

PLANNING FOR ISDN IN THE 5ESS™ SWITCH

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The 5ESS™ switch is a world-class switching exchange system. It is designed to handle many applications over a full range of office sizes and with a wide variety of customized services. Its modular hardware and software architectures and its feature-customization capabilities provide this flexibility, and form the base for adding Integrated Services Digital Network (ISDN) capabilities. By the end of 1986, the 5ESS switch will begin offering ISDN services and, with simple hardware and software changes, will evolve from a conventional digital switch into an ISDN switch. This paper presents an overview of the 5ESS switch implementation plan. It describes the target user groups for the initial offering of ISDN services on a 5ESS switch, why the ISDN concept benefits these users, and what ISDN capabilities the 5ESS switch offers to meet their needs. It also describes the ISDN architecture of the 5ESS switch and how the ISDN capabilities are built incrementally on the switch's existing distributed, modular architecture.

Market Needs

Targeted for the initial offering of 5ESS switch ISDN are business users who demand a variety of diversified, advanced voice and data services to meet their increasing and changing telecommunications needs. They may subscribe to centrex services from a central office, or may have their own private branch exchanges (PBXs) or local area networks on their premises.

ISDN is a unified approach for providing these 5ESS switch users with cost-effective, flexible services that evolve easily in a timely manner. The ISDN concept offers them integrated access, end-to-end

digital connectivity, and out-of-band message signaling, resulting in complete digitization of communications between customers. These attributes also make it easy to introduce new ranges of services such as packet-switched data services.

With the ISDN standard interface, a user has integrated access to simultaneous voice and data services for all telecommunications needs, flexibility for selecting and reconfiguring services as needs change, and the facility for adding new services as needs grow. In addition, by eliminating the need for multiple, service-associated interfaces for today's multiple services, ISDN integrated access reduces the overall cost of services. Furthermore, no additional building wiring is needed to provide multiple services over the standard ISDN open interface.

Users will have a new generation of customer premises equipment, with increased intelligence, that will provide new capabilities and will make existing services easier to use. In addition, the new message-signaling capability will open a new era of advanced calling features and increased user control of communications.

To ensure world-wide applicability, the 5ESS switch ISDN implementation will follow the standards for ISDN recommended by the International Telegraph and Telephone Consultative Committee (CCITT). Following these standards is also important for compatibility of the 5ESS switch ISDN with existing and future equipment and for user satisfaction. (See Aldermeshian's article, "ISDN Standards Evolution," page 19.)

5ESS Switch ISDN Capabilities

To meet these diverse market needs, the 5ESS switch will provide both the CCITT-standard, 2B + D basic-rate interface and 23B + D and 30B + D primary-rate interfaces in its ISDN offering. (See Roca's article, "ISDN Architecture," page 5.)

With the basic-rate interface, the 5ESS switch supports both the CCITT-standard, four-wire, "T" digital

subscriber loop (T-DSL) interface and a pre-standard two-wire, "U" DSL (U-DSL) interface. The 5ESS switch ISDN primary-rate interface, called the extended DSL (EDSL) interface, is offered over existing DS-1 carrier facilities. Technical specifications for these 5ESS switch ISDN interfaces have been published.^{1,2}

These ISDN capabilities are added incrementally on the existing 5ESS switch. As Figure 1 shows, the switch has a modular, distributed architecture consisting of switching modules (SMs), a communications module (CM), and an administrative module (AM).

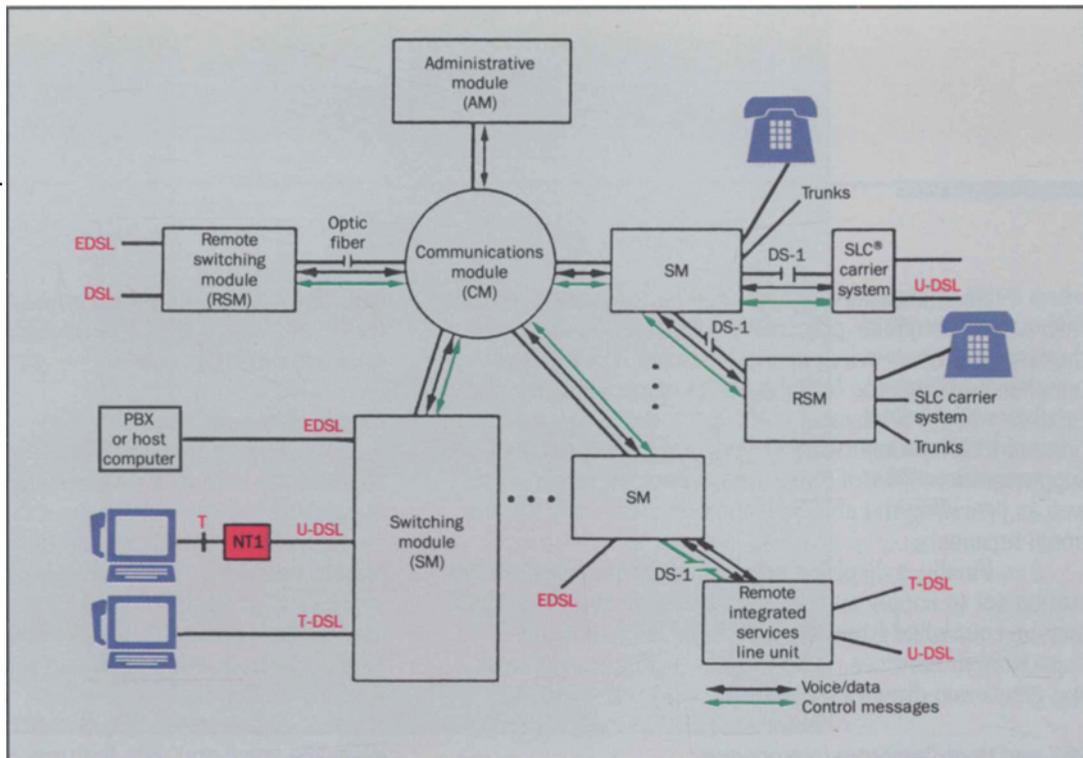
Switching modules provide the interface to the subscriber access and transmission systems and contain all the software needed to support the terminal features. The SM-CM-SM complex provides a time-space-time switch for circuit-switched communications, and the administrative module provides global services and an interface to operations systems.

By adding new hardware units and software, a switching module can be configured for ISDN services, yet can serve varying combinations of both ISDN and non-ISDN users. Furthermore, to serve ISDN users at remote sites, switching modules can be connected via DS-1 carriers or fiber optics to a host 5ESS switch. Distant ISDN users may also be served via other 5ESS switch remote units, such as SLC[®] carrier system remote terminals or remote integrated services line units.

As a result, any 5ESS switch can grow or be retrofitted incrementally with ISDN capability to meet the needs of all 5ESS switch applications.

Adding ISDN capability to the 5ESS switch is a major step in the evolution to universal information services, a vision of the future telecommunications network. The ISDN concept of an open, public, standard interface for future networks is a basis for the concept of a single access-and-transport network that supports a complete range of voice, data, and image services simultaneously, with high efficiency. Plans are being formulated to build

Figure 1. ISDN access arrangements (shown in color) for the 5ESS system.



incrementally on the 5ESS switch ISDN architecture the components that will further enhance the switch's capabilities for universal information services.

Four distinct application areas are being planned for the initial 5ESS ISDN implementation: centrex services, PBX and host-computer interconnect, private networks, and operator services.

Centrex Services

The 5ESS switch ISDN offers simultaneous voice and data services to centrex users over the basic-rate 2B + D access with either the T-DSL or U-DSL interface. For ISDN voice users, the 5ESS switch supports the full range of centrex voice features using ISDN out-of-band message signaling. ISDN centrex data also offers circuit-switched and packet-switched data services.

Basic-rate 2B + D access can provide simultaneous voice and data services in several ways, giving users flexibility for configuring their services. They may use a B channel for voice service, circuit-switched data transport or packet-switched data services. Or, the D channel may

carry packet-switched data, interleaving data with the signaling packets.

Circuit-switched data services include 64-kb/s clear-and-restricted data transport as well as 56-kb/s digital-data transport. The 56-kb/s capability may be used to communicate with existing circuit-switched digital capability terminals in a data-only mode. Both 56- and 64-kb/s data transport may also be used for accessing host computers via the host-computer interface described below.

Packet-switched data services include X.25 local area network services from the 5ESS switch and access to external public packet networks via a 5ESS switch gateway. The X.25 standard is a CCITT recommendation for packet-switched networks. As noted above, packet data may be carried in either the B or D channel.

In addition, the 5ESS switch ISDN offers modem-pooling capability for data access and communication with existing customer terminals through the conventional public network.

ISDN centrex improves on conventional multibutton-key-system services in several ways.

The simultaneous voice and data capability of the DSL access simplifies premises arrangements, eliminating the large bundle of wires needed in non-ISDN key systems. In addition, the out-of-band message signaling capability of the D channel enhances the call-control functions of ISDN multibutton-key sets. ISDN centrex also supports the full set of conventional centrex features, as well as providing the ability to communicate with conventional terminals.

Finally, a display element may be provided on the station set to supply customer information about calls and may be controlled from the switch for improved call-management services. Interworking with message-desk and electronic-directory services is also provided.

PBX and Host-Computer Interconnect

The 5ESS switch provides an ISDN primary-rate interface to users with PBXs via the 23B + D or 30B + D EDSL interface.

The EDSL interface supports existing 5ESS switch central-office to PBX services as well as circuit-switched data transport at 64-kb/s clear-or-restricted and 56-kb/s rates. EDSL access is also compatible with AT&T's digital multiplexed interface message-oriented signaling specification³ for a host-computer interface and, therefore, can interconnect the 5ESS switch with host computers.

A set of Q.931/I.451 messages provides transparent, end-to-end transport of user-specified information—such as caller name, security check, or feature transparency—between PBXs or host computers. These CCITT-standard, primary-rate signaling messages are carried on the D channel.

Real-time facility management also uses these signaling messages to allocate facilities dynamically call by call, giving users more per-call control. With this capability, an EDSL B channel can be assigned to a particular service for one call and to a different service for the next

call. The service-independent interface leads to more traffic-efficient use of access channels, and reduces the total number of channels.

Private Networks

The 5ESS switch is deployed in private network applications both as PBXs serving individual end users and as tandem switches interconnecting PBXs. The 5ESS switch ISDN applications just described are being used in private networks to meet these needs. Through synergistic application of intelligent vehicles, private networks that involve the 5ESS switch and other ISDN PBXs, such as AT&T's System 75 and 85, can satisfy customers' total networking needs.

For example, ISDN centrex services provide PBX-like voice and data features to individual end users over the ISDN standard, basic-rate interface. Similarly, the ISDN host-computer interconnect capability provides an effective interface to host computers for PBX data services, and PBX interconnect features provide tandem switch-like features for interconnecting PBXs with ISDN primary-rate interfaces.

Operator Services

The 5ESS switch Operator Services Position System (OSPS)—which provides directory assistance, toll and assistance, and coin services—is based on the ISDN implementation, demonstrating the flexibility of simultaneous voice and data capabilities.

OSPS functions include switching a caller to an operator position via an automatic-call distributor, switching the caller to an automatic announcement system, and switching data from an operator to data bases and vice versa. These functions use ISDN Q.931/I.451 messages to control B-channel circuit-switched and D-channel permanent and virtual circuits for voice and data needs.

As a result, the ISDN OSPS implementation minimizes interfaces and fully integrates voice and data.

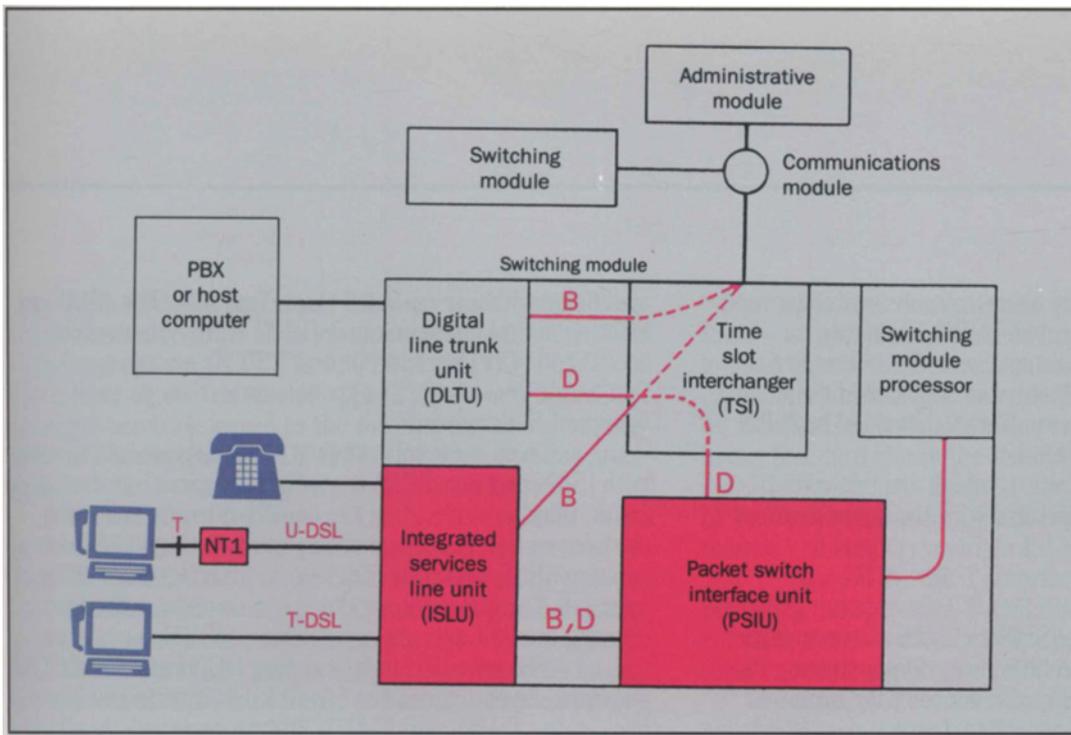


Figure 2. 5ESS switch ISDN hardware architecture. New units (identified in color) added to the switching module support ISDN access and protocol.

5ESS Switch ISDN User Interface

Figure 1 shows the ISDN access arrangements that the 5ESS switch will offer for its T-DSL, U-DSL, EDSL, and remote access user interfaces.

T-DSL—The T interface implements the CCITT I.430 recommendation for specifying layer 1 of the basic-rate user-network interface. It provides a four-wire connection to ISDN station sets, has a 1-km distance limit, and is used in a protected environment because over-voltage protection has not yet been specified. As a result, the T interface is not suitable for outside-plant distribution.

The T interface will be offered directly from the 5ESS switch and from its remoting vehicles.

U-DSL—The two-wire U interface is not specified in the CCITT recommendations. (Practices, such as loop bridging that impairs transmission quality, are not global.) The U-DSL interface must be used if the distance from the switch exceeds 1 km or if the transmission facility is in outside plant. The CCITT-standard T interface may be derived from the U interface at the user's premises through NT1 network terminating equipment.

The 5ESS switch's U interface incorporates echo-canceled hybrid circuitry to transmit full $2B + D$ on a conventional, unloaded two-wire subscriber loop. Very-large-scale-integration (VLSI) technology is used to integrate echo canceling, clock recovery, equalization, and scrambling or descrambling circuitry into a custom chip set.

Although a technology-related distance limit exists, the 5ESS switch U-DSL offering will exceed the carrier serving area range in 1987.

EDSL—The 5ESS switch EDSL offering supports a $23B + D$ or $30B + D$ channel format, with one channel of the DS-1 facility serving as a 64-kb/s D channel that carries signaling information for the 23 B channels. The EDSL uses the existing 5ESS switch DS-1 carrier, which meets the CCITT I.431, layer-1 recommendation, for an ISDN primary-rate, user-network interface.

In addition, the EDSL interface supports the existing, domestic DS-1 framing and line formats for those users or regions that do not support 64-kb/s clear-channel transport.

Remote Access—ISDN services may be provided to distant users using several 5ESS switch remoting vehicles.

For high-density clusters of users, remote switching modules may be deployed to provide ISDN interfaces to individual users. The remote integrated services line unit may be used for smaller clusters of users. Additional flexibility to serve dispersed customers is provided by ISDN access in SLC carrier systems.

These remote vehicles, which are transparent to end users, provide remote users with the same features and services as local users.

ISDN Switch Architecture

The 5ESS switch ISDN capabilities are built incrementally on the existing architecture, demonstrating the switch's continuing flexibility and capacity for evolution.⁴

To support ISDN access and protocol, new intelligent hardware units—the integrated services line unit (ISLU) and the packet switch interface unit (PSIU)—are

added to switching modules (see Figure 2). The ISLU and existing digital line trunk unit (DLTU) provide physical access to ISDN users, while the PSIU is a packet switch that terminates users' D channels as well as packet-switched B channels.

These new units allow a switching module to serve both ISDN and non-ISDN customers, minimizing startup costs. Furthermore, they can be added to any switching module, so that ISDN service is upward compatible with existing 5ESS switches. These new interfaces are being integrated into existing modules in a way that will allow offering present service capabilities to ISDN customers.

The new ISLU and existing DLTU provide CCITT-standard, layer-1 functions for all ISDN interfaces. The basic-rate, T-DSL and U-DSL interfaces are physically terminated on the ISLU, while the primary-rate EDSL interface terminates on the DLTU.

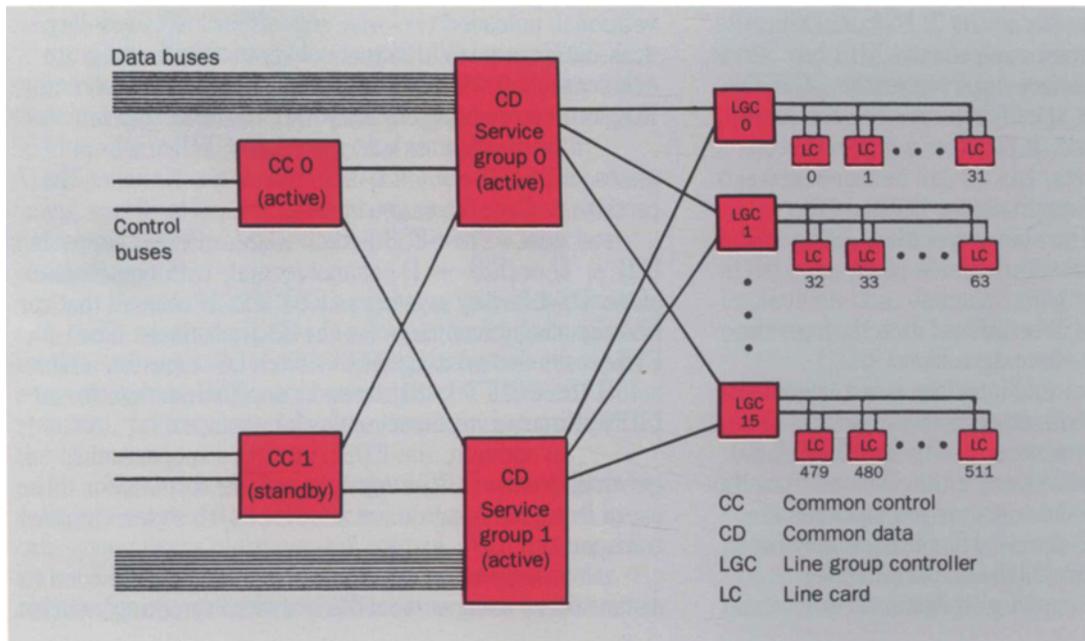


Figure 3. Integrated services line unit.

From these two units, ISDN-access D channels and packet-switched B channels are connected to the PSIU where appropriate CCITT Q.921/I.441 LAPD or X.25 LAPB layer-2 procedures are applied. D-channel signaling messages are transferred to the existing switching-module processor where the CCITT Q.931/I.451 procedures are applied and call-processing functions are performed.

Layer-3 processing for X.25 packets is split between the PSIU and the switching module processor. The PSIU handles most X.25 layer-3 functions, although some data-base information, e.g., call routing information, requires access to the switching module processor. This separation of functions properly partitions real-time intensive aspects of X.25 data traffic and minimizes the impact of adding ISDN services in a switching module.

ISDN Hardware Architecture

Figure 2 shows the hardware architecture of a switching module configured for ISDN services.

A directly connected data bus provides basic-rate access, D-channel connectivity between the ISLU and PSIU. This path can also be used to connect packet-switched B channels to the PSIU. The time-slot interchanger, a time switch for circuit-switched connections, provides EDSL D-channel connectivity between the DLTU and PSIU and circuit-switched paths for ISDN B channels.

The communications module includes a space switch that provides 64-kb/s circuit-switched paths between switching modules. It supports B channel traffic between switching modules, as well as packet traffic between PSIUs in different switching modules. The switching-module processor provides call-processing and overall control-and-maintenance functions for the switching module. Switching-module processors in different switching modules communicate with each other and with the administrative module through a message switch in the communications module, using the 5ESS switch's internal-message protocol.

For both domestic and export applications, the ISLU—a versatile and flexible line unit—supports all analog and digital 5ESS switch subscriber-line termination types. Each subscriber line the ISLU serves is terminated on a dedicated, specialized line card that may be installed in any line card slot in the ISLU (see Figure 3). This allows the ISLU to support up to 512 lines in an arbitrary mixture of line types (dependent on the application). A switching module can support multiple ISLUs.

For ISDN, the T-interface line card is available for providing the four-wire T-DSL interface, while the U card provides the two-wire U-DSL interface. The T card can be used in export applications to terminate the international "S" interface. A Z card is also available for terminating non-ISDN analog lines. Different U- and Z-card versions will be available to meet country-specific requirements. Automatic line sparing is also available for U- and Z-interface line cards.

The ISLU can provide digital concentration from 1-to-1 to 16-to-1. Like other peripheral units, the ISLU interconnects to the rest of the switching module through data and control buses. These data buses may be connected either to the time-slot interchanger for circuit-switched, B-channel voice and data transport or to the PSIU for D-channel and packet-switched, B-channel connectivity. Also, the ISLU can be located remotely from the host 5ESS switch via DS-1 carrier facilities.

The PSIU, an intelligent packet switch, supports ISDN signaling messages and switches X.25 data packets using protocol handlers that communicate with each other and with the switching module processor via a serial packet bus (see Figure 4). The packet bus—a high-speed, fully arbitrated, unstructured communication path—is configured as a star network for efficient fault isolation and repair. For reliability, each packet bus is duplicated and provides each half of a duplex switching-module processor with access to any protocol handler in a PSIU.

To minimize per-line costs, the PSIU uses VLSI circuits extensively to maximize the number of D channels

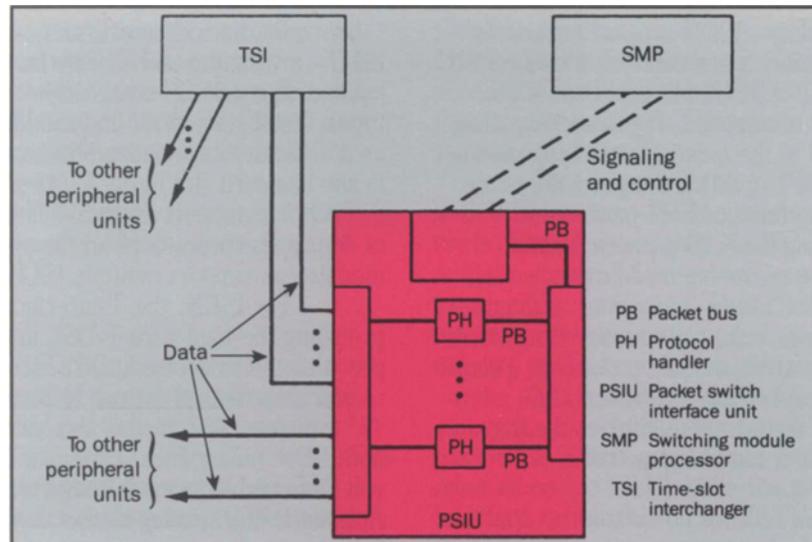


Figure 4. Packet switch interface unit.

supported by a protocol handler. The PSIU can grow from one to five shelves, with each containing up to 16 protocol-handler boards, depending on the number of DSLs that the ISDN switching module services. This growth configuration permits small startup costs and considerable flexibility for growth.

ISDN Software Architecture

The 5ESS switch software architecture is structured as a hierarchy of modular systems with clearly separated functions and with hardware details isolated from application software.

The operating system manages the switch's computing resources, supporting all software systems. A data-base-management system provides a general, but switch-specific, relational data base for all application-related data. An abstract-switching-machine system provides a constant view of the hardware, yet hides

hardware details from the application software. The application software—the highest layer in the hierarchy—provides system functions such as call processing, maintenance, and administration by using the services of the lower software systems. This architecture simplifies future technology changes, such as the addition of ISDN capabilities and beyond.

To support the PSIU that was added for ISDN services, the operating system is extended to provide an execution environment in the protocol handler with message communication between the protocol handler and the switching module processor. The abstract-switching-machine system was also extended to provide an abstract view of the signaling interface between the D-channel messages and application-level software in the switching module processor when the protocol handlers relay signaling messages to the switching module processor for delivery to application software.

Operational software for the application is distributed among the protocol handlers, switching modules, and administrative module. For ISDN circuit-switched calls, the switching module and administrative module have the same call-processing roles as they do currently for the 5ESS switch circuit-switched calls. For packet-switched calls, however, the protocol handlers are now responsible for establishing and disconnecting virtual calls. Software in the administrative module and switching module will provide routing, traffic-reporting, and billing-data reporting functions.

Conclusion

ISDN is a quantum jump in the evolution from today's digital network into tomorrow's visionary network. The 5ESS switch ISDN plan described here brings the concept of universal information services one step closer to reality. The introduction of 5ESS switch ISDN in the telecommunications market meets customers' needs, while providing a key building block for the evolving network.

Furthermore, the timely deployment of 5ESS system ISDN services will maintain AT&T's role as a leader in providing telecommunications equipment that embodies the evolution of a visionary network.

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