5ESS®-2000 Switch:
The Next Generation Switching System

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One of the most important trends in telecommunications is the opportunity to exploit the vastly increased bandwidth that fiber optics makes available. Fiber, together with Synchronous Digital Hierarchy/Synchronous Optical Network transmission, will alter network topologies and necessitate new methods of bandwidth management. The 5ESS-2000® Switching Module-2000 makes the most of this bandwidth by providing both multi-megabit data switching and a high-bandwidth, intraswitch message network to interconnect SM-2000s. The SM-2000 hardware:

- Implements a duplex switching fabric that can be engineered to 33,792 time slots,
- Supports optical and electrical links to peripheral interface units,
- Provides wideband circuit switching of multiple 64 kbits/s data streams as one stream,
- Supports increased SM-2000 processor capacity, enhanced significantly through processor technology upgrades and wider-bandwidth busses, and
- Supports substantially increased message protocol-handling capabilities.

While continuing to support traditional switching applications, the 5ESS-2000 Switch will make possible a host of new wideband services. These include video conferencing, high-speed data transfer, and integrated switched and non-switched networking.

Introduction

For over a decade, digital switching has been evolving to meet changing subscriber needs. Recently, integrated services digital network (ISDN) and message-based interoffice signaling systems have led to a wide variety of intelligent network (IN) services including, most recently, wireless Global System for Mobile (GSM) Communications. In the near future, digital switches must provide an ever-increasing number of services, including wideband and broadband switched services.

Switching manufacturers will have to satisfy future telecommunications needs by gracefully evolving today's in-service switches to provide the platform for future services. These services require enhanced processing capacity, performance, reliability, and systems—for operations, administration, maintenance, and provisioning.

This paper addresses the evolution of the key component of the 5ESS® Switch, the switching module (SM-2000), and how it provides an enhanced platform for wideband switching. An overview of the SM-2000 hardware and software architecture is provided, as well as an introduction to the types of wideband service applications made possible by the new platform.

Switching Evolution

Introduced in 1982, the 5ESS Switch was designed from the beginning with the flexibility to meet the demands of telecommunication service providers worldwide. This flexibility was achieved with an innovative modular architecture that took advantage of

the then emerging microprocessors, as well as fiber optics (see Figure 1). The building blocks of the 5ESS Switch are the:

- Switching modules (SMs)—Each SM contains its own switching fabric, terminating up to 5,000 lines or 500 trunks, and a call processor based on the Motorola 68000 microprocessor family,
- Communication module (CM)—Interconnects the SMs over fiber-optic links, and the
- Administrative module (AM)—Provides system-wide functions, such as the maintenance interfaces and billing data collection.

Three advantages offered by this architecture are flexible modular growth, remoting capabilities, and the ability to adopt new features. By flexibly configuring the SMs, a mixture of local, toll, operator position, international gateway, and cellular applications can be supported on one switch. Although periodic upgrades have been made to the SMs to keep pace with advances in microelectronics, the 5ESS Switch has never required the major reconstruction and change-out of equipment that other switching systems have experienced.

Since the 5ESS Switch was introduced, there has been an accelerating change in network design, subscriber services, standards, and switching technology itself, including the transition from analog to digital. This transition, nearing completion, has introduced a new set of challenges and opportunities to digital switching. These challenges are not unique to switching, and AT&T has articulated Service Net-2000 as its unified platform for network and service evolution. One of the principles of Service Net-2000, taking advantage of the bandwidth made available by the increasing use of optical facilities, was the major goal in introducing the SM-2000.

First seen in the trunk network, fiber is now also being applied in subscriber-access networks around the world. Once the fiber is in place, new circuits can be added, and additional bandwidth can be offered to subscribers at a low incremental cost. One obvious area of opportunity is new switched-wideband services, flexibly extending the current 64 kbits/s switched services up to E1/T1 rates of 2.048 Mbits/s and 1.544 Mbits/s. These services include video conferencing, multimedia calls, and on-demand local area network (LAN) interconnect. Standards such as CCITT H.261 for video-conferencing, and Motion Pictures Experts Group (MPEG) for video retrieval, already allow non-proprietary applications. The

Panel 1. Acronyms and Terms Used In This Paper

AM — Administrative module

ATM — Asynchronous transfer mode

Broadband — Rates of 45/53 Mbits/s, and higher

CCITT — International Telephone and Telegraph Consultative Committee

CM — Communication module

CM2 — Communication module model 2

DNU-S — Digital Networking Unit-SONET

DSP — Digital signal processor

E1 — European primary rate of 2.048 Mbits/s

GSM — Global System for Mobile Communications

IN — Intelligent network

ISDN — Integrated services digital network

LAN — Local area network

MH — Message handler

MPEG — Motion Pictures Experts Group

OA&M — Operations, administration, and maintenance

OC — Optical carrier rate of $N \times 53$ Mbits/s

PSU — Packet switch unit

QGP — Quad gateway processor

QLI — Quad link interface

QLPS — Quad link packet switch

QPH — QLPS protocol handler

RAM — Random access memory

SDH — Synchronous digital hierarchy, CCITT optical transmission standard

SM — Switching module

SMP — Switching module processor

SONET — Synchronous optical network, Bellcore optical transmission standard

STS — Synchronous transfer system

STM — Synchronous transfer mode

T1 — Terrestrial (North American) primary rate of 1.544 Mbits/s

TMS — Time multiplexed switch, space-division switch between SMs/SM-2000s

TSI — Time slot interchange, time-division switch in each SM/SM-2000

VC — Virtual container

VT — Virtual tributary

Wideband — Data rates of 1.522/2.048 Mbits/s

only remaining roadblock to deploying these valuable services is the convenience of being able to dial-up these "wideband" services through the public switched telephone network—just like an ordinary phone call. This roadblock is overcome with the 5ESS-2000.
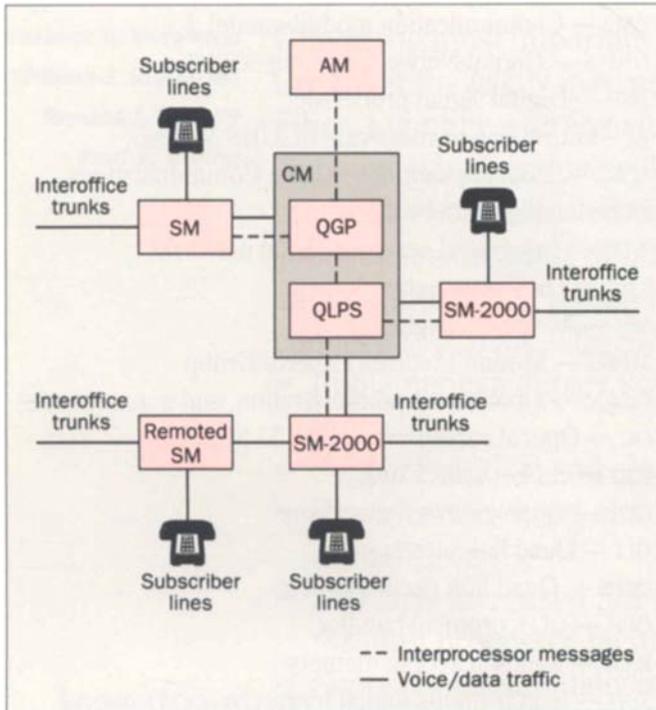
Figure 1. The 5ESS Switch has evolved into the 5ESS-2000 Switch. In addition to the current Switching Modules (SMs), the switch supports the Switching Module 2000 (SM-2000), which has an enlarged switching fabric, enhanced peripheral interfaces, and N × 64 kbits/s switching. The Communication Module (CM) has the quad link packet switch (QLPS), which handles an increased volume of call-processing messages between switch processors. The new quad gateway processor (QGP) provides an access point in the QLPS network for messages destined to and from the AM or SMs.

The abundance of bandwidth also is driving new network topologies. Hand-in-hand with the falling cost of bandwidth has come a new set of standards for managing it. These include Synchronous Digital Hierarchy (SDH), which is being implemented in Europe and other countries, and Synchronous Optical Network (SONET), which is being implemented in North America and other countries. Besides standardizing high-speed rates over optical facilities, SDH/SONET will simplify the management of bandwidth services. SDH/SONET will allow data streams, called virtual containers (VCs) in Europe and virtual tributaries (VTs) in North America, to pass through the network without being demultiplexed down to 64 kbits/s circuits. At its lowest level, the VC12 and VT1.5 will, respectively, carry the 2.048 Mbit/s (32-channel) and 1.544 Mbit/s (24-channel) primary rates.

Although the falling cost of transmission and the new management capabilities of SDH/SONET will open up many new opportunities in the network, they also will place new demands on digital exchanges. The virtual containers will not be "opened" until just before reaching the switch. Transmission facilities will be less and less filled, as bandwidth becomes more affordable, and as smaller remote access units are deployed. New flexibility also will be required to handle the ever-growing number of non-switched services. The standardization of high-speed transmission, however, offers the opportunity to minimize equipment and operations expenses if bandwidth management is integrated directly in the switch. A single STS-1 (53 Mbits/s) would replace 28 T1s, and a STM-1/OC-3 (155 Mbits/s) would replace 63 E1s or 84 T1s.

In addition to addressing the trends above, the new SM-2000 incorporates many recent advances in technology. Call processing capacity can be increased, providing both more terminations per SM, and supporting new protocols, such as TR-303 for ISDN and other services, V5 for integrated access, and GSM for wireless services. In addition to meeting these new demands, the 5ESS Switch must maintain its reputation of not requiring major replacements of equipment in order to provide new services. With over 2,000 5ESS Switch exchanges worldwide, and 50 million lines in service, it was essential that the SM-2000 be easily added to existing in-service 5ESS Switches.

Platform for Higher Bandwidth

The 5ESS Switch is evolving into a powerful telecommunications platform, called the 5ESS-2000, capable of providing the services described above. The architecture and new additions to the 5ESS Switch are shown in Figure 1.

The workhorse in the new architecture is the SM-2000 switching module, which provides an enhanced fabric for wideband switching. This new fabric allows an increased number of time slots—the basic package of information in the switch module—to be managed in a flexible fashion to allocate bandwidth to new services. A new intraswitch messaging network, named the quad link packet switch (QLPS), was introduced to handle the

increased volume of call-processing messages that are anticipated between switch processors due to the large SM-2000 capacity, the proliferation of intelligent network, and Signaling System 7 services.

The software in the 5ESS-2000 Switch was re-engineered to accomodate an increasing volume of terminations and traffic throughput. This new 5ESS-2000 Switch platform allows the graceful addition of higher bandwidth and optical peripherals, while expanding the 5ESS-2000 Switch's circuit-switching capabilities. The modular architecture of the 5ESS-2000 Switch also permits additional switching technologies, such as Asynchronous Transfer Mode (ATM) switching fabrics, to be integrated with the 5ESS-2000 Switch platform in the future.

The SM-2000 Switching Module. The SM-2000 switching module allows the 5ESS-2000 Switch to meet the increasing demands of the network:

- With an *enlarged switching fabric,* the SM-2000 can terminate multiple high-speed facilities at the STM-1 or STS-1 rates.
- With the *enhanced peripheral interface,* the SM-2000 supports both existing peripherals, with the current register-based control interface, and new higher-bandwidth peripheral units with message-based control.
- Through *wideband (N× 64 kbits/s) switching,* the SM-2000 maintains time-slot integrity with virtually no blocking.
- With *efficient management of 64 kbits/s circuits,* the SM-2000 supports larger wire centers terminating an increasing number of E1 (2.048 Mbit/s) or DS1 (1.544 Mbit/s) facilities.
- With *remote capabilities,* the SM-2000 is able to host remote SMs.
- With *flexible provisioning,* the SM-2000 switching fabric, and the number of terminations, will grow with the needs of the network applications.

New Intraswitch Messaging Network—QLPS. Future services in the network will include a proliferation of intelligent network offerings, and larger call volumes, which will increase the messaging within the 5ESS-2000 Switch. In anticipation of this increase, the quad link packet switch (QLPS)—the new high-capacity, high-bandwidth, low-latency message transport network—can be engineered into the 5ESS-2000 Switch. The QLPS provides the intraswitch messaging linkage between the

SM-2000s, the CM, and Signaling System 7 or other external signaling networks.

Software and Data Scaling. To meet an increased number of line terminations on equipment, and the larger volume of call traffic, the expanded capacity of the SM-2000 required a re-engineering of the software and data structures in the 5ESS-2000 Switch. A flexible internal naming scheme, for the equipment and circuit pack databases, allows the software to easily support the introduction of new equipment and services. In addition, the increased capacity required software extensions, called scaling, for generating and storing measurement, billing, and other data records. Maintenance software algorithms were modified to handle the complexities of increased equipment and larger capacities.

Higher Bandwidth and Optical Peripherals. The 5ESS-2000 Switch provides the hardware and software platform required for the introduction of higher bandwidth and optical peripherals. This switch makes possible cost-effective implementations of N× DS1, DS3 dial-tone, and direct connections to optical facilities.

SM-2000 Components

The design of the SM-2000 core hardware, shown in Figure 2, results in less power consumption and space (footprint) than the current SM. Both the time slot interchange (TSI) unit and the switching module processor (SMP) unit contain two shelves. To ensure reliable operation, the SM-2000 uses the duplex service group strategy found in the SM: one service group will be active while the other is in a standby state, ready to be put into operation if any faults are detected in the active service group. Service circuits are contained in a single shelf, and operate independently, with service requests distributed evenly across the service circuits.

Communication Module Interface. The SM-2000 uses multiple pairs of fiber-optic cables for the connection to the Communication Module Model 2 (CM2). These fiber-optic connections transport voice, data, and messaging traffic between the SM-2000 and the rest of the switch. Each fiber-optic cable operates at a 65 Mbits/s data rate, and carries a maximum of 512 64-kbits/s voice channels, plus 512 signal channels, between the SM-2000 and the CM2. To provide flexibility in equipment, cross-connect, reliability, and independence from the fabric, the circuitry for the CM2 interface is contained on paddle-boards—small circuit packs located on the

Figure 2. The Switching Module-2000 (SM-2000) core hardware requires less power and space than the current SM. The time slot interface (TSI) unit terminates TSI links to the Communication Module (CM), peripheral interface hardware, and the processor message bus. Each TSI link can be used for connecting to either the CM Model 2 interface circuitry or to the peripheral interface circuitry. This flexibility allows engineering of the relative number of CM2 and peripheral connections.
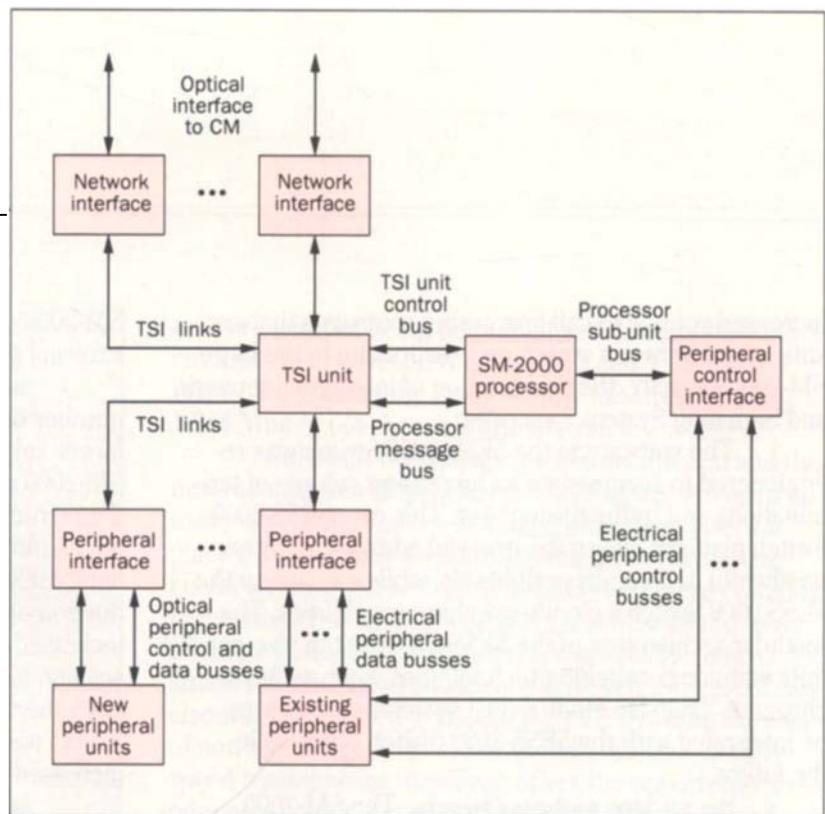
backplanes of the TSI unit. This CM2 interface provides the high bandwidth needed among SM-2000s to support new services, while providing an evolutionary design for interfacing with the existing CM design.

By using paddle-boards to combine two existing 256 time-slot links to create the 512 time-slot streams, the existing CM design is unaltered. At the SM-2000 end, different paddle-boards convert the 512-time-slot format to that needed by the TSI. In some cases, the paired links can be handled by the software as a single entity. When that is inappropriate, they are treated like separate 256-time-slot links, as in SMs, reducing both the design effort and customer retraining for operations, administration, and maintenance (OA&M).

Time Slot Interchange Unit. To provide flexibility in size, the TSI unit for SM-2000 is built around a new switching architecture. It can be engineered up to a total of 33,792 time slots to meet a variety of customer needs. TSI growth is accommodated by adding packs that linearly increase the total TSI size in increments of 3,072 time-slots. The TSI also collects and filters signaling-bit activity, which indicates the state of a line or trunk. To ensure reliable operation, the TSI unit includes two redundant service groups, which operate in an active/hot-standby configuration. The TSI unit is under the control of the SM-2000 processor, via the TSI unit control bus.

A new chip set incorporates state-of-the-art techniques for built-in self-testing at the device, circuit pack, and TSI unit levels. The testability aids manufacturing, as

well as in-system diagnostics and maintenance, and assures quick and accurate fault resolution.

The TSI unit terminates the TSI links to the CM2 and peripheral interface hardware, as well as the processor message bus to the SM-2000 processor. Each TSI link is used to transport voice channels, signaling information for the voice channels, and maintenance information. Each TSI link in the TSI unit can be used for connecting to either the CM2 interface circuitry or to the peripheral interface circuitry (See Figure 2). This flexibility allows engineering of the relative number of CM2 and peripheral connections. Links to the periphery can terminate up to 768 voice channels per optical TSI link.

The TSI unit also provides selective double buffering, a mechanism that guarantees byte ordering and frame integrity of the E1 or DS1 channels that are used for $N \times 64$-kbits/s wideband services. Double buffering re-buffers "early" time slot samples, allowing them to be transmitted in the same frame as "later" time slot samples. The TSI unit hardware can complete an intra-SM-2000 connection without using or blocking a CM2 connection. The TSI unit provides an abundant pool of time slots that can be flexibly provisioned between the CM2 and peripheral units, as shown in Figure 3. This now makes it possible to economically introduce consolidation, nail-up, and separation functions in the switching fabric itself.

- *Consolidation:* TSI time-slot consolidation, the reordering of customer data samples from one time slot to another, enables the SM-2000 to economically
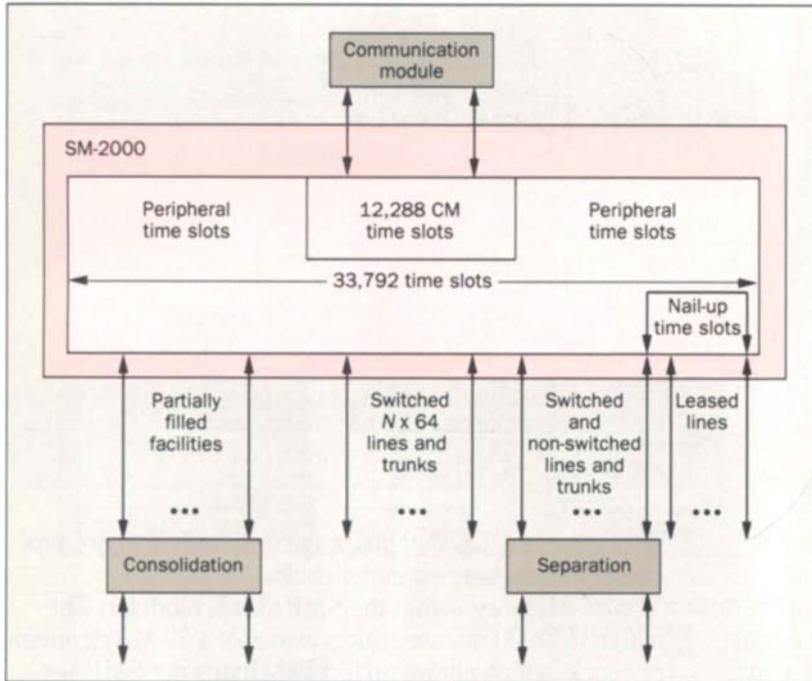
Figure 3. The Switching Module-2000 (SM-2000) can be engineered to have up to 33,792 time slots, of which 12,288 can be used to connect to the Communication Module (CM), and the remainder used for switched and non-switched connections. *Consolidation* permits the time slot interchanger (TSI) to reorder customer data samples from one time slot to another, enabling the SM-2000 to economically terminate partially filled facilities from remote locations. *Nail-up* permits the TSI to permanently connect leased lines by the month or year, without consuming other switch resources. *Separation* permits the separation of switched and leased-line circuits that were multiplexed at remote locations onto the same incoming facility. Switched circuits are routed to the switched network, and leased circuits are routed to the private-line network.

terminate partially filled facilities from remote locations. Flexible time-slot allocation enables the TSI to consolidate this traffic before passing it on to other parts of the 5ESS-2000 Switch. Traffic engineering is greatly simplified by having 33,792 time slots per SM-2000.

- *Nail-up:* The combination of this TSI time-slot allocation capability, and the size of the TSI fabric, make it economical to nail up, or permanently connect by the month or year, leased lines directly through the SM-2000. In this case, TSI time slots could be allocated directly from one line or trunk unit to another, without consuming other switch resources.

- *Separation:* In some cases, a single remote node might mix both switched and leased circuits on a single facility. In this case, the SM-2000 can provide a separation function. Switched circuits would be routed normally, while leased lines would be separated, within the SM-2000, and routed to the private line network.

With consolidation, nail-up, and separation functions, the SM-2000 becomes, in essence, a 64-kbits/s digital cross-connect. Without manual recabling, the leased-line services can be provisioned more quickly, with fewer errors, and with reduced administrative expenses. In addition, these circuits can now take full advantage of the

administrative and maintenance capabilities of the 5ESS-2000 Switch.

To maximize the compatibility with the existing 5ESS Switch, the SM-2000 data interfaces are basically unchanged. While the control interface changed to support the increased number of time slots and additional capabilities (e.g. double buffering) of the SM-2000 TSI, the basic mechanism for TSI control remains unchanged. Registers and control random-access memories (RAMs) are mapped into the processor's address space. The layered structure of the 5ESS-2000 Switch software allows these alterations without wholesale software rewrites; only the low-level hardware manipulations need changing. These include operational control, maintenance, and initialization functions. Moreover, some software complexities— such as increased signaling detection in the TSI, and indirect addressing for time-slot control access—were eliminated with the new hardware.

Peripheral Interface. The SM-2000 is designed to support both optical and electrical interfaces to peripheral units (e.g., line and trunk units). Electrical interfaces provide backward compatibility with peripheral units that are offered on the current SM. Optical interfaces, using circuitry that is similar to the CM2 interface, provide a new high-speed peripheral interface that combines data

Figure 4. In the SM-2000 architecture, a new switching module processor (SMP) distributes processor power between the core circuit pack and the message-handler (MH) circuit packs. Multiple processor busses increase the amount of parallel processing that can be achieved. The message-handler pack processes both inter-SM-2000 message traffic and, in a future release, message traffic between the SMP unit and new peripheral units. Memory within the SMP also is modular.
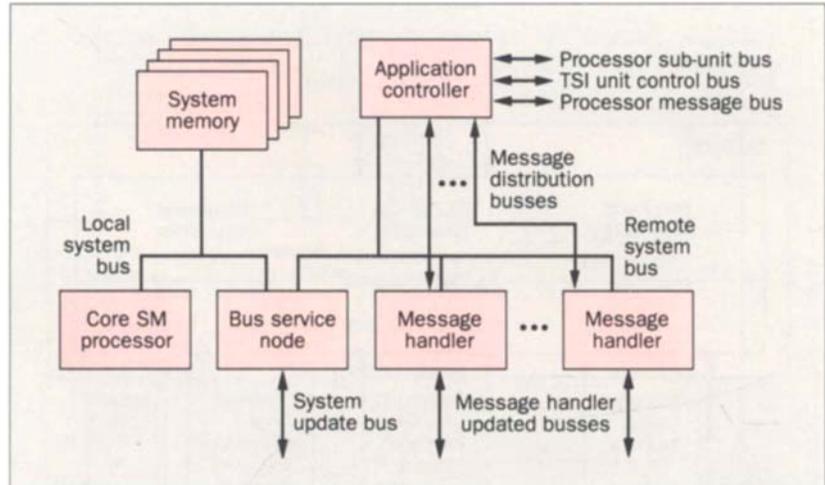
and control. This 768-time-slot interface is first used by a new peripheral, the Digital Networking Unit-Sonet (DNU-S), and allows for direct switch termination of SONET transmission facilities at the STS-1 rates. The DNU-S is a high-capacity digital trunk termination vehicle that can support up to 12 STS-1 interfaces or 336 T1s. The DNU-S is envisioned to support TR-303 interfaces at an OC-3 rate. With either type of peripheral interface, the number of circuit packs in an SM-2000 TSI is determined by both the CM2 configuration and the number and types of peripheral units that it hosts.

Switching Module Processor Unit. The SM-2000 architecture includes a new switching module processor (SMP), shown in Figure 4, in which the processor power is distributed between the core circuit pack and the message-handler (MH) circuit packs. Multiple processor busses increase the amount of parallel processing that can be achieved, as well as allowing busses to be optimized to the services required. Each processing element in an SMP service group is equipped with an update bus, which connects to its corresponding element in the other service group. These update busses are used to ensure reliable duplex operation of the SM-2000.

The message-handler pack processes both inter-SM-2000 message traffic and, in a future release, message traffic between the SMP unit and new peripheral units. Each SMP service group in an SM-2000 can be equipped with one core-processor pack and multiple message-handler circuit packs. Since increased SMP capacity is needed to support the increased number of peripheral terminations, the initial SM-2000 release

incorporates MC68040 processors on both the core processor and message-handler packs.

Memory within the SMP also is modular. The initial SM-2000 release makes available a 32-MByte memory pack, which allows up to 128 MBytes per SMP service group. Memory packs also incorporate built-in self-test capabilities.

Like the TSI, the SMP hardware-software interface reuses existing concepts and register definitions to reduce the impact on existing code. The performance of the SM-2000 is increased by high clock speeds and burst-memory access to main memory with error correction. Burst memory, the ability to request several words of memory but give only one address, is used primarily to fill cache memory quickly. The major techniques used to achieve these increases include wider busses (16 bits now evolved to 64 bits—all with parity) and faster processors and clocks (from 9 MHz MC68000s to 33 MHz MC68040s). Additional processor power is gained by off-loading jobs into other entities, such as the message-handler packs, while maintaining the existing designs.

Service Circuits. The SM-2000 architecture also includes a new digital service-circuit pack that uses state-of-the-art digital signal-processing (DSP) technology. This circuit pack is capable of flexibly providing local service-circuits, such as tone generation and digit reception, over bi-directional channels via electrical interfaces. Each SM-2000 can be equipped with both local service-circuit packs and global service-circuit packs. The number of packs is expandable, with adequate space provided to allow for future service-circuit functions
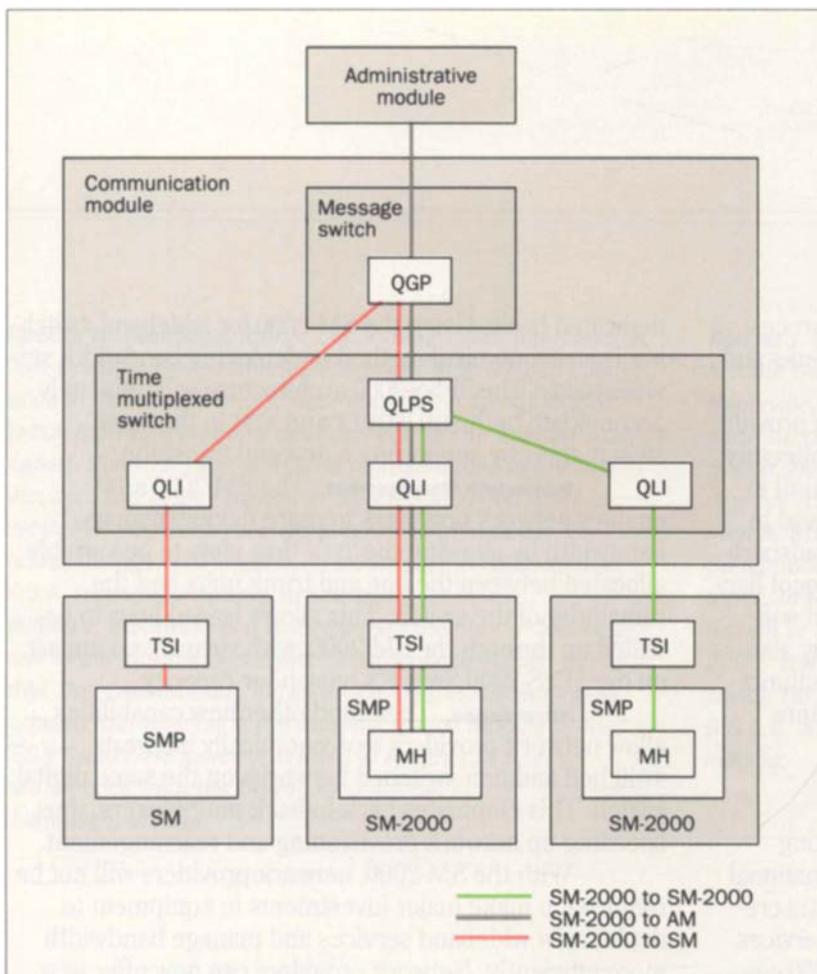
Figure 5. The quad link packet switch (QLPS) subsystem consists of three new hardware subunits. The *QLPS board* performs the functions of a high-speed message router, based on a proprietary protocol. Since QLPS is optional in a 5ESS-2000 Switch, interprocessor messages can use the existing communication links or QLPS links. The *quad gateway processor* (QGP) provides an access point in the QLPS network for messages destined to and from the AM or SMs. QGPs also are optional, and interprocessor messages will automatically use the QGP, if it is so equipped. The *message handler* resides in the SM-2000 and provides the termination point for interprocessing messages

covering the range, from simpler signal-monitoring functions to more advanced voice-processing features. The service-circuit hardware provides flexibility by means of a software-downloadable architecture, which permits not only downloading control functions, but signal-processing functions as well — including selective mapping of processing task types to different DSPs.

As the basic set of digital services have not changed, the general software control is little altered from the current SMs. This similarity is enhanced by the use of existing interfaces for both control and data-channel connections.

Quad Link Packet Switch. The QLPS subsystem is a major new component that significantly increases the interprocessor messaging capacity required by the SM-2000s. The QLPS subsystem consists of three new hardware subunits, which provide a high-speed, low-latency messaging and data network internal to the 5ESS-2000 Switch, as shown in Figure 5. These three subunits provide the core platform for the QLPS subsystem. Each subunit can be grown into the existing 5ESS Switch architecture as an integrated system component, as capacity is needed. In addition, the dual-duplex hardware architecture, and supporting maintenance software, are designed to provide a high level of reliability and availability.

The key hardware subunit resides in the time multiplexed switch (TMS) of the CM2. It occupies the same physical locations as the current quad link interface (QLI) board, which terminates SM links. This new subunit is referred to as the *QLPS board*. It performs the functions of a high-speed message router, and is based on a proprietary protocol. The hardware and software interface to the QLPS board is similar to the quad link interface. Since QLPS is optional in a 5ESS-2000 Switch, interprocessor messages can use the existing communication links or QLPS links.

Residing in the message switch of the CM2, the second subunit, the *quad gateway processor* (QGP) provides an access point in the QLPS network for messages destined to and from the AM or SMs. Message communication from the AM's and the SMs' points of view is unchanged by QLPS. The processor circuit of the quad gateway processor reuses an existing pack, making it compatible with the existing message switch. QGPs also are optional, and interprocessor messages will automatically use the QGP if it is so equipped.

Located in the SM-2000, the third subunit, the *message handler*, resides in the SM-2000 and provides the termination point for interprocessing messages destined for the SM-2000. Each SM-2000 must have at least one

message handler, because it is used for all interprocessor messages over the existing communication links and the QLPS.

The QLPS subsystem can be expanded to provide other access points in the 5ESS-2000 Switch architecture. The QLPS protocol handler (QPH), which is a subunit in the packet switch unit (PSU), is an access point used in the International 5ESS Switch architecture for transporting Signaling System 7 messages. The QLPS protocol handler is an existing circuit board with new resident software. In future releases, the protocol handler may also be used to transport ISDN packet-switched data, adjunct-processor data, or other for applications that require high-capacity, low-latency data transport.

Service Provider Applications

In addition to continuing to support existing 5ESS Switch applications, such as ISDN and international gateways to other networks, the SM-2000's new TSI creates opportunities for deploying new wideband services with $N\times$ 64-kbits/s switching. Because an SM-2000 can co-exist and interwork with existing SM's, it is easily incorporated into an in-service 5ESS Switch. This preserves the service provider's investment in the embedded base of 5ESS Switches.

Video conferencing. One of the major drivers for $N\times$ 64 kbits/s switching is video conferencing, which appears poised for rapid service expansion. A major barrier to faster growth is the need for easier access and greater convenience in placing a video conference call.

Traditionally, video conferencing calls have required leased lines, which are often uneconomical except for large business subscribers. The SM-2000's TSI allows $N\times$ 64-kbits/s calls to be switched through the SM-2000 on a per-call basis, together with other basic telephone services and ISDN calls. This allows subscribers to economically place a video call through the public network, rather than through the leased-line facilities. Furthermore, the large size of the TSI means that these calls are virtually non-blocking. In turn, equipment purchases for network providers are minimized, since the $N\times$ 64-kbits/s calls are switched concurrently with other 5ESS-2000 Switch calls through the same SM-2000.

High-Speed Data Transfer. $N\times$ 64 kbits/s also will facilitate new high-speed data services, such as LAN interconnect and multimedia services, on either a per-call or

dedicated basis. Using the SM-2000 for wideband switching is an economical method of deploying bandwidth services today. The 5ESS-2000 architecture will ultimately accomodate both SDH/SONET and ATM in the same switch, thereby supporting a graceful transition.

Bandwidth Management. The SM-2000's TSI enables network providers to more flexibly manage bandwidth by allowing the TSI's time slots to be variably allocated between the line and trunk units and the remainder of the switch. This allows leased lines to be nailed up through the SM-2000, with virtually no impact on the 5ESS-2000 Switch's busy-hour capacity.

Advantages. These and other new capabilities allow network providers to economically integrate switched and non-switched networks on the same digital switch. This eliminates back-to-back multiplexers, thus speeding up network provisioning and rearrangement.

With the SM-2000, network providers will not be required to make major investments in equipment to deploy new wideband services and manage bandwidth more efficiently. Network providers can now offer new services—economically—in time to meet the needs of their end-customers.

Summary

Future telecommunication networks will provide information-age services that require high-bandwidth switching. Customers want responsiveness, flexibility, and reliability in their services, and network providers want simpler control over their equipment. We have examined the SM-2000 technology as an example of the evolution of an existing switching product into a platform for future services.

Reference

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