OSPS SYSTEM ARCHITECTURE

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Operator services position system (OSPS) architecture builds on the 5ESS® switch Integrated Services Digital Network (ISDN) base to provide modern, flexible operator services. This article details some major operator system innovations provided by the OSPS system architecture.

Introduction

The 5ESS® switch operator services position system (OSPS) provides toll and assistance services and listing services for both North American and international applications.[1] (Toll and assistance is called *traffic assistance* for international applications.) Toll and assistance service allows the telephone customer to complete calls such as coin, calling card, and person-to-person, with operator assistance or—in certain cases—automatically. Listing services enable operators to supply telephone customers with listing information (such as directory numbers). OSPS adds hardware and software to the 5ESS switch Integrated Services Digital Network (ISDN) base[2] to produce a system that is ideal for implementing these operator services. (See page 2 for a list of acronyms used in this issue.)

A number of system innovations are provided by the OSPS system architecture. OSPS is the first ISDN-based operator system. It uses ISDN basic rate interfaces[3] (BRIs) to link operator terminals and data links to the switch, which minimizes the number of wires and provides integrated high-quality voice and data. In addition, remote system options allow flexible location of operators over a wide geographical area.

A major goal of the OSPS software architecture is to create a system which is adaptable, flexible, and portable across North American and international applications. This operator system software includes innovative distribution of system intelligence to multiple system modules and operator terminals. In addition, automatic call distribution software provides flexible engineering and control of operator serving teams and queues.

A design challenge was to provide open network interfaces so that the full power of external administrative and database systems could be utilized. These open interfaces allow external computer-based systems to be connected to OSPS using industry-standard interfaces and protocols. An important requirement was rapid access to external

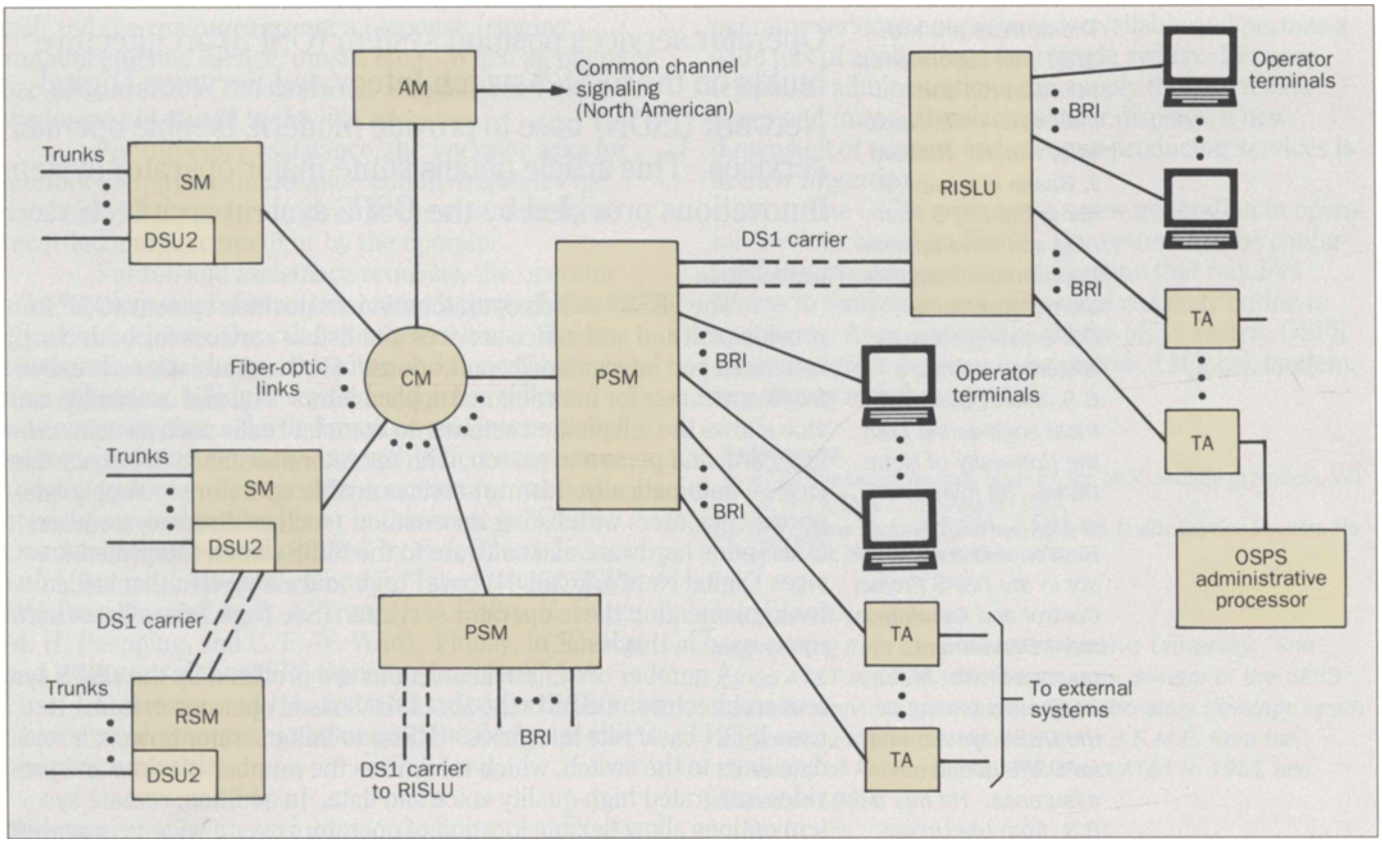


Figure 1. OSPS hardware architecture.

databases. Innovative use of packet switching and special software provides operators with rapid, simultaneous access to multiple external databases.

OSPS Hardware Architecture

OSPS hardware is designed so that the operator terminals and data links communicate with the switching hardware over ISDN communication channels. Also, OSPS hardware and processing power is distributed (for example, each operator terminal contains a processor which can perform independent functions). This allows economical system growth and provides a modular increase in system processing power as hardware is added. These significant system attributes have been introduced into an operator system for the first time with OSPS.

Major System Components. Figure 1 depicts the OSPS hardware architecture. Operator terminals connect to position switching modules (PSMs) via ISDN basic rate interfaces, which allow both voice and data to be sent over the same set of wires. PSMs are 5ESS switch ISDN switching modules (SMs) that are used for the OSPS application and contain the hardware and

Table I. Operator Terminals and Their Applications

Terminal	Application
Video display terminal (VDT)	North American toll and assistance
Basic services terminal (BST)	Listing services
Combined services terminal (CST)	North American toll and assistance plus listing services
Intelligent communication workstation (ICW)	International traffic assistance

software necessary for interfacing and controlling operator terminals and data links. Other 5ESS switch SMs terminate analog and digital trunks and contain digital service circuits, such as conference and announcement circuits, required by OSPS. Remotely located SMs, called *remote switching modules* (RSMs) or *optically remoted switching modules* (ORMs), can also be used to terminate OSPS trunks. An OSPS system can grow incrementally by adding more SMs, PSMs, RSMs, or ORMs. In addition, it is possible to grow the module hardware by adding equipment units. Only the PSMs are dedicated to the OSPS application. Other types of switching modules can be shared with other 5ESS switch features.

Figure 1 shows the standard 5ESS switch communication module (CM) and administrative module (AM).[4] The CM contains the center space stage of the time-space-time division network that provides 64 kb/s (kilobit per second) digital communication channels between the SMs for transmitting voice or data. It also contains a message switch, which provides internal data communications between modules. The AM performs overall system administrative and maintenance functions and provides the automated call distribution function for OSPS.

Processors located in each SM provide a high degree of distributed intelligence for handling operator calls. This distributed intelligence is further increased by the operator terminals. Each terminal contains a microprocessor-based system that allows the terminal to perform a number of local functions independently of the switch. These functions include rapidly confirming input commands, local editing, generating specialized displays, and running terminal self-diagnostics.

Table I lists the operator terminals and their applications.[5]

All the terminals communicate with the PSM using the CCITT standard 2B + D basic rate interface (BRI).[3] One of the B channels is for 64-kb/s digital pulse-code modulation (PCM) voice transmission, while the D channel provides 16-kb/s data communications (the second B channel is available for future use). The BRI between the terminals and the PSM is implemented with the CCITT standard four-wire T digital subscriber loop interface.

Connections between OSPS and external support and database systems use terminal and rate adapters, which convert the ISDN BRI to a format compatible with the connecting systems. These external system connections can be made from any SM equipped with ISDN hardware. In addition, OSPS provides access to other external systems over common channel signaling (CCS) networks. The CCS network interfaces are provided from the AM for North American OSPS applications and from SMs for international OSPS applications. More information on OSPS external system interfaces will be given in the section "OSPS Data Communications."

Position Switching Module. The PSM shown in Figure 2 contains 5ESS switch hardware units configured to support the OSPS application. A PSM contains a switching module processor and time slot interchanger, which are standard parts of each 5ESS switch SM. ISDN packet switching is provided by the packet switch unit, which allows operator terminals to communicate via data packets with the switching module processor and external database computers. ISDN BRI links from operator

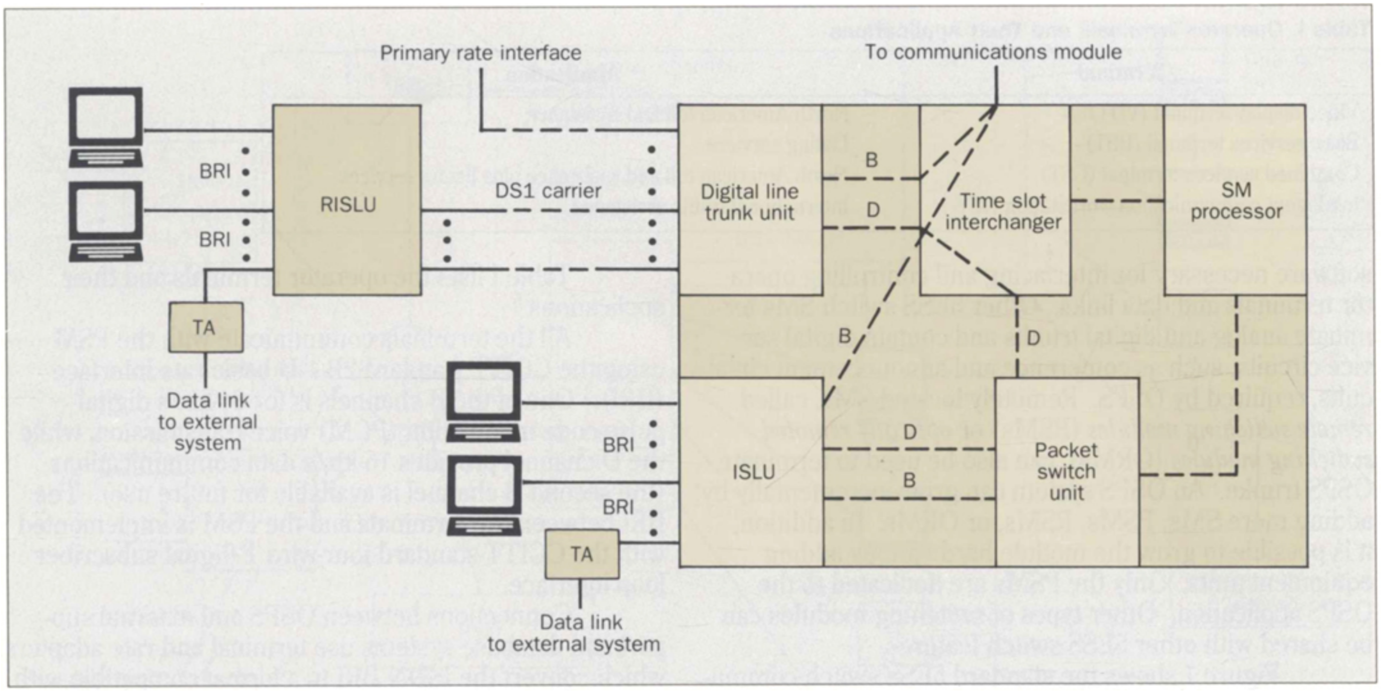


Figure 2. OSPS position switching module.

terminals and external systems terminate on either an integrated services line unit (ISLU), if they are physically close to the PSM, or on a remote integrated services line unit (RISLU), if they are remotely located from the PSM. The ISLU is physically part of the PSM, while the RISLU connects to the digital line and trunk unit in the PSM via digital carrier facilities. No concentration is used in the ISLU or the RISLU for OSPS, so each incoming link has guaranteed access to the PSM's time division and packet switching circuitry.

After the B and D channels from a RISLU enter the PSM, they are connected to the time slot interchanger. The B voice channels are digitally switched to their destination via the 5ESS switch time division network while the D channels are connected by "nailed up" (permanently set up) time division links to the packet switch unit. D channels from an ISLU are directly connected to the packet switch unit while ISLU B channels connect either to the packet switch unit for data communications or to the time division network for voice.

OSPS Operator and Automated Calls. Calls come into OSPS via digital or analog trunks terminating on an SM (see Figure 1). A time division network path is then set up between the trunk and the appropriate BRI link to an operator. A talking path is established between the operator terminal and the trunk over the time division connection and one of the B channels on the BRI link. In addition, the D channel allows the terminal's processor to communicate with the switching module processor via the packet switch unit in the PSM. The operator can now talk to the customer and handle the call using the terminal's display and keyboard.

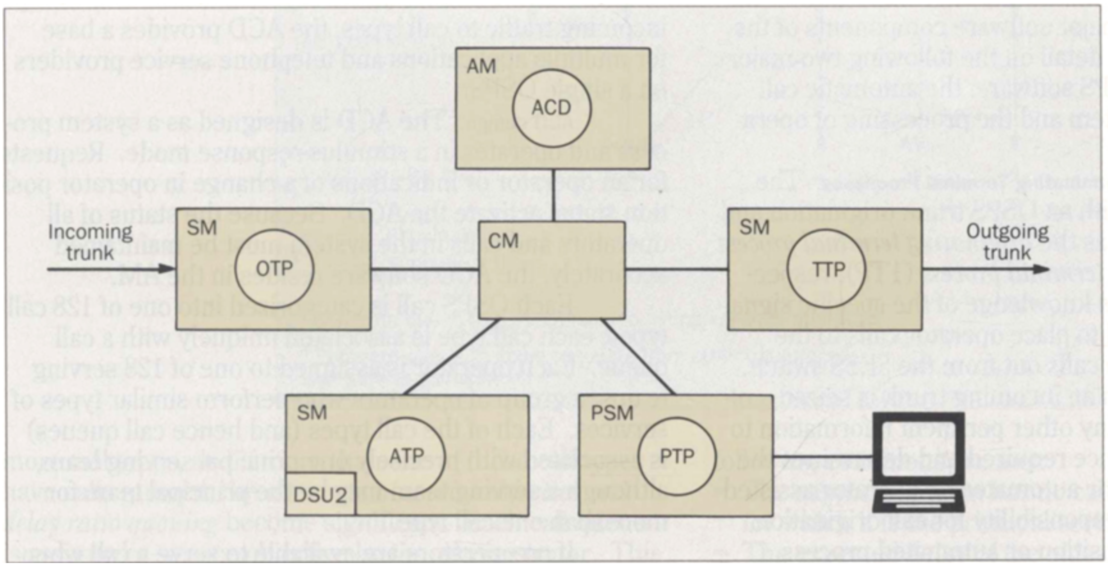


Figure 3. OSPS common software architecture.

Special hardware and software is provided to allow certain types of calls, such as calling card and coin, to be handled without an operator. Digital services units located on the SMs (the blocks labeled DSU2 in Figure 1) provide the required digitally synthesized announcements and perform tone detection functions. These circuits are connected to a call in place of an operator when it is determined that automated call handling is possible.

The following section describes in more detail how the software controls OSPS operator-assisted and automated calls.

OSPS Common Software Architecture

The OSPS call processing software architecture has been configured for maximum commonality across applications while allowing a software system that can evolve and be expanded to meet demands for additional features.

The software architecture builds on the basics of the 5ESS switch call processing architecture and reuses basic functions, such as routing and signaling. Because of the distributed nature of the hardware architecture, the software architecture is similarly distributed. The architecture consists of a set of system and terminal processes, described below. Terminal processes are typically associated with peripheral equipment, such as a trunk or an operator terminal, while system processes are associated with a global resource, such as the set of operators on the system. The 5ESS switch operating system for distributed switching (OSDS)[6] manages these processes and provides a mechanism for interprocess messages for communication. The OSPS processes operate concurrently across the switch. Software running in each process has only the knowledge about the system and its features required to do its function. Standard message interfaces exist between major components of the system. Consequently, new features can be added to the system without changing significant portions of the base OSPS system.

Figure 3 illustrates the common software architecture of OSPS and shows the relationship of the software and hardware architectures. The following sections describe the major software components of the system, with additional detail on the following two major innovations used in OSPS software: the automatic call distribution (ACD) system and the processing of operator keystrokes.

Originating and Terminating Terminal Processes. The processes associated with an OSPS trunk origination and termination are known as the *originating terminal process* (OTP) and *terminating terminal process* (TTP), respectively. This software has knowledge of the specific signaling systems being used to place operator calls to the 5ESS switch or to route calls out from the 5ESS switch. The OTP, created when an incoming trunk is seized, collects dialed digits and any other pertinent information to identify the type of service required and determines the next course of action (for automated or operator-assisted call handling). It has responsibility for call origination, setup to the operator position or automated process, monitoring of a call in progress, and call tear-down and billing. If the call is to be routed to an operator position, the OTP determines the call type, classifying it into one of 128 OSPS call types. The classification is based on factors such as incoming trunk group and dialed digits. The software in the OTP is designed to be data-driven (according to the trunk type or signaling system used, for example) and state-driven (according to origination, operator setup, talking, routing, and termination, for example). Common functions are provided for standard needs, such as connection to an operator position.

The TTP is created when a call is placed out from the switch; its primary function is to provide signaling interfaces on outgoing trunks. These trunks can be used for reaching another party or to route a call to an external announcement source.

Automatic Call Distributor. The major innovation in the OSPS automatic call distributor is its sophistication and flexibility. As the core component of all OSPS applications, the ACD is designed to support large numbers of call types, queues, and serving teams. By permitting flexible assignments of operators to serving teams and incoming traffic to call types, the ACD provides a base for multiple applications and telephone service providers on a single OSPS.

ACD design. The ACD is designed as a system process and operates in a stimulus-response mode. Requests for an operator or indications of a change in operator position status activate the ACD. Because the status of all operators and calls in the system must be maintained accurately, the ACD software resides in the AM.

Each OSPS call is categorized into one of 128 call types; each call type is associated uniquely with a call queue. Each operator is assigned to one of 128 serving teams, a group of operators who perform similar types of services. Each of the call types (and hence call queues) is associated with precisely one principal serving team, although a serving team may be the principal team for more than one call type.

If no operators are available to serve a call when it arrives, the ACD queues the request and compares the expected delay for the call to administratively defined thresholds. Expected delay is the product of queue length and call removal rate. Depending on the thresholds and the expected delay, one of four levels of caller alerting is chosen, and the OTP is informed of the specified treatment to apply. The initial delay treatment consists of audible ringing, while the next two treatments consist of administrator-specified announcements followed by audible ring. For calls experiencing the highest level of expected delay, an administrator specified announcement is played, and the call is not queued.

The ACD is notified of all status changes for each operator position on the PSM: made busy, busy, or available. (*Made busy* is a state used by an operator who is logged in, not handling a call, and is not ready to accept the next call.) When one or more operators on a team are available, and a call type associated with that team arrives, the operator who has been idle the longest is selected to handle the call. Similarly, calls of a given call type are queued and distributed on a first-in, first-out basis.

If a team is a principal serving team for two or

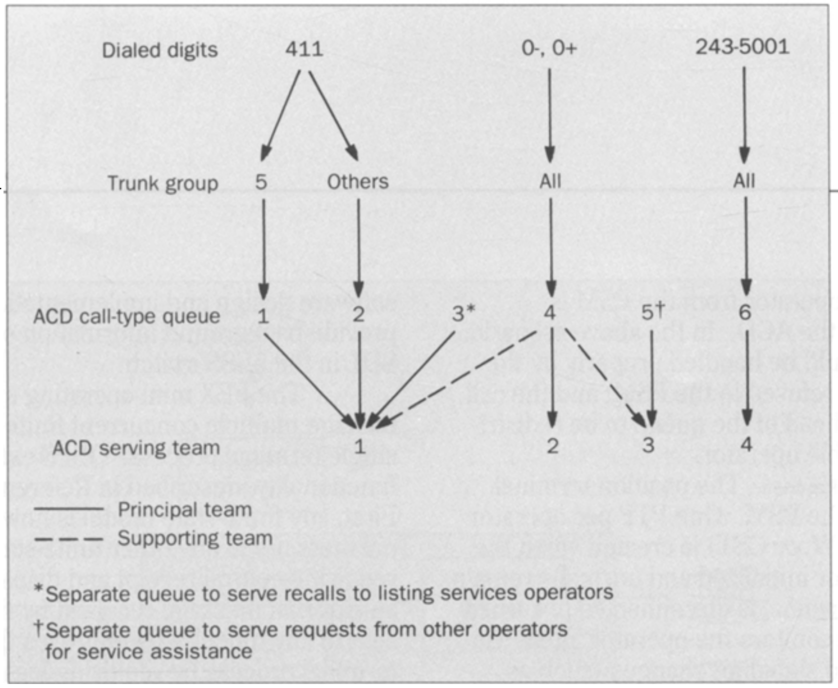


Figure 4. Example of ACD call type and serving team configuration.

more call types, and if more than one of those call types have calls queued, the concepts of *service objective* and *delay ratio queuing* become significant. Each call queue is assigned a service objective by the administrator. This is the average length of time a call to an operator can be expected to wait in queue when the administrator has forecasted traffic volume accurately and staffed the operator positions accordingly. When an operator becomes available, the ratio of the waiting time of the oldest call in the queue to the service objective is calculated for each queue served by the operator's team. This ratio is the delay ratio for that queue. The queue with the highest delay ratio is selected to have a call distributed to the next available operator. This flexibility allows the administrator to set priorities for different queues, based on a desired service objective, without having to "starve" one queue of callers to serve another.

The association of call types to serving teams is further generalized by the intraflow feature of the ACD. Up to eight supporting teams, in addition to the principal team, may be associated with a call type. This provides a flexible and powerful way of increasing the number of operators who may handle a call without affecting the primary call-handling responsibilities of the operators in the supporting teams. A supporting team can handle traffic normally destined for the principal team when the following conditions are met:

- The supporting team has no calls waiting in any queue for which it is the principal serving team.
- The expected delay of the oldest call in the queue is longer than an administratively defined "outflow threshold."
- The percent of operators on the supporting team serving intraflowed traffic is less than an administratively defined "call percentage threshold."

When operators from several qualifying supporting teams are available, the supporting teams for a call type are searched in a predefined order to select the first team that meets the above qualifications. Delay ratio queuing is used to select one of several supporting queues to be served when an operator is available, when the intraflow conditions are satisfied for more than one queue, and when no calls are waiting on a principal queue. Figure 4 shows a potential mapping of OSPS call-type queues to serving teams.

ACD design challenges. Because the ACD operates in a distributed environment, issues associated with potential race conditions and interprocessor audits exist. For example, the ACD can attempt to distribute a call to a position that has just logged out, causing race conditions for the relevant messages. The design philosophy followed is to make the ACD self-correcting. Any status message regarding an operator from the PSM is assumed to be valid by the ACD. In the above scenario, the logout message would be handled properly by the ACD; the call would be refused in the PSM; and the call would be placed at the head of the queue to be redistributed to the first available operator.

Position Terminal Process. The position terminal process (PTP) runs in the PSM. One PTP per operator position (BST, VDT, ICW, or CST) is created when the position is powered up or initialized and normally remains in existence until the terminal is disconnected or turned off. The PTP software monitors the operator inputs via keystrokes and reacts to signaling changes (such as disconnects) or system actions (such as receiving an incoming call). The PTP provides many common features across OSPS applications, for example, login, hold, and conference or transfer to another operator. The PTP architecture is common, but each application develops specialized new features, specific to a given market need. The challenge for the PTP architecture is to ensure a common base that can be expanded easily, while providing an excellent human interface to the operator (i.e., fast response time, clearly understandable displays, etc.).

The key technical concept of the PTP architecture is the use of finite-state models. The finite-state model approach is particularly applicable because operator-handled calls have many inputs coming asynchronously from multiple sources (operator, customers, system), and processing those inputs puts the calls into multiple states (idle, setting up a connection, processing a database query). Moreover, because many interfaces to the PTP exist (operator terminal, back party, forward party, database enquiries, etc.), the architecture defines multiple concurrent finite-state models that distribute the processing intelligence. The OSPS is designed to use an enhanced version of the feature execution (FEX) mini-operating system, and significant portions of the PTP are written in the Specification and Description Language (SDL),[7,8] which is a CCITT standard language for software design and implementation. References 9 to 11 provide background information on the use of FEX and SDL in the 5ESS switch.

The FEX mini-operating system is designed to manage multiple concurrent finite-state models within a single terminal process. OSPS extended the basic FEX functionality, described in Reference 12, in two ways. First, any finite-state model is now able to send an internal message to any other finite-state model, instead of requiring central receipt and dispatch of messages, and an external message received by the PTP can be directly sent to any model; this improves the performance of the terminal process by requiring less message forwarding. Second, FEX was enhanced to support queuing of messages destined for each model; this ensures that all messages sent to a model are acted on in the order in which they are sent and that no messages are overwritten.

Operator Actions. The common PTP architecture used for all OSPS applications contains a base set of common models. The finite-state models are defined with specific responsibilities, and, like other terminal processes, each model has only limited knowledge of feature implementation. Each model defines its own inputs and states as needed. Figure 5 shows the basic architecture of the models for the PTP. The various components are described below.

- *Virtual terminal (VT)*—The VT model is designed to buffer the PTP software from the specific terminal implementation being used. Keystroke inputs from the operator are processed by VT and parsed for acceptability and legality, then internal messages are passed on to the appropriate model for further processing. Enhancements or changes to the human interface can be done by the VT, independently of the remaining software.
- *Feature model (FM)*— The FM is responsible for the state of the position. All interfaces to the ACD are through this model. For example, the model handles plugging in a headset by an operator to indicate the position is now staffed, logging in by the operator with

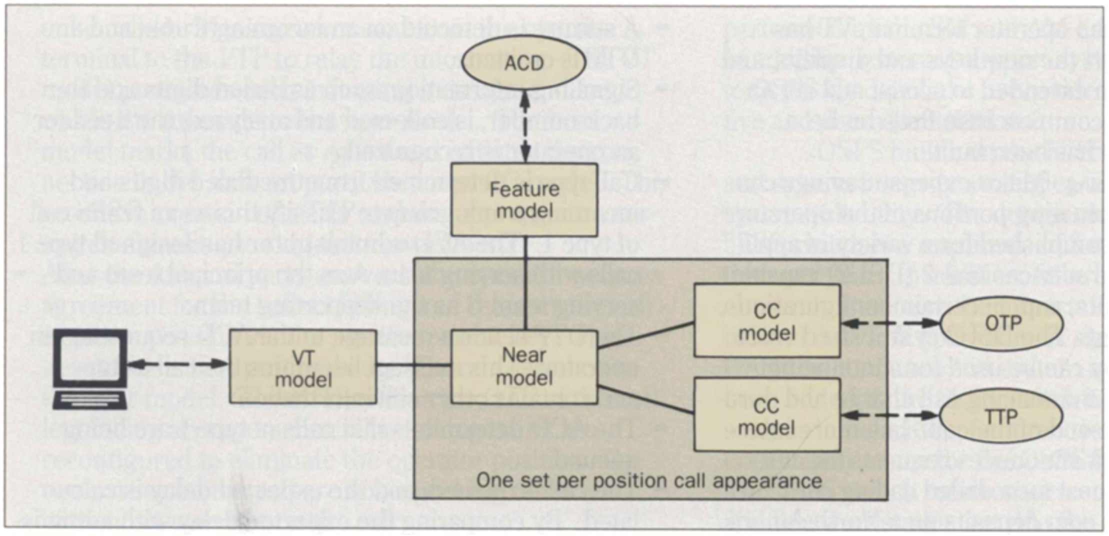


Figure 5. Common position terminal process architecture.

a personal login ID, and toggling the make-busy key by an operator to indicate whether a position is ready to accept a call. Other models in the PTP do not know the state of the position with respect to the ACD.

- *Near model*—The near model is responsible for processing most of the keystrokes entered by the operator and has much of the logic for features specific to an OSPS application. While the near model provides the same type of functionality in every application, the software is often different because of the features offered. Some of the common areas would be operator conferencing and call transfer from one operator to another.
- *Call coordination (CC) models*—The CC models are responsible for any communication and coordination between the PTP and other terminal processes. For example, on a call with a back party and a forward party, there are two CC models—one that communicates with the back party, and one that communicates with the forward party. Any specific software that is needed for communication or signaling between the PTP and OTP/TTP would be handled by a CC model. When one operator is conferenced to another operator, a CC model handles that interface and ensures that the correct data are sent to the second operator's PTP to display the appropriate information on the operator's terminal.

The advantages of this architecture have become apparent as the OSPS project added new features for various applications. The OSPS North American toll and assistance development added a *Query* model to coordinate sending queries and receiving responses from external database systems. The OSPS international traffic assistance development added a *Retrieval* model for coordinating queries and responses from internal database systems. The basic listing services application initially allowed only one incoming call at the position, but the other applications needed to handle multiple concurrent calls. The architecture was extended to allow up to three near models, each associated with its own call, and as many CC models as were required across these calls. The listing services feature added an *external information system* model for communication to an external system data link. As additional features are added requiring new keys on the operator terminal, VT has been extended to support the new keys and displays, and the near model has been extended to accept and act on the new inputs. Thus a common base that can be expanded incrementally has been built.

Automated Processing. Major expense savings can be realized through automating portions of the operator job function. This is accomplished for a variety of applications by using a digital services unit 2 (DSU2) capable of playing announcements, and, in certain configurations, accepting customer input. The DSU2 synthesized voice announcement capability can be used for announcing phone numbers and for announcing call charge and duration to a customer at the end of the call. In a more interactive use of the DSU2, it announces requests for customer input (such a request for a dialed calling card number or a request for coin deposits on a North American network coin-paid call) and then detects the customer input. In combination with the OSPS switch software, fully automated services can be constructed. Examples are automated coin toll service and automated calling card service.

An automated terminal process associated with a DSU2 port is created when a DSU2 is needed on the call for a specific function. When the DSU2 function is completed, the terminal process is terminated. The automated terminal process is typically created by a request from the OTP when the OTP logic decides that automated processing is appropriate. The announcement function in the DSU2 is driven by data sent from the switch software and special firmware in the DSU2, which contains the digitized speech. Depending on the DSU2 application, appropriate software is downloaded to the DSU2. Signals detected are forwarded to the automated terminal process. The automated terminal process differs among the various automated processes depending on the automated feature.

Typical Call Scenario. The following scenario illustrates a basic collect call. It would apply in either a North American or international application.

- A seizure is detected on an incoming trunk, and an OTP is created.
- Signaling information, such as dialed digits and the back number, is collected and analyzed; the need for an operator is recognized.
- Call type is determined from the dialed digits and incoming trunk group to classify this as an OSPS call of type 1. The ACD administrator has assigned type 1 calls with serving team A as the principal team and serving team B as the supporting team.
- The OTP sends a message to the ACD requesting an operator. This message identifies the call as type 1 and contains other call information.
- The ACD determines that calls of type 1 are being queued.
- The call is queued, and the expected delay is calculated. By comparing the expected delay with administratively specified delay thresholds, the ACD determines whether a delay announcement should be provided to the caller.
- A message is sent to the OTP with this information.
- The OTP first connects the delay announcement, then provides audible ring to the caller.
- At this point, an operator from serving team B becomes available, and the call of interest has migrated to the head of the call type 1 queue. The ACD determines that no calls are waiting in any of the principal queues for team B, and further determines that the next call in the call type 1 queue is eligible to be intraflowed to team B. The ACD informs the OTP to send the call to the available operator from team B by sending a message to the PTP in the PSM. It then marks that position as busy with a call.
- The PTP, via the CC model, establishes the voice path between the caller and the operator and sends appropriate display messages to the operator terminal, via the VT model, to provide the initial call seizure information.
- The customer requests a collect call from the operator who depresses the collect key and enters the number

to be called. Messages are sent from the operator terminal to the PTP to relay the information. The VT model processes each incoming message and forwards the message to the near model. The near model marks the call as *collect* and initiates the connection to the forward party via a new CC model. This results in creation of a TTP and the appropriate interswitch signaling to ring the forward party.

- After the forward party answers, the operator secures agreement for the collect billing and releases the call from the position via the *position release* key. This keystroke is first processed by VT and passed on to the near model. The PTP notifies the OTP of the collect billing arrangements. The talking paths are reconfigured to eliminate the operator position. The two parties on the call are now speaking directly without an operator on the call.
- The operator terminal screen is cleared by VT. The FM reports its status back to the ACD as available to handle another call.
- At the conclusion of the call, a billing record is made by the OTP.

Administration and Maintenance

Administrative processors are used to provide many of the OSPS administrative functions. The OSPS administrative processor (OAP), shown in Figure 1, is used for listing services and toll and assistance applications. One OAP normally is provided per operator service center. The OAP provides measurement and performance information, which is used for serving team administration and force management. In addition, input commands can be used to change serving team sizes, call queue lengths, etc. Other OAPs are used as centralized force management computers at force management centers. Force management computers are used to help administer and perform force management across more than one operator service center.

Administrative functions, such as the generation of automatic message accounting billing records, are performed by the SM and AM hardware and software. In addition, external support systems can be connected to OSPS via data links to provide specialized administrative and database functions.

OSPS builds on the 5ESS switch maintenance and system integrity strategies in order to provide high system reliability. The design objective for the OSPS 5ESS switch is a maximum of 3 minutes of system downtime per year. In addition, failure group sizes have been chosen to minimize the impact of single faults on terminal and data link operation. A significant amount of OSPS maintenance and system integrity software has been added to the 5ESS switch base to provide functions, such as initialization, fault recovery, diagnostics, and craft maintenance for the OSPS hardware and software. The 5ESS switch maintenance control center and trunk and line workstation provide the primary human-machine interface for maintenance. In addition, OSPS terminals are designed to allow internal terminal diagnostics and initialization procedures to be initiated by keyboard commands and executed in a standalone mode without switch involvement.

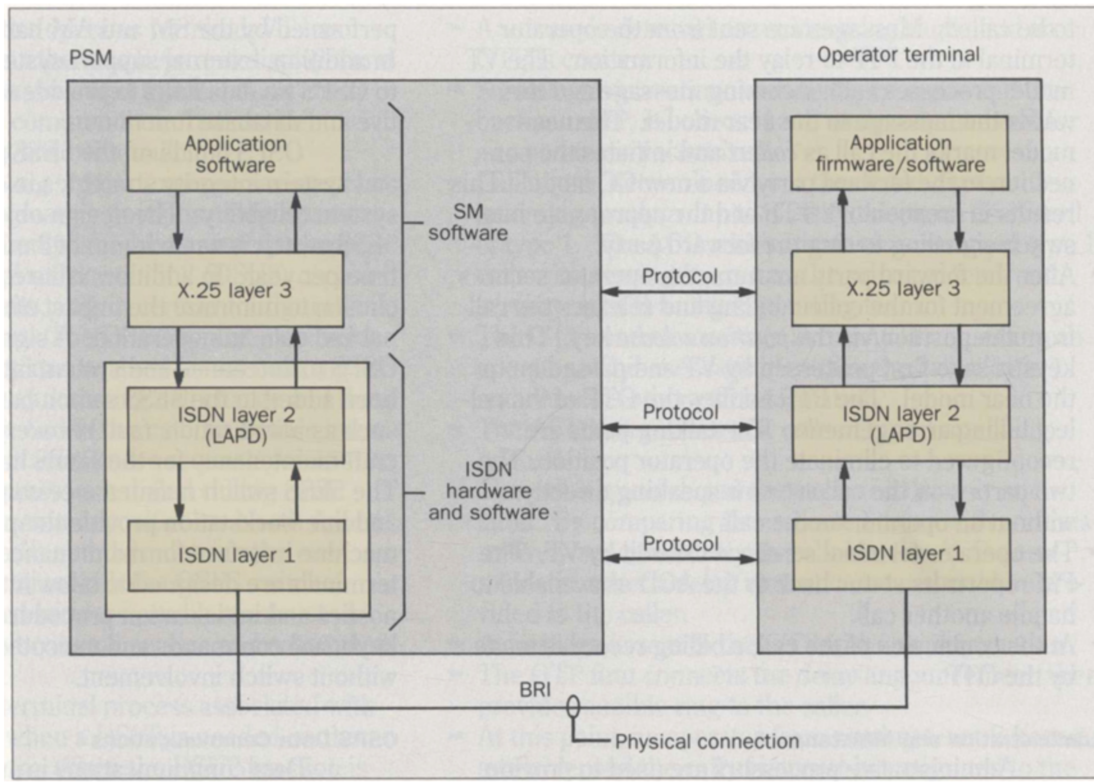
OSPS Data Communications

Data communications is used extensively both internal and external to the OSPS. Internally, OSPS 5ESS switch hardware and software implement ISDN protocols that support data communications between the OSPS terminals and the switch. Externally, for North American applications, both CCS and point-to-point data links provide communications with a variety of database and administrative systems. One of the challenges was to design standard open interfaces so that the full power of these external systems could be realized.

OSPS Operator-Switch Communications. ISDN communication protocols are used for OSPS internal data communications. Figure 6 shows the protocol layers used to reliably transmit data between the OSPS terminal and the switching module processor in the PSM.

- Layer 1, the physical layer, is provided by the basic

Figure 6. Example of the three levels of protocol used by the OSPS.



rate interface D channel which supports the 16-kb/s synchronous data transmission between the terminal and the ISLU or RISLU. This layer is specified by CCITT Recommendation Q.911.

- Layer 2, the link layer, defined by CCITT Recommendation Q.921, provides point-to-point data link communications between the terminal and the packet switch unit in the PSM.
- Layer 3, the packet layer, ensures correct end-to-end communications. X.25 layer 3 protocol is used for this layer. In the OSPS terminals, there are two packet layer entities. One entity supports a single permanent virtual circuit that is used for packet communications between the terminal's processor and the switching module processor. The other entity supports switched virtual circuits and will be described in the section "Multiple Database Access."

The operator terminals use firmware (for the BST and VDT) or software (for the CST and ICW) to implement and control the three protocol layers. This includes providing the layer 3 permanent and switched virtual circuits. OSPS application firmware/software in the terminal interfaces with the layer 3 terminal firmware/software in order to send and receive messages. At the PSM end, layers 1 and 2 are provided by the ISDN units (ISLU, RISLU, and packet switch unit), while layer 3 is implemented by switching module processor software. OSPS application software in the switching module processor interfaces with the layer 3 software to send and receive messages.

Open Network Interfaces. North American OSPS applications are required to interface with a number of different administrative and database systems. For example, OSPS requires a wide variety of supporting data regarding the back party stations, forward party stations, calling cards, and call charges to process both automated and operator-assisted calls properly and to prevent fraud. Nearly all calls require one or more "database accesses" to retrieve the needed data. For large-capacity systems such as the OSPS (which can handle 100,000 calls per busy hour), this can equate to millions of data queries per day. These data not only vary with the telephone service providers and sites, but also change frequently. In the North American application, the resulting memory requirements and administrative considerations make it prohibitive to include these data within the OSPS/5ESS switch.

Consequently, the architecture of OSPS incorporates a number of open network interfaces that permit efficient interaction with computer-based systems external to the switch. These interfaces, characterized by open, published specifications that adhere to national and international standards, fall into two categories: common channel signaling and external data links.

Common Channel Signaling. OSPS uses, to advantage, the connectivity to the CCS network provided by the 5ESS switch. The common network interface circuit[12] located in the AM, is used by the North American OSPS software to communicate with a variety of network elements and databases.

CCIS6 (common channel interoffice signaling no. 6) direct signaling[13] is used by OSPS to communicate with certain external computer systems. A full destination address is included as part of the message being sent. This address is used to steer the message through the CCS network to the correct external computer system.

OSPS also communicates with external computer systems using the transaction capability application part protocol of CCS7 (common channel signaling no. 7). Both the CCITT and American National Standards Institute (ANSI) versions of the protocol can be used.

For both CCIS6 and CCS7, call details such as the forward number, back number, and/or calling card number are transmitted to specific nodes on the CCS network. These nodes return information and instructions to the OSPS—for example, which services are to be allowed or denied. Typical nodes that interact with OSPS in this manner are the line information database (LIDB) on the CCS7 network and the billing validation application (BVA) database on the CCIS6 network. The LIDB and BVA currently provide information to OSPS for the processing or rejection of collect, bill-to-third number, and calling card calls for the regional Bell operating companies and AT&T, respectively.

External data links. In addition to CCS, the OSPS design provides a number of other open interfaces with external computer-based systems that perform administrative functions, support call processing in real time, or receive call data unique to OSPS. These are data link interfaces that originate from either an ISLU or RISLU as ISDN basic rate interfaces as shown in Figure 1. Conversion from basic rate interfaces to formats compatible with commercial computer data link standards, such as X.25 Link Access Procedure B layer 2, is performed by specially designed terminal adapters.

One example of an external system connected to OSPS by X.25 data links is the real-time rating system. This system provides North American OSPS applications with the "rate" information (e.g., cents per minute) for calls from coin stations, hotels, and motels. With this information OSPS computes the charges for the call and collects the appropriate coins or advises the hotel/motel of the charges.

Each of the data link interfaces is characterized by an open, published interface that permits the telephone service providers to procure the systems from vendors of their choice and, to a limited degree, to customize their operations. It also provides significant flexibility for future enhancements via new CCS or data-link-based services.

Multiple Database Access

The OSPS operators may access up to 15 databases over the ISDN D channel via packet-switched data calls. The first application of this feature is the interface with an operator reference database that provides toll and assistance operators with rapid access to multileaf bulletin information, such as emergency numbers and procedures. Previously, telephone companies had maintained multileaf bulletin information in paper format at each operator workstation. Future applications of this feature include combining the functions of toll and assistance with listing services on the same terminal[14] and providing new services that require interactions with external systems.

Database Access System Architecture. The multiple database access system architecture is illustrated in Figure 7. This figure shows an operator terminal having two active switched virtual circuits; the first connects to a directory assistance (DA) database for listing services calls and the second connects to an operator reference database for toll and assistance calls.

The ISDN packet-switched network was selected as the data transport facility because of its flexibility and its standard interfaces for setting up and tearing down switched virtual circuits between the terminal and the external database. The connection of operator terminals and external databases to a packet network allows the operator terminal to request packet connections to any selected database dynamically. Each external database is identified by an ISDN directory number. A set of directory numbers is stored in office-dependent data to permit administrative personnel to specify the external databases that are to be accessed by each operator.

The multiple database access feature uses the following X.25 standard packet-switching facilities:

- *Calls barred (incoming)*—Restricts any ISDN customers from placing packet calls to an operator terminal.
- *Closed user groups*—Restricts unauthorized ISDN customers from placing packet calls to the external database and ensures that only the authorized operator terminals can connect to a database.
- *Multiline hunt group*—Used to implement the routing of packet calls from each operator terminal to the appropriate database. Thus, each database can be assigned one telephone number and support a large number of simultaneous incoming data calls.

As illustrated in Figure 7, the operator terminal supports multiple virtual circuits multiplexed on the D channel of its basic rate interface. The operator terminal supports up to 15 switched virtual circuits using the X.25 layer 3 protocol over the D channel. The D channel also supports a permanent virtual circuit for communicating with call-control software in the PSM. The operator terminal uses layer 3 of the X.25 protocol to establish and control the switched virtual circuit connections to the external databases.

The operator terminal supports multiple simultaneous sessions with multiple external databases by reserving internal memory for each session. The internal memory stores protocol and screen information for each session, and each session's memory can be updated continuously and independently.

Summary

The OSPS system architecture builds on the 5ESS switch ISDN base to provide modern, flexible operator services. The hardware architecture uses ISDN basic rate interfaces to link operator terminals to the switch. The basic rate interfaces provide integrated voice and data transmission, which is ideal for supporting operator functions. These functions include operator terminal keyboard commands and displays as well as access to multiple external databases.

The OSPS software architecture is built around the distributed structure of the 5ESS switch. This architecture is composed of software processes located in multiple switch modules and firmware or software

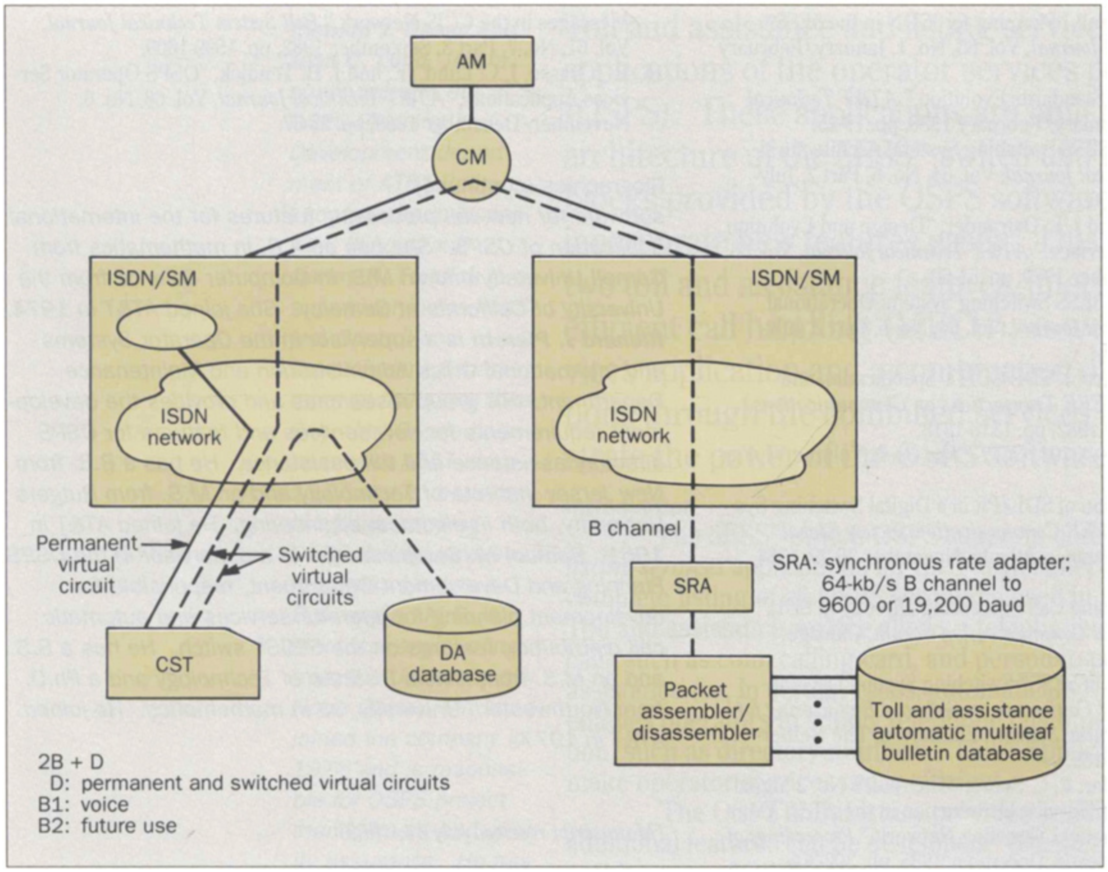


Figure 7. Multiple database access architecture.

resident in the operator terminals. The software and firmware/software cooperate in performing call processing, administrative, and maintenance functions. Distribution of intelligence allows economical modular system growth and provides advantages such as rapid acknowledgment of operator input commands. In addition, the OSPS ACD software allows very flexible engineering and control of operator serving teams and queues.

OSPS's open network interfaces allow a wide variety of external administrative and database systems to be accessed by using standard data links and protocols. This provides maximum flexibility to users of OSPS by enabling them to chose external systems that best match their requirements.

The combination of an ISDN-based, growable hardware architecture and a flexible software architecture enables telephone service providers to tailor OSPS to optimally meet their needs.

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Biographies (continued)

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