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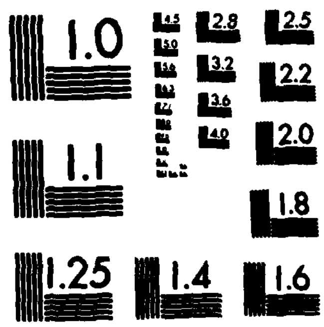
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Switch Features that Permit an Outboard Processor to Control Routing and Preemption

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6 July 1984

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FOR THE COMMANDER

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SWITCH FEATURES THAT PERMIT AN OUTBOARD PROCESSOR TO CONTROL ROUTING AND PREEMPTION

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ABSTRACT

New routing and preemption capabilities desired in the DSN can be obtained using commercial switches by adding outboard processors connected to switches via attendant console ports. This report lists and describes 22 switch features that allow an outboard processor to provide non-standard routing and preemption capabilities without extensive modifications to switch software. To the best of our knowledge, a modern class 4/5 switch designed for use with common channel signaling has all the features needed to support an outboard processor. The call-handling capacity of a switch/outboard-processor combination is limited by the bandwidth of the switch-to-outboard-processor connection and by the ability of the switch's central processor to handle the unexpected demands placed on it by outboard processors. The bandwidth limitation can be overcome by interfacing the outboard processor to the switch using multiple attendant console ports or by using a custom higher-speed interface. The switch processor limitation can be overcome if the switch processor is sized appropriately and software tasks associated with outboard processors are given high priority. The outboard processor call-handling capacity can also be increased if calls with routine precedence are controlled by the switch and only higher precedence calls are controlled by the outboard-processor.

CONTENTS

1. INTRODUCTION

The Defense Switched Network (DSN) is a planned circuit-switched network that will contain many small switches located near users, both terrestrial and satellite links, small earth stations, and common channel signaling (CCS). The DSN must provide both survivable communications under stress and economical service under normal operation. Some candidate routing and preemption procedures for the DSN designed to meet these goals are described in [1-5]. All these procedures require more control over calls and more inter-switch communications than is currently available in commercial switches.

One technique that could be used to obtain new routing and preemption capabilities desired in the DSN is to add an outboard processor to existing commercial switches. The outboard processor would control routing and preemption of calls going out over DSN trunks using the monitoring and control capabilities available through the attendant console port. An operator normally uses the console on this port to complete incoming or outgoing calls, to monitor the status of trunks, to check the quality of trunks, and to access special switch features. An outboard processor would have to read the displays on an attendant console, push buttons, and provide special announcements and tones. This could be done with the addition of a custom interface attached between the attendant console port and the outboard processor. Such an interface must be designed for each different switch type. The outboard processor concept for use in controlling preemption was first suggested in [5] which also lists switch features required for preemption. A description of an outboard processor that can control both preemption and routing is presented in [2], and a block diagram of the outboard processor concept is provided in Fig. 1.

The purpose of this report is to list those switch features that, if present in a switch, would allow an outboard processor to provide new routing and preemption capabilities. This list can (1) aid in the selection of commercial switches that could be used with outboard processors in the DSN, and (2) aid in specifying software modifications needed to use outboard processors. The switch features listed permit an outboard processor to route calls between DSN switches and to preempt calls already in progress over DSN switches with no extra hardware except an interface to the attendant console port. The names selected for features are often original because there is no standard terminology among switch manufacturers. Other features that are desirable in the DSN (e.g., conference calls, hot-line calls, off-net routing, etc.) are not listed if they are not required for routing and preemption.

In this report it is assumed that the outboard processor is connected to the switch through one or more attendant console ports or through another higher bandwidth link that provides access to the features available from the attendant console. It is also assumed that outboard processors are connected to each other using Common Channel Signaling links and that switches are connected using terrestrial or satellite voice trunks. Signaling for DSN voice trunks is carried only by the CCS links and switches should normally ignore any signaling leads associated with DSN voice trunks. Finally, it is assumed that the outboard processors will implement a CCS protocol based on CCITT No. 7 [6]. Link-level components

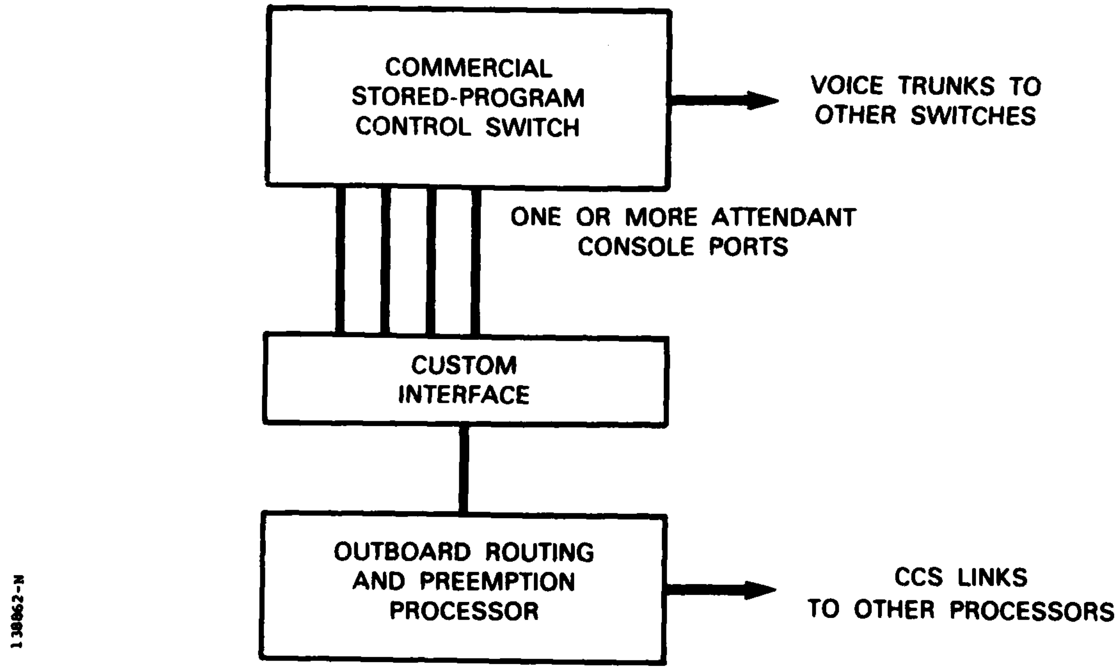

Figure 1. Block diagram of outboard routing and preemption processor connected to a commercial switch via attendant console ports.

of this new protocol are assumed to be be similar to those used in CCITT No. 7. Link-level protocols may be implemented in the outboard processor, in the switch, or in a separate CCS processor. The outboard processor, however, implements a DSN Telephone User Level protocol similar to the Telephone User Part of CCITT No. 7 but tailored to the types of routing and preemption selected for the DSN. This new protocol need not follow the single-stage call setup sequence specified in CCITT No. 7. It may use a two-stage call setup sequence in which a CCS SETUP packet first finds a path under control of outboard processors and then a SEIZE packet initiates trunk seizures via outboard processor-switch interactions. The new protocol will certainly include new CCS messages for preemption and may also use flooding techniques to route calls.

The organization of this report is as follows. Sections 2 and 3 describe the switch features required for control of routing and preemption respectively. Section 4 discusses the availability of these features on modern class 4/5 switches and on the UTX-1200 PBX used with the current Lincoln Outboard Routing/Control Processor [2]. Section 5 describes some additional issues including call-handling limitations, CCITT No. 7 implementation, and switch hardware and software modifications required for effective application of outboard processor techniques.

2. FEATURES REQUIRED TO CONTROL ROUTING

The typical scenario for routing a call with an outboard processor is as follows. First a caller picks up a phone and receives dial tone from the switch. The caller then dials a DSN access code (e.g., 7) optionally followed by special information to specify the call type and precedence (e.g., *P4* meaning the precedence level is flash-override), followed by the DSN number. The switch decodes and records all digits of this number and alerts the outboard processor to the presence of a new outgoing call by sending a signal to the attendant console (an operator would normally see a 'DSN call' button light up on the attendant console). The outboard processor signals the switch when it is ready to receive information on the call (an operator would normally push the 'DSN call' button on the attendant console) and then receives all digits of the dialed number and the station number from the switch (an operator would normally read an alphanumeric display on the attendant console).

At this point, the caller's station is connected to one side of the active three-port bridge controlled by the attendant console and the outboard processor has received the dialed DSN number. The outboard processor analyzes the number to determine if it is a valid DSN number. If so, it signals the switch to lock the current call to the attendant console (an operator would push an available locked-loop button). The attendant console is now free to handle other calls, but it can bring the caller back into the active loop when necessary. If the number is invalid the outboard processor connects the caller's station to a port on the switch and releases the call from the outboard processor. The port provides an intercept tone or an appropriate announcement.

After receiving a valid number, the outboard processor communicates with other outboard processors over the CCS network, and selects a call path. It then instructs the switch to bring the caller's station back to the active three port bridge controlled by the attendant console, connects the station to a desired outgoing trunk or trunk group, and releases the caller's loop (an operator would push the locked-loop button used previously, sele t a trunk by pushing a button or dialing a special access code, and push the 'release loop' button). Outboard processors at tandem switches are alerted by CCS messages and instruct switches to connect specific incoming and outgoing trunks. If voice trunk continuity checks are desired, outboard processors must also instruct switches to connect trunks to continuity tone transmitters and receivers and to loop trunks back to the switch that is testing continuity (as described in CCITT No. 7).

When the caller or called party hangs up, switches at the end of the call path must note that a station connected to a DSN trunk has hung up and must alert the outboard processors. Outboard processors at the call path ends must then communicate with the other processors in the call path to free all voice trunks in the call path for use by other calls.

Switch features listed below are required for the above scenario.

<u>Ignore Trunk Signaling</u>

Signaling for voice trunks connected to other DSN switches should be carried exclusively by CCS links and DSN voice trunks should not carry any type of in-band signaling. In-band signaling would, however, be expected by the type of commercial switches being purchased to replace AUTOVON switches. These switches must have a feature that allows in-band signaling to be ignored on DSN trunks. Ideally a simpler, less expensive trunk termination interface card could also be used on DSN trunks. This card would not support any type of trunk signaling. It would only provide voice paths from the switch to trunks.

Recognize DSN Access Code

Callers at a station dial a unique one to three digit DSN access code to specify that the call should go over the DSN. The switch must recognize the code and apply special call handling for the following digits. It must also restrict those stations that can use the code.

Restrict Access to Outboard Processor

The switch must allow only certain stations to access the outboard processor via the DSN access code. It must also restrict access provided from tie lines to other PBXs and switches.

Special DSN Call Handling

After receiving the DSN access code, a switch must provide special call handling. The switch may optionally provide a second dial tone and then must receive and store up to 16 digits dialed by the caller. After receiving the last digit of a DSN number, the switch must select an available attendant console port connected to the outboard processor and signal that a new call is offered. When the outboard processor responds to the signal, the ID of the call source must be provided to the outboard processor and the call source must be brought into the working attendant console loop.

Display Call Source

When the attendant console requests, the switch must provide the ID of the call source for the current working loop. This source may be a station on the switch or an incoming tie line to another PBX or switch. This information could also be provided automatically when the attendant console responds to the switch after the DSN access code and a DSN number is received. It is used to determine allowable precedence levels, billing, call type, etc.

Display Dialed Number

When the attendant console responds to the switch after the DSN access code and a DSN number is received, the switch must provide all digits of the DSN number.

Locked Loop Operation

When the attendant console requests, the switch must lock the calling station on the attendant console's current active three-port bridge to the console. The switch must then allow the attendant console to service other calls and later bring the calling station back to the active bridge for connection to a trunk or a switch port. This frees the outboard processor to handle new calls while a path is being found using the CCS network.

Busy Tone or Intercept Announcement

When the attendant console requests, the switch must connect a calling station on the attendant console's active three-port bridge to a switch port that provides fast busy tone or an intercept announcement. This will be done when the dialed number is invalid or when the call cannot be completed.

Directed Trunk Group Access

When the attendant console requests, the switch must connect a calling station on the attendant console's active three-port bridge to a specific trunk group. This is required to route calls on specific links. Preferably, the switch should automatically report the ID of the trunk selected to the outboard processor. This would allow the outboard processor to determine the specific trunk that was selected without using the trunk identification feature.

<u>Trunk Identification</u>

When the attendant console requests, the switch must report the trunk ID number of a trunk in the working loop. This is required to confirm the ID of trunks selected using directed trunk group access.

<u>Tandem Trunk-To-Trunk Connect</u>

When the attendant console requests, the switch must connect one specific DSN trunk within a trunk group to a free trunk in another trunk group. This is required at tandem switches in a call path when calls are setup in the DSN.

<u>Tandem Trunk-To-Trunk Release</u>

When the attendant console requests, the switch must sever an existing connection between two DSN trunks currently connected in tandem. The ID of one of the two trunks must be sufficient to sever the connection. This is required when a call is taken down.

<u>Trunk Available Notification</u>

When the station connected through the switch matrix to a DSN trunk hangs up, a special signal must be sent to an attendant console port attached to the outboard processor. When the outboard processor responds to the signal, the switch must provide the trunk identification number of the free trunk or the station number of the station that hung up. This permits the outboard processor to take down voice trunks in a DSN call path when a call is over.

Trunk Group Status Display

When the attendant console requests, the switch must report the number of busy, free, and out-of-service trunks in a specific trunk group. This is required to update the information describing trunks in the outboard processor when the outboard processor suspects its information is corrupted or out-of-date.

Trunk Status Display

When the attendant console requests, the switch must report the status (free, busy, out-of-service) of a specific trunk within a trunk group. This is required to update the information describing trunks in the outboard processor when the outboard processor suspects its information is corrupted or out-of-date.

Continuity Check

When the attendant console requests, the switch must check the continuity of a specified trunk by applying a check tone to the outgoing voice circuit of a trunk and monitoring the incoming voice circuit. When a valid check tone is received the switch must alert the attendant console. When the attendant console responds,it must provide the trunk ID of the trunk just tested. The switch must also disable any echo suppressors present in trunks during the continuity check. The switch must timeout if the continuity check fails and then alert the attendant console.

Loop Trunk for Continuity Check

When the attendant console requests, the switch must loop the incoming and outgoing voice circuits on a trunk and disable any echo suppressors on these circuits. When the attendant console requests, the switch must disconnect this loop and restore echo suppressors. This is required at the remote end of a trunk being tested for continuity.

3. FEATURES REQUIRED FOR PREEMPTION

The typical scenario for preempting a call with an outboard processor is as follows. First the outboard processor must decide that a new outgoing call must preempt another lower-precedence call for completion and it must select the lower-precedence call. Call precedence levels are known because an optional precedence code was dialed or because calling stations were assigned precedence levels. Once the lower-precedence call is selected, outboard processors at all switches in the path of this call are alerted. Processors at the two ends of the call path bring the station and trunks for this call back to the attendant console. If the station is not the destination of the higher-precedence call, the station is connected to a switch port that provides a preemption tone and the trunk is made available for use by other calls. If the station is the destination of the higher-precedence call, a preemption tone is also provided to the station, and the station can be required to go on-hook as is currently done with camp-on in many commercial switches. Tandem switches in the path of the lower-precedence call are directed to release voice trunks not required by the preempting call. Connections at tandem switches between voice trunks required by the preempting call are maintained.

Outboard processors in the path of the preempting call establish a voice path from the caller's station to the destination switch after preemption is complete. Once this path is completed to the destination switch, the outboard processor at the destination switch directs the switch to connect the last voice trunk in the path to the destination station. If desired, the switch can wait for the called station to go on hook briefly after a preemption tone and only then connect the station to the incoming higher precedence call.

Many of the important switch features required in the above preemption scenario are also required for routing. Those features in addition to the features listed above under routing that are required for preemption follow.

Attendant Control of Facilities

When the attendant console requests, the switch must bring a desired trunk and the connected trunk or station into the active attendant console three-port bridge even though the station or trunk had not been placed in locked loop operation. This is required to regain control over a call for preemption after the call has been released by the attendant console.

Call Splitting

When the attendant console requests, the switch must sever the voice connection between the two ports of the attendant console's three-port bridge that are not connected to the attendant's voice circuit. The switch must then allow the trunks or stations on these two ports to be independently reconnected to other stations, switch ports or trunks.

Preemption Tone

When the attendant console requests, the switch must connect a station or a trunk on the attendant console's active three-port bridge to a switch port that provides a preemption tone. This, along with call splitting, allows preemption tones to be applied separately to parts of a call path not needed for a preempting call. If the station is not the destination of the preempting call it allows the preemption tone to overlap the talking phase of the high-precedence call.

Station Status Display

When the attendant console requests, the switch must report whether a given station is busy, free, or out-of-service. This is required to determine the status of stations for incoming DSN calls. The outboard processor cannot know the status of all stations because stations can place local or non-DSN calls without interacting with the outboard processor.

Preemption Camp-On

When the attendant console requests, the switch must present a preemption tone to a station that is busy. After the station goes on-hook briefly, the switch must then alert the attendant console. When the attendant console responds, it must be able to connect the station to a new trunk. If the station does not go on-hook, the switch must timeout and alert the attendant console. The attendant console can then use attendant control of facilities to forcibly terminate the call. This is required to connect a high precedance call to a station being used by a low-precedence call.

4. AVAILABILITY OF FEATURES

The availability of switch features required to use an outboard processor is presented in Table I. The second column of this table lists the availability of features on the UTX-1200 PBX used in [2], the third column list the availability in modern class 4/5 switches, and the final column indicates whether the feature is new. Features that require a

TABLE I

AVAILABILITY OF SWITCH FEATURES

Feature	On UTX-1200 ?	On 4/5 Switch[1] ?	New[2] ?
Ignore Trunk Signaling	No	No	Yes
Recognize DSN Access Code	Yes	Yes	No
Restrict Access to Outboard Processor	Yes	Yes	No
Special DSN Call Handling	No	Yes	No
Display Call Source	Yes	Yes	No
Display Dialed Number	No	Yes	No
Locked Loop Operation	Yes	Yes	No
Busy Tone or Intercept Announcement	Yes	Yes	No
Directed Trunk Group Access	Yes	Yes	No
Trunk Identification	Yes	Yes	No
Tandem Trunk-to-Trunk Connect	No	No	Yes
Tandem Trunk-to-Trunk Release	No	No	Yes
Trunk Available Notification	No	Yes	No
Trunk Group Status Display	Yes	Yes	No
Trunk Status Display	Yes	Yes	No
Continuity Check	No	No	Yes
Loop Trunk for Continuity Check	No	No	Yes
Attendant Control of Facilities	No	Yes	No
Call Splitting	Yes	Yes	No
Preemption Tone	Yes	Yes	No
Station Status Display	Yes	Yes	No
Preemption Camp-On	Yes	Yes	No

[1] If yes, this feature is available on modern class 4/5 switches.

[2] If yes, this is a new feature expected to be available on modern class 4/5 switches with CCS.

special preemption tone instead of an existing intercept tone are marked available in this table because they could be obtained by adding new tone generators to a switch.

An important point to note from Table I is that almost all the features needed to use outboard processors are currently available in commercial switches. The only features listed as new in this table are those required to control trunks via CCS messages instead of with in-band trunk signaling. These features would be available on newer switches that support CCS signaling. A modern class 4/5 switch designed for use with CCS would thus have all the features needed to support an outboard processor.

In the UTX-1200 PBX used in [2] the features marked missing in Table I were obtained using custom trunk-interfaces and a custom tone transmitter/receiver. The cost of this extra hardware was reasonable for a small test network but would be prohibitively expensive in an operational system. As indicated in Table I, this extra hardware would not be needed with a modern class 4/5 switch. The only extra hardware required on such a switch would be an interface to the attendant console port.

5. ISSUES FOR FURTHER CONSIDERATION

Call Handling Limitations with Outboard Processors

The call-handling capability of the switch/outboard-processor combination shown in Fig. 1 is limited by the bandwidth of the switch to outboard processor connection and by the ability of the switch's central processor to keep up with the unexpected demands placed on it by the outboard processor. The bandwidth limitation can be very severe if only one, unmodified attendant console port is used. For example, in the

UTX-1200 used in [2], the bandwidth of attendant console port connections was roughly 600 bits per second and roughly 2400 bits were required for all the switch-outboard processor communications needed for one call. On the average, the outboard processor could thus handle only one call every 4 seconds. This type of limitation could be expected on both PBXs and class 4/5 switches because the bandwidth to the attendant console is sized by the ability of an operator to generate and absorb commands, not by the size or capabilities of the switch. This limitation can be overcome by using multiple attendant console ports or by using some other high-bandwidth connection between the switch and the outboard processor. For example, if four attendant console ports were used with the UTX-1200 PBX, the call handling capacity would increase from one call every 4 seconds to one call every second.

The call handling limitation caused by restricted switch/outboard processor communications can also be alleviated if only higher precedence DSN calls use outboard processors and routine calls use the normal table-driven routing provided by the switch. Under normal operations, this would greatly reduce the demands placed on the outboard processor and transfer much of outboard processor processing and communications requirements to the switch. A smaller size, lower cost outboard processor could thus be used at DSN nodes. This solution would be least expensive if high and low precedence calls used common channel signaling carried by the same CCS links. In this case, a single CCS processor could be used by both the switch and the outboard processor as shown in Fig. 2. In this figure, both the switch and the outboard routing and preemption processor have

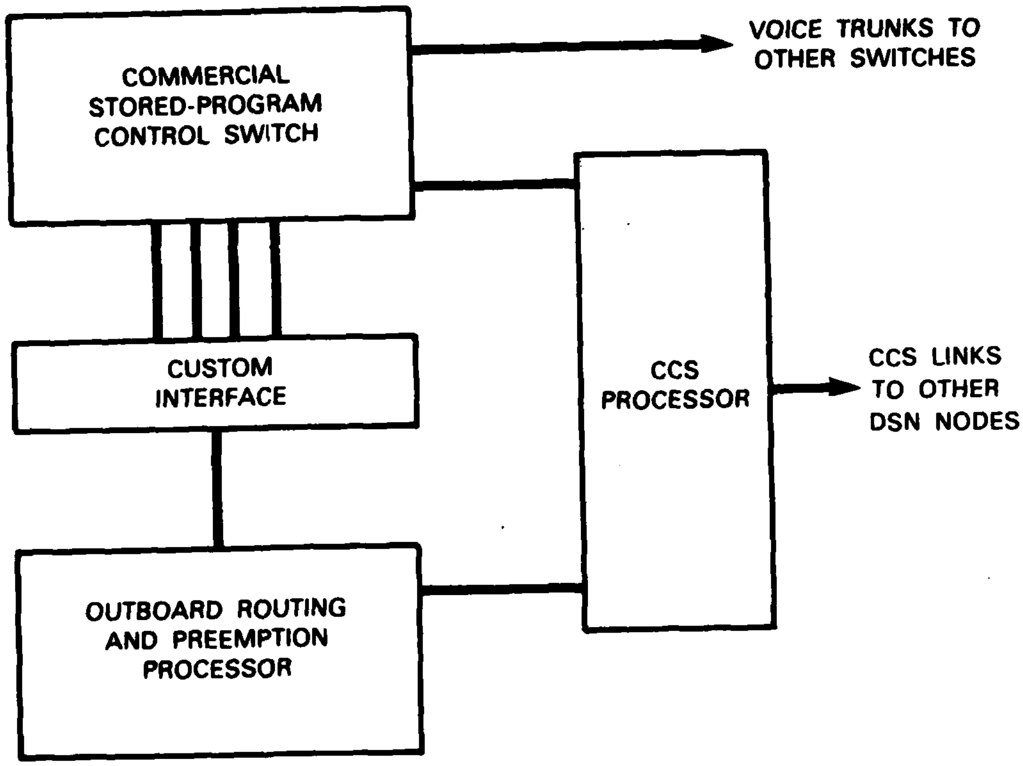

Figure 2. Block diagram of DSN node including a CCS processor that performs the link-level components of CCITT No. 7 for both the switch and an outboard routing and preemption processor.

high-bandwidth, standardized connections (possibly RS232) to the CCS processor. The CCS processor is connected to another CCS processor at a distant DSN node via CCS links with data rates that might vary from 1200 to 64000 bits/sec. This processor implements a new version of the Message Transfer Part of CCITT No. 7 specialized for the DSN. The switch implements a slightly modified version of the Telephone User Part of CCITT No. 7. These slight modifications are needed to support the communications protocol between the switch and the CCS processor. They do not, however, support preemption, or advanced types of routing. The outboard processor implements a highly modified version of the Telephone User Part of CCITT No. 7 that does support new types of routing and preemption [3,4]. One such modified form of CCITT No. 7 that supports routing and preemption is currently being developed and tested using Routing/Control Processors [2].

The limitation in call processing caused by the inability of the switch to keep up with the outboard processor's demands can only be overcome if the switch processor has enough extra capacity to handle these demands. This depends on the switch type and size and on the internal priority given to tasks associated with attendant console ports. In some cases, changes in switch software might be necessary to give higher priority to tasks associated with attendant console ports.

Implementing the Message Transfer Part of CCITT No. 7

The Message Transfer Part of CCITT No. 7 (Q.701,Q.702,Q.703) does not have to be implemented in the routing and preemption outboard processor. It would be better to implement this protocol in an external CCS processor as shown in Fig. 2. The CCS processor in this figure performs the real-time, link-level communications tasks for both the switch and the outboard processor and reduces the complexity, cost, and size of these devices. The CCS processor is similar in function to the Peripheral Unit Controller-Data Link (PUC-DL) used in the Bell System to provide CCS for the No. 1/1A ESS switch [7]. The CCS processor in Fig. 2 differs from a PUC-CL in that it does not use the CCIS protocol and in that it includes the functions of a Bell System CCS Terminal and Modem. The CCS processor must support a modified version of the Message Transfer Part of CCITT No. 7 specially designed for the DSN. Two major modifications may be required. First, some form of link-level encryption may be needed to protect CCS messages from being altered or intercepted. Second, substantial modifications would be required to support the use of broadcast, demand assigned satellites for voice trunks and CCS. Extensions to CCITT No. 7 to support broadcast satellite links are currently being developed and tested using Routing/Control Processors [2].

Switch Hardware and Software Modifications

As stated above, a switch used with outboard processors must have a high bandwidth link to the outboard processor and must also be able to handle the additional processing load caused by the outboard processors. Other changes to the switch hardware and software will also be necessary. One major change is that the switch must service DSN calls before non-DSN calls. This involves servicing DSN attendant console ports, trunks, and stations before other ports, trunks, and stations. This change would prevent DSN calls from being locked out during an emergency when both DSN and non-DSN calls are competing for the switch's main processor. Other administrative and maintenance changes in the switch software may also be required to support special DSN calls.

Two changes to the switch interface hardware would reduce the cost of trunk and outboard processor interfaces when all the features listed in Table I are available. First, the audio component of attendant console bridges connected to outboard processors is not required. Only the control afforded by an attendant console is needed. Second, trunk interfaces for DSN trunks do not have to support in-band signaling. Such trunk interfaces would be available on switches that support CCS.

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circuit-switching	MFC	network	RCP
communications	military function controller	outboard processor	

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

New routing and preemption capabilities desired in the DSN can be obtained using commercial switches by adding outboard processors connected to switches via attendant console ports. This report lists and describes 22 switch features that allow an outboard processor to provide non-standard routing and preemption capabilities without extensive modifications to switch software. To the best of our knowledge, a modern class 4/5 switch designed for use with common channel signaling has all the features needed to support an outboard processor. The call-handling capacity of a switch/outboard-processor combination is limited by the bandwidth of the switch-to-outboard-processor connection and by the ability of the switch's central processor to handle the unexpected demands placed on it by outboard processors. The bandwidth limitation can be overcome by interfacing the outboard processor to the switch using multiple attendant console ports or by using a custom higher-speed interface. The switch processor limitation can be overcome if the switch processor is sized appropriately and software tasks associated with outboard processors are given high priority. The outboard processor call-handling capacity can also be increased if calls with routine precedence are controlled by the switch and only higher precedence calls are controlled by the outboard-processor.

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