, designers made the following changes:

- A 32 Mbit/s DL3 interface replaces sixteen 2 Mbit/s DL2 switch interfaces.
- Four time switch module (TSM) functions are grouped onto one board, yielding 2,048 ports per board (Figure 4).
- A space switch module (SPM) function for 16,384 ports now fits on a single board (Figure 5).
- Switching equipment and the RPs that control the equipment are co-located in the same subrack.

These design changes gave rise to a switch subrack that contains eight TSM boards, providing a total of 16,384 switch ports; one SPM board; and four RP boards. Since the switch is duplicated, another plane is located in a second subrack with exactly the same configuration.

The 64K group switch

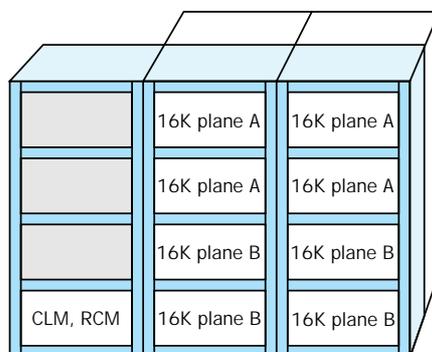


Figure 3  
The new group switch in a 64K configuration, including synchronisation equipment.

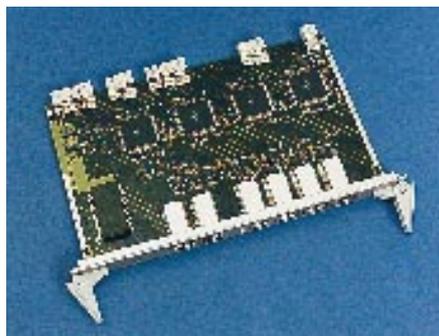


Figure 4  
The new time switch module board, which contains 2,048 ports, replaces four BYB 202 subracks.

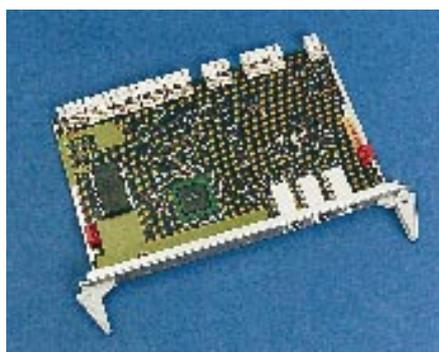


Figure 5  
The space switch module board, which handles 16,384 ports, replaces one subrack in the BYB 202.

Some mobile systems employ subrate switching to handle bit rates below 64 kbit/s (8 kbit/s; 16 kbit/s; 24 kbit/s ... 64 kbit/s). In its maximum configuration, which has 4,096 ports, the subrate switch is housed in two small subracks: the A-plane is located in one subrack and the B-plane is located in the other.

As in earlier versions of the group switch subsystem (GSS), wideband ( $n \times 64$  kbit/s) is supported up to 2 Mbit/s.

The synchronisation equipment, which occupies another two small subracks, consists of:



Figure 6  
The APZ 212 25 occupies only half a subrack in the BYB 501.

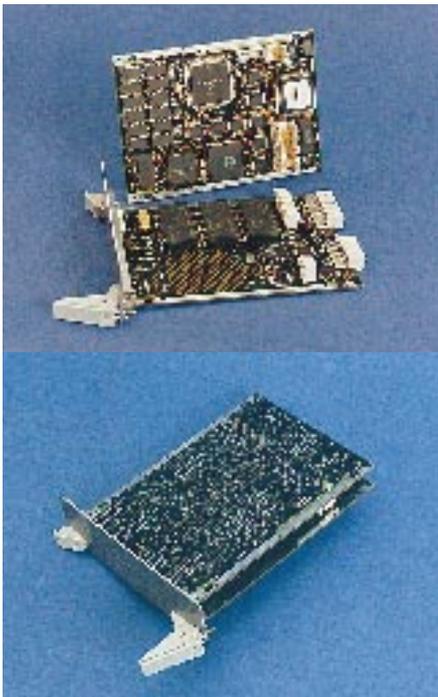
- three clock modules;
- two highly accurate reference clock modules;
- two incoming clock reference boards (for connecting additional clock references);
- regional processors for controlling the synchronisation equipment.

Designers have also constructed a compact switch subrack for switching applications that require less than 4,096 ports. This subrack contains a 4,096-port switch, three clock boards for synchronisation, 1,024 ports for subrack data transfer, and regional processors for controlling the equipment. The two switch planes are co-located in one subrack.

The new group switch was designed to provide backward compatibility. Accordingly, a DL3-to-DL2 converter subrack has been developed. The converter connects hardware that uses a DL2 cable interface to a new switch that uses the DL3 interface. Another way of connecting an old switch to hardware that uses the new DL3 interface is to add an interface board (which supports a DL3 cable interface) in existing TSM64C subracks.

The new design concept also allows the GSS switch to be extended to up to 131,072 ports.

Figure 7  
The RPG consists of two boards mounted together into one plug-in unit. Every interface is to the backplane.



## Central processor

Designers of the AXE central processor have always emphasised high processing capacity. This holds true even today. Nonetheless, while developing the next generation high-capacity central processor (APZ 212 30), AXE designers also produced a smaller, power-efficient processor (APZ 212 25) for switching applications that require moderate processing capacity.

The APZ 212 25 has a very small footprint (Figure 6) and consumes only 75 W of power. Designers reduced power consumption by replacing the 5 V supply voltage with 3.3 V, and by using 0.5  $\mu\text{m}$  complementary metal-oxide semiconductor (CMOS) ASIC technology with ball grid array (BGA) packaging. The maximum memory capacity of the APZ 212 25 is 64 Megawords (MW), program store; and 256 MW, data store. Despite its small size, this computer processor is 1.5 to 1.7 times more powerful than its much larger predecessor, the APZ 212 11.

Although it was designed for use in the BYB 501, where it uses the serial RP bus, the APZ 212 25 is fully compatible with the

parallel bus used in earlier versions of AXE switching equipment. In a minimum configuration, the APZ 212 25 may connect four of the new serial RP buses, controlling up to 128 regional processors. If more regional processors are required, or if parallel and serial RP buses must be used simultaneously, then extension subracks may be added that allow up to 512 regional processors to be connected.

## Regional processors

A new regional processor, called the RPG (regional processor with group switch interface, Figure 7) has been introduced for applications that require high processing capacity. Most applications that previously ran on the regional processor device (RPD – Motorola 68020) have been transferred to the RPG, which has at least four times as much processing capacity as the RPD. The RPG is a single-board processor based on the general-purpose Motorola 68060 running at 50 MHz. On the same board is a communications processor (a Motorola 68360) for handling the switch interface and a 10 Mbit/s Ethernet interface. Although it may be used for any application that requires high processing power, the RPG will initially be used with the following applications:

- signalling system no. 7 – signalling terminal according to ANSI;
- signalling system no. 7 – signalling terminal according to ITU-T;
- signalling terminal central (STC) – signalling terminal for base stations and remote subscriber switches;
- transceiver handler – base station signalling in GSM;
- authentication in all mobile systems;
- integrated services digital network (ISDN) Internet access server (IP routing function).

In AXE, the RPG is the platform for handling packet switched data communication. With respect to traffic handling, these types of regional processor have a more independent role, relative to the CP, than traditional AXE regional processors.

A new version of the traditional regional processor, called RP4 (regional processor generation 4), is used for controlling extension modules. The RP4 is compatible with earlier versions of the regional processor. A prime benefit of the RP4 is that it is co-located in a subrack with the extension modules it controls. This design does away with

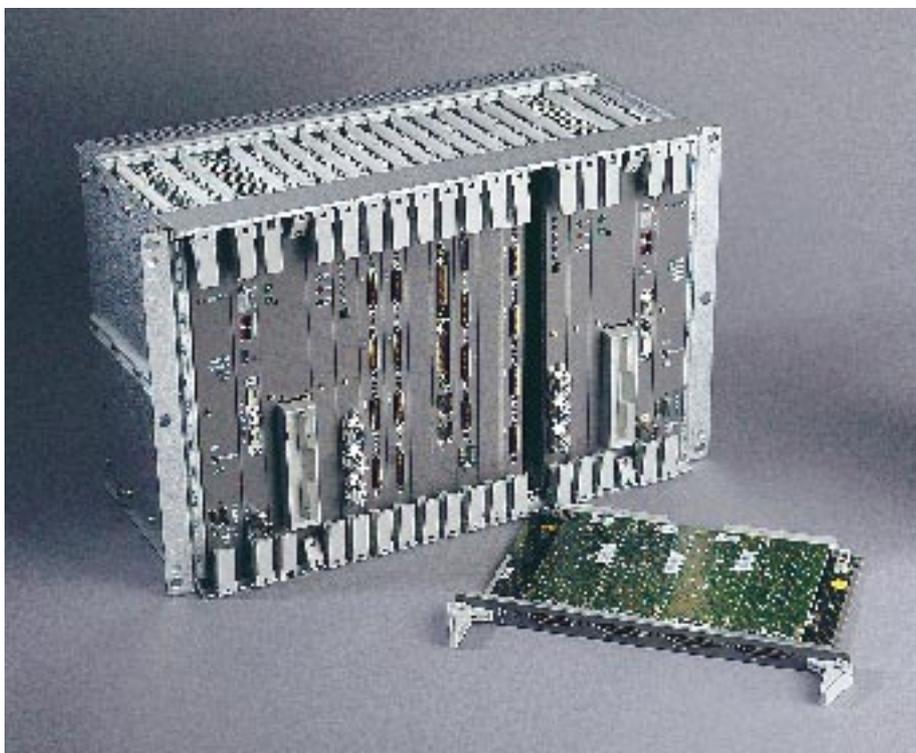


Figure 8  
The IOG20C with A- and B-sides in one sub-rack. With its daughter boards, the line unit module can handle four different interfaces.

a large amount of cable, reduces size, and simplifies equipment handling considerably.

Earlier versions of the central processor may not be connected to new hardware without first modifying their side of the RP bus interface.

The regional processor bus interface VME (RPV) is a conversion product for the connection from the CP to the Versa Module Eurocard-based IOG20, through the RP bus. There are two RPVs: the first, known simply as RPV, is used for the parallel bus connection; the second, called the RPV2, is used for the serial bus connection.

## IOG20, the AXE I/O system

A duplicated input/output (I/O) system, known as the IOG20, handles data transport to and from an AXE exchange. Communication to and from the AXE I/O system may be broken down into customer administration and element handling.

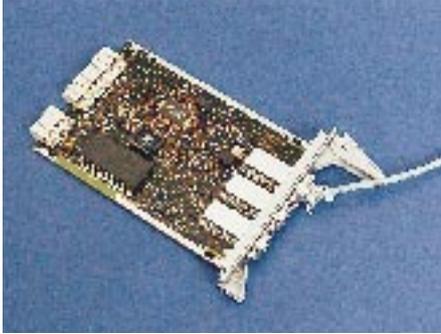
The IOG20 is much smaller than the IOG11 – the previous generation I/O system. For example, whereas the IOG11 fills a whole cabinet in the BYB 202 equipment practice, the IOG20 fits into a single sub-

rack. Moreover, the IOG20 outperforms the IOG11 by as much as four to five times but consumes only one third as much power.

The new I/O system, whose design is characterised by modern technology and greater integration, contains relatively few printed circuit board types (seven instead of 25). In taking steps to make the system open to commercially available components, designers used the industry standards Versa Module Eurocard (VME) bus, Ethernet, and small computer system interface (SCSI). Similarly, they implemented Ethernet for connections between nodes and as a line interface. The IOG20 is currently available in three configurations:

- IOG20 – a fully compatible version of the twin-subrack configuration with an interface to a parallel RP bus;
- IOG20B – a twin-subrack version with one node in each subrack (maximum configuration);
- IOG20C – a single-subrack version with two nodes (minimum configuration).

The IOG20B and the IOG20C are designed to operate with the new serial RP bus. The IOG20C is probably the most compact and powerful I/O system ever produced for telecommunications applications (Figure 8).



**Figure 9**  
The 32-channel E1 interface is now made on one small board.

In its maximum configuration, the IOG20 stores data on three duplicated 3.5 inch/4 Gbyte hard disks and one duplicated 3.5 inch/640 Mbyte magneto-optical disk. In the compact version, the IOG20 stores data on one duplicated 3.5 inch/4 Gbyte hard disk and one duplicated 3.5 inch/640 Mbyte magneto-optical disk.

To connect data communication interfaces to the I/O system, the twin-subrack version may contain up to four duplicated line unit module (LUM) boards. Likewise, the compact version may contain up to three duplicated LUM boards. A LUM board consists of a main board and as many as four independent line module daughter boards for almost any type of line interface, including V.24, V.28, V.35, V.36, X.21, G.703 E0, G.703 E1, and Ethernet.

An alarm interface (ALI) function consists of two boards: one for supervising fans and external alarm input/output, and another for displaying alarms.

In terms of software and applications, the IOG20 is fully compatible with its predecessor, the IOG11.

## Connecting hardware to the group switch

Hardware is connected to the switch either by a trunk (for example, exchange terminals) or by means of pooling (for example, of echo cancellers). In AXE, only exchange terminals and some signalling terminals are connected by trunks. All other equipment is connected in pool, which heightens reliability, flexibility, economy, and maintainability.

### Announcement machines

Designers have also developed a new generation of system-integrated announcement machines – AST-DR-V3. The new machines are substantially smaller than their predecessors, but have more capacity for speech storage and for a larger number of dual-tone multifrequency (DTMF) receivers. The announcement machines are available in different sizes (configurations). The largest machine has capacity for 256 DTMF receivers, up to eight hours of stored speech, and provisions for backing up speech on the hard disk.

The smallest configuration has capacity for 32 DTMF receivers and two hours of stored speech. Depending on how often stored phrases are changed, speech may be stored in either random access memory (RAM) or in read-only memory (ROM) on

memory boards that support up to one hour of speech per board. The high-capacity announcement machine occupies one and a half subracks: one subrack for the control subrack that contains the DTMF receivers, and half a subrack for the memory boards and hard disk. The smallest machine occupies only half a subrack. As many as 20 systems may be run in parallel, providing a total of 5,120 ports. The systems may also be used in large intelligent network (IN) nodes or in other service-providing functions. The AST-DR-V3 forms a powerful voice-response system that may be used as a base product for the future development of such applications as voice or fax mail, cashless calling, and the virtual telephone.

### Exchange terminals

AXE supports every kind of trunk interface that has been incorporated into the new equipment practice. By integrating all functionality into one ASIC, designers were able to fit the 32-channel E1 (2 Mbit/s digital link) interface onto one small board (Figure 9). New versions of the 24-channel T1 and the Japanese 32-channel interface have also been designed.

In time, STM-1 (155 Mbit/s synchronous transfer mode) terminations will be designed in AXE for each relevant standard. Once they become available, the terminations will greatly reduce (possibly completely eliminating) operator requirements for transmission equipment and generally simplify system handling.

### DSP platform

To date, much of the telephony devices in AXE – conference call device (CCD); trunk continuity check device (TCD); code sender/receiver (CSR) for R1, R2, and no. 5 code; code sender for DTMF (CSK); code sender for FSK tones (CSFSK); code answer (CANS); keyset receiver device (KRD); and several maintenance functions – is delivered from separate subracks that range in size from 3 to 12 building modules (BM) in the BYB 202 equipment practice. Nonetheless, designers have developed a new digital signal processor platform board that can be programmed to provide the functionality of any one of these applications. Initially the boards will be programmed at the factory. In a second step, operators will be able to change the onboard software from the AXE system, giving them tremendous flexibility and excellent means with which to handle redundancy and spare parts. Should a fault occur

on a board that provides the functions described above, then an operator can remotely activate an unprogrammed standby board by command, taking it into operation. This feature will simplify maintenance and reduce operating costs.

### Echo cancellers

The ECP 303<sup>+</sup> has been replaced with a new echo canceller, called the ECP 404. The ECP 404 has a capacity of 512 channels per subrack, which is twice the capacity of the ECP 303. As with its predecessor, the ECP 404 is connected to the group switch by means of pooling.

### Transcoders

Transcoders, which are included in all digital mobile telephony systems, are used for speech compression – from 64 kbit/s to bit rates below 16 kbit/s in the downlink direction, and from bit rates below 16 kbit/s to 64 kbit/s in the uplink direction. Limited bandwidth in the air interface, which is a major challenge of mobile telephony systems, requires that speech be compressed before it can be sent over the interface.

As with all other devices, the transcoders are connected to the switch and supervised by AXE. The capacity of each board differs depending on the mobile standard for which it has been deployed (for example, D-AMPS, GSM or PDC). Each standard uses unique algorithms that require different processing capacity.

By employing the latest techniques in digital signal processing, designers have been able to more than double the capacity of the transcoder boards. This represents a significant achievement since the transcoders make up a large part of mobile exchanges.

### Data transmission interworking unit

Interworking functions are needed to provide the digital transmission of data services within mobile networks as well as between them and other networks. This is because protocols for the standard network use analogue tones, which are not suitable for transmission over the radio interface to mobile terminals.

An interworking unit (IWU) extracts analogue information received from a public switched telephone network (PSTN) modem and sends it to the mobile terminal by means of a digital protocol. The opposite function is performed for signals from the mobile terminal to the PSTN modem. The interworking function is implemented in a 7.5 BM subrack, which can handle up to 32

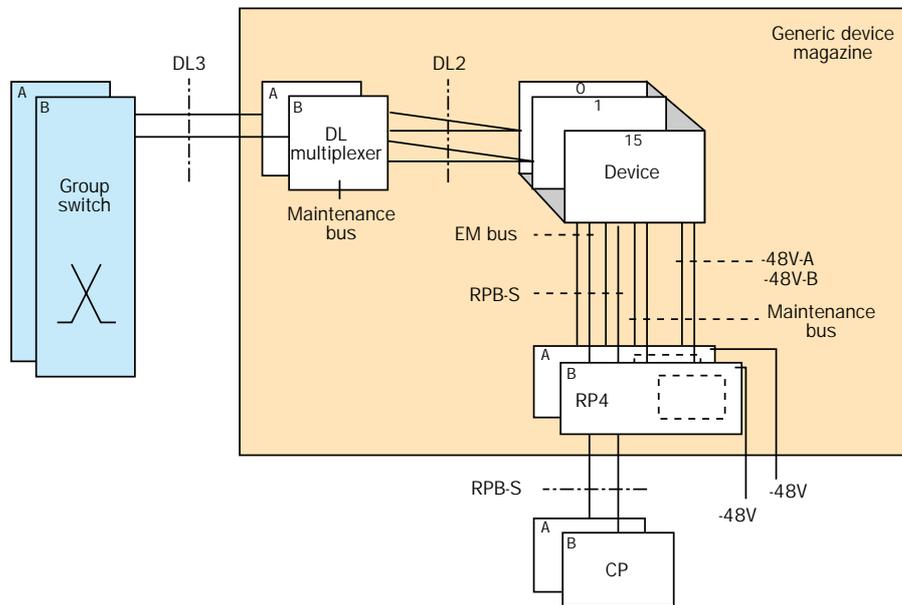


Figure 10 Hardware architecture of the generic device magazine (subrack).

simultaneous data or fax calls. The subrack fits in the new equipment practice.

This function was previously used as a stand-alone product in the Ericsson GSM system, but it will now be integrated into the system and supervised by AXE.

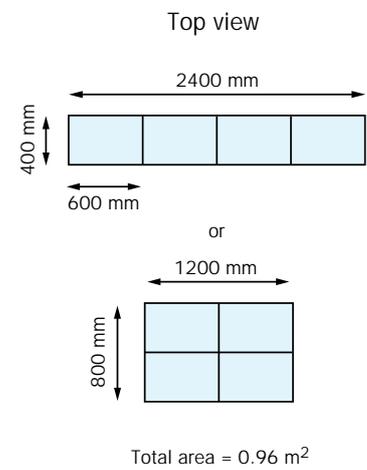
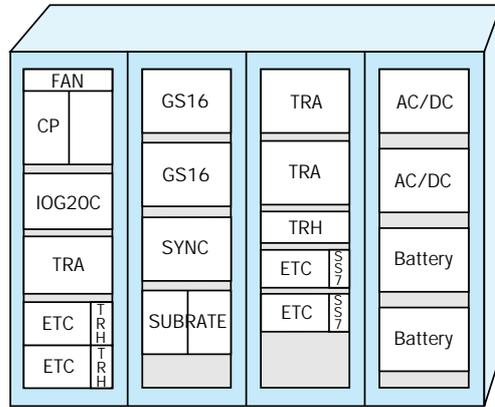
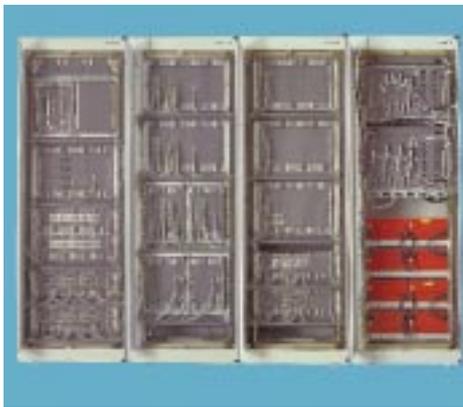
### Remote measurement subsystem

The AXE remote measurement subsystem (RMS) measures characteristics and transmission quality between telephony exchanges. It performs digital, analogue and signalling tests. To date, this function – which occupies one subrack in the BYB 202 equipment practice – has been used solely in transit exchanges. In the new rationalised version of the RMS, the function will be constructed from powerful DSPs on a single board.

### Subracks for switch-connected hardware

Nearly all telephony devices in AXE are now single-board applications, giving rise to the development of a new concept for generic device magazines (subracks). The concept is based on a subrack with 16 slots for device boards. From the backplane, the boards are connected to a duplicated group-switch interface, a duplicated RP bus interface, a duplicated EM bus interface, and a maintenance bus. Moreover, each board is given an EM bus address and supplied with duplicated -48 V (Figure 10).

Besides the 16 device boards, two multiplexers on the front of the board are connect-



**Figure 11**  
A powerful BSC with capacity for more than 300 transceivers including power supply and batteries. The configuration is similar to a small local exchange (subscriber stage excluded) or to a small MSC.

**Figure 12**  
A complete AXE exchange in one cabinet. This configuration can be used for any of the following applications: HLR, STP, SCP, or BSC (more than 120 transceivers).

ed to the switch by means of a DL3 interface. The multiplexers split the DL3 interface into 16 DL2 connections in the backplane, one connection per board. The other interfaces are connected to a pair of regional processors, one at each end of the subrack. Moreover, since the RP bus is also distributed in the backplane, it is possible to mix – in the same subrack – boards that use the EM bus with boards that use the RP bus. Because some applica-

tions require a large board size while others require a small one, two versions of the generic subrack have been constructed.

### Product identification

A new function has been introduced for checking the hardware of an AXE exchange. Each board contains a small programmable read-only memory (PROM) that stores the unique serial number, product number, revision state and manufacturing date of that board. Operators may fetch and read this information by command (on site or remotely), which enables them to check:

- hardware when replacing faulty units;
- revision states when upgrading hardware;
- for compatibility when introducing new software.

### Visual indication

Most boards in the new AXE system contain a light-emitting diode (LED) on their front. The LEDs help operators in various maintenance situations; for example, when locating boards that need to be removed for repair or for upgrade.

The indicator does not necessarily indicate that a board is faulty. Instead, it indicates whether or not a board may be removed without disturbing traffic.

### Power supply

An optional battery backup and modular power supply are offered for exchanges whose power consumption is below 6 kW. The batteries and rectifiers are housed together with the switching equipment. A



single cabinet with battery backup can provide a 3 kW power supply for nearly two hours. A 6 kW power supply is sufficient to operate approximately 15 AXE cabinets, which more or less corresponds to a high-end mobile switching centre (MSC) in a mobile telephony system.

Most hardware in the BYB 501 equipment practice is fed with a redundant power supply to each subrack through two branches of -48 V. Each branch of power is filtered and distributed to the subrack backplane, from which each board is supplied through a double-diode configuration. This arrangement increases reliability, since the subrack continues to work even if one branch of the power supply is lost.

The power distribution system also allows boards to be inserted into a subrack that is in service, which greatly simplifies procedures when boards in the subracks must be replaced.

## Results

At the system level, recent developments in the AXE hardware evolution programme have reduced the number of board types used in AXE and made them smaller and much more power-efficient. For example, it was possible to reduce the size of a base station controller (BSC) for a GSM configuration that supports approximately 300 transceivers by nearly 90% – including power supply, battery backup (Figure 11) and transcoders. Today, power consumption for a complete base station controller of this type is less than 1500 W. Moreover, when the BSC is delivered for installation, very little additional work is required, since the cabinets are equipped with subracks and internal system cables at the factory.

For the first time, a complete AXE exchange fits into a single cabinet (Figure 12). This configuration can be used for a home location register (HLR), signalling transfer point (STP), service control point (SCP), or for a base station controller application.

## Conclusion

The AXE hardware evolution programme has successfully reduced the size of hardware by between 70% and 90%; cabling in the exchange has been reduced by 90%, and power has been reduced by 75%. Therefore, operators can expect that the time and re-

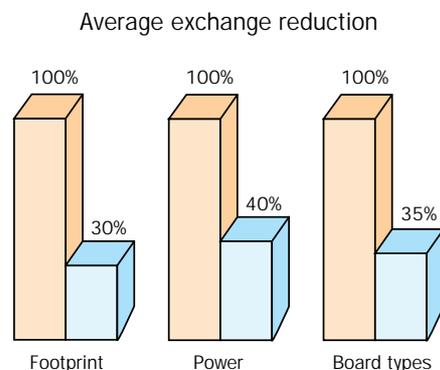


Figure 13  
Average reduction in footprint, power, and board type for an AXE exchange.

sources needed for installing the hardware will also decrease by between 70% and 90%. The delivery of fully equipped and tested exchanges will further simplify installation.

The following aspects contribute towards reducing operator costs for running the new exchanges:

- smaller footprints require less floor space (reduced overhead);
- costs of power (batteries, rectifiers and kW) and cooling are reduced (reduced overhead);
- fewer spare parts are needed (smaller facilities, smaller stores);
- operations have been simplified (less staff, less training);
- less hardware implies that the mean time between failures (MTBF) increases, while the repair time decreases – in that way, the total down time, due to hardware failures, will decrease;
- pooled devices;
- programmable platforms.

The hardware evolution described in this article represents only a first step in Ericsson's AXE hardware evolution programme. In subsequent phases of the programme, AXE will be migrated towards an open hardware architecture that supports datacom functionality, asynchronous transfer mode (ATM) switching, high-speed interfaces and multiprocessor configurations.

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