NTP 297-3601-100

DMS-10 Family

600-Series Generics

General Description

07.01
For Generic 602.20   Standard   August 2006

NORTEL

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Contents

Section 1: Introduction

Scope and purpose of this publication

This Nortel technical publication (NTP) introduces the basic system configuration of the 600-Series DMS-10 switch. It is designed to be used with its companion NTP, *Features and Services Description* (297-3601-105), which presents the range of features available in the 600-Series DMS-10 switch.

General DMS-10 switch characteristics

The 600-Series DMS-10 switch is a time-division, multiplexed digital switching system that uses stored-program control and a solid-state digital network to switch voice-band signals encoded as 8-bit, pulse code modulation (PCM) signals.

The DMS-10 switch provides switching for a community dial office or for a medium-size central office for up to 20,000 lines. Standard Class 5 features are incorporated.

Telephone sets, private branch exchanges (PBXs), and other subscriber equipment are interfaced to the switch by way of subscriber loops that connect to the DMS-10 switch line circuits. Trunk facilities linking the switch to other switching machines in the telephone network terminate on DMS-10 switch trunk circuits. Interfaces to other facilities such as toll operators, repair services, directory information services, tones, and recorded announcements are provided also.

The 600-Series DMS-10 switch supports originating, terminating, and tandem services using conventional signaling formats, including dial pulse (DP), Digitone (or equivalent), multifrequency (MF), and ISUP signaling. Bellcore standard formats are supported for interoffice signaling, including the transmission of calling party identification to the Class 4 office on which the DMS-10 switch is homing.

The Packet Gateway Interface (PGI) on the DMS-10 supports Voice over Internet Protocol (VoIP) call using the Session Initiation Protocol for lines. This functionality allow the DMS-10 to switch calls in a broadband IP network and to interwork calls between a broadband IP network and the PSTN TDM network.

Section 2: System architecture

Introduction

The 600-Series DMS-10 switch is architecturally organized into three functional blocks: (1) the control equipment, (2) the network equipment, and (3) the line and trunk equipment, which is in turn composed of peripheral equipment (PE), line concentrating equipment (LCE) and LCE based remotes (RLCM, RSLE, RCM, OPM, and OPSM), subscriber carrier SLC (SCS), Subscriber Carrier Urban (SCU), Remote Subscriber Carrier (RSC-S), Enhanced Subscriber Carrier Module Access (ESMA), and the Packet Gateway Interface (PGI) to provide Voice over Internet Protocol (VoIP).

Control equipment

The control equipment is housed in a Common Equipment (CE) bay and consists of duplicate Control shelves, one shelf active while the other shelf is kept in hot stand-by state to assume control if the active shelf fails.

The CPU, memory, and system clock are contained in a single circuit pack, the NT3T98 (System Processor). A 32-bit PowerPC CPU provides a high-speed cache control interface. The NT3T98 requires an NT3T84 paddleboard for connection to two physical Ethernet links and inter-CPU connectivity.

Real Time Operating System

The 600-series DMS-10 switch uses a Real Time Operating System (RTOS) which provides:

- application scheduling
- memory allocation and protection
- disk drive file system
- internet protocol stacks and applications

Memory system

The 600-Series memory system consists of a 128 Megabyte Synchronous Dynamic RAM (SDRAM) socketed module organized in two physical banks of 8M x 72

SDRAM using nine 64 Mbit SDRAM components on each bank. The system's addressing architecture provides address ranges of up to 1 gigabyte of main memory.

Field Programmable Gate Array

The Field Programmable Gate Array (FPGA) is a static random access memory (SRAM) device programmed to provide control functions for the 600-Series switch. In addition to providing communication between the PowerPC (PPC) bus, the GPIO backplane bus, and the inter-CPU multiplexed cable bus, the FPGA also provides the following functions:

- PCI bus arbiter
- interrupt controller
- two periodic interrupt timers
- standard UART interface
- time-of-day clock
- calendar
- two elapsed-time counters
- software debug tools

The FPGA provides a PPC bus interface that operates as a bus slave on the active CPU and as a bus master on the inactive CPU. The active CPU interface monitors write cycles to specific address ranges, loads them into a write buffer, and forwards that data to the inactive CPU FPGA. This function ensures that both the active and inactive CPU maintain identical memory storage. The FPGA is programmed from Flash memory when the NT3T98 faceplate switch is enabled, or when power is restored to the pack with the switch enabled.

Flash Memory

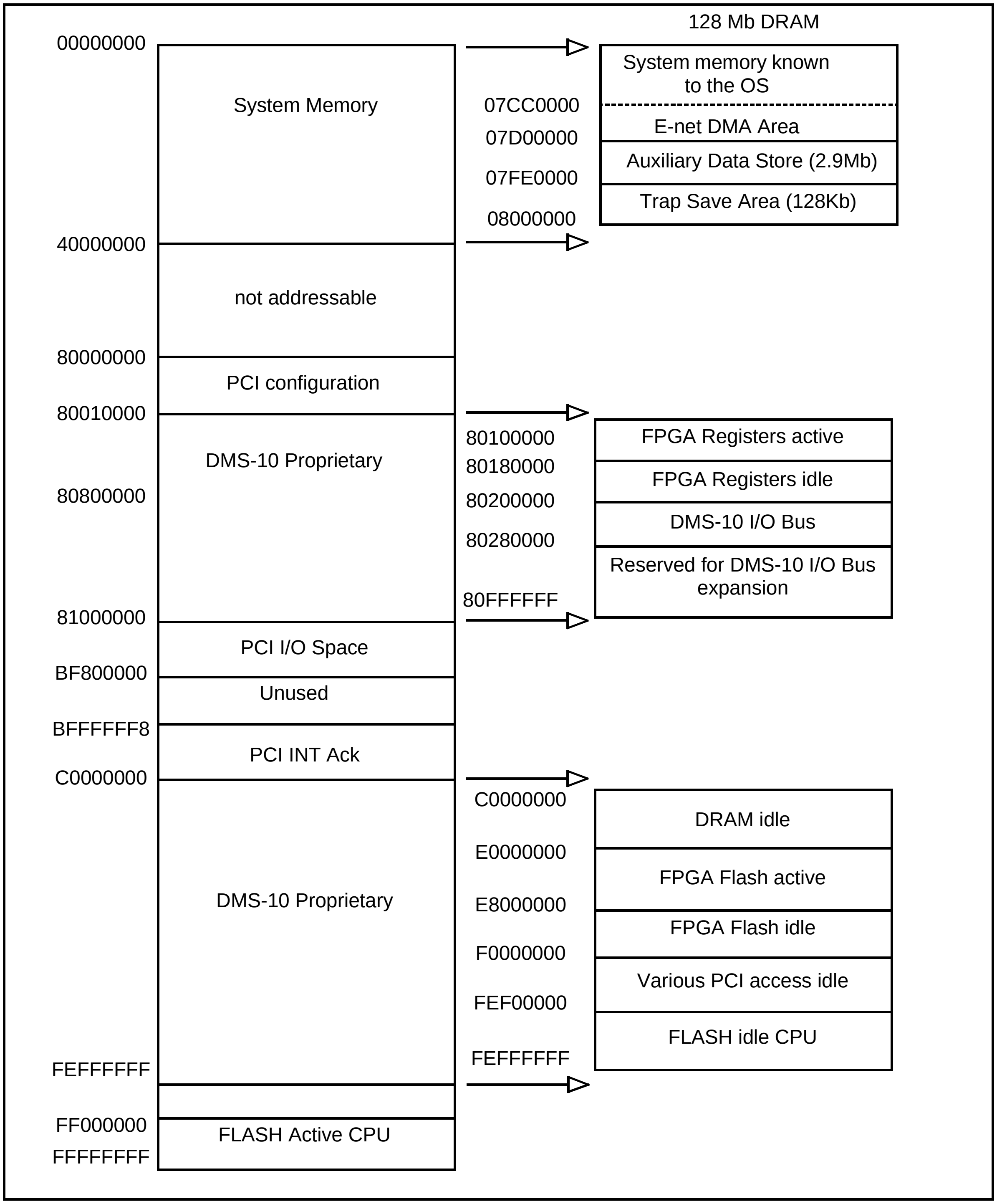
Flash memory is a nonvolatile on-chip memory that can be electronically programmed. Unlike volatile memory such as DRAM and SRAM, Flash memory retains stored data even during power loss. The System Processor uses two types of Flash Memory, system processor and the FPGA. The Flash can be read and written by software.

Physical Memory Addressing

System Processor memory addressing is based on a PowerPC address map. This design adheres to PowerPC and Peripheral Component Interconnect (PCI) bus standards. In Figure 2-1, the basic PowerPC memory map appears on the left. The detail displayed on the right shows specific DMS-10 addressing that falls within standard PowerPC memory ranges.

In Figure 2-1, system memory corresponds with the 128 Mb DRAM that is read and written to by the CPU. All information written within this memory range is reflected, through the FPGA, to the inactive processor's write buffer. The remaining addresses are used for device access or processing. DMS-10 proprietary address ranges are determined by address matching within the FPGA.

Figure 2-1: System Processor Physical Memory Map



Virtual Memory

In the System Processor, 128 Mb of physical memory provides up to 4 GigaBytes of virtual addressing for each process. Virtual Memory allows a layer of isolation that prevents a process from accessing memory and possibly writing to critical data or code. Virtual memory is managed by the CPU and RTOS which translate virtual addresses into physical addresses. The translation is accomplished using page tables. Each page table entry also contains access control information.

For most applications, physical memory and virtual memory are divided into individual 4kb pages. Each page has a unique number known as a page frame number (PFN) or virtual page frame number (VPFN). The RTOS uses Block Address Translator (BAT) registers to map large sections.

A virtual memory address contains a VPFN and an offset. The VPFN provides an index to the page table for determining the matching physical PFN. The offset is used to determine the exact address on the physical page. For example, process "*x*" in Figure 2-2 at VPFN A00, offset 24000, translates through a page table to physical address 20024000.

Figure 2-2: 600-Series Virtual Memory to Physical Memory Mapping

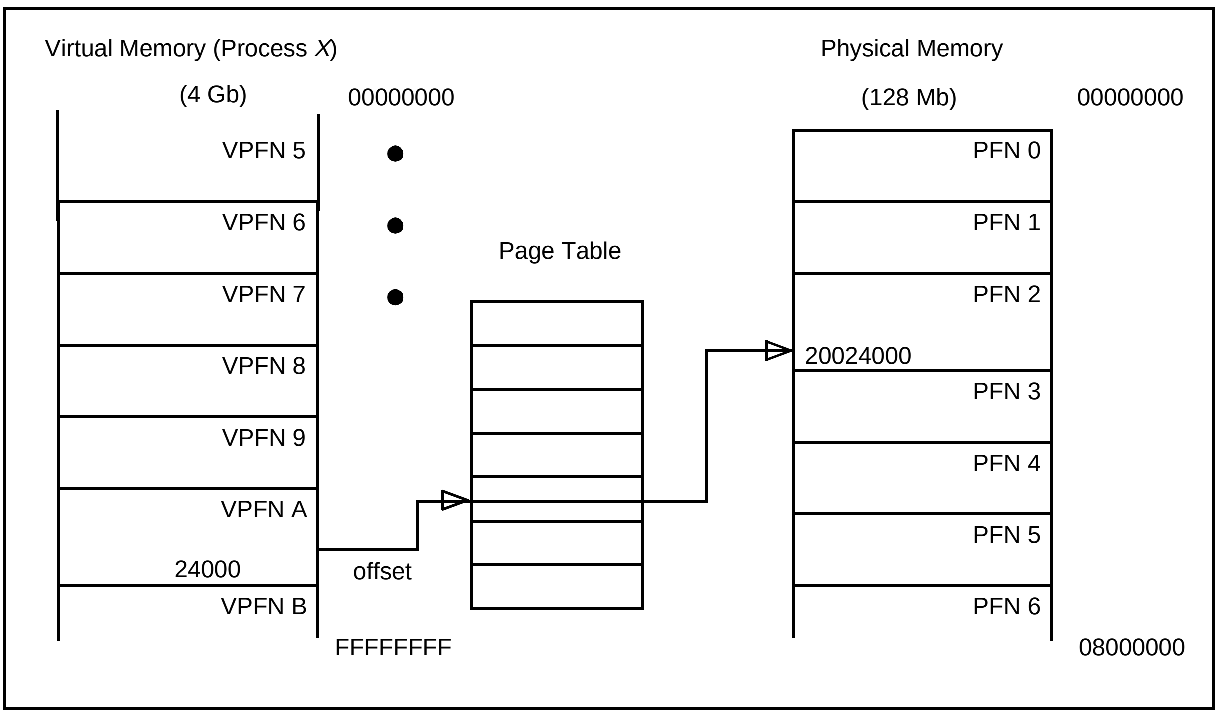
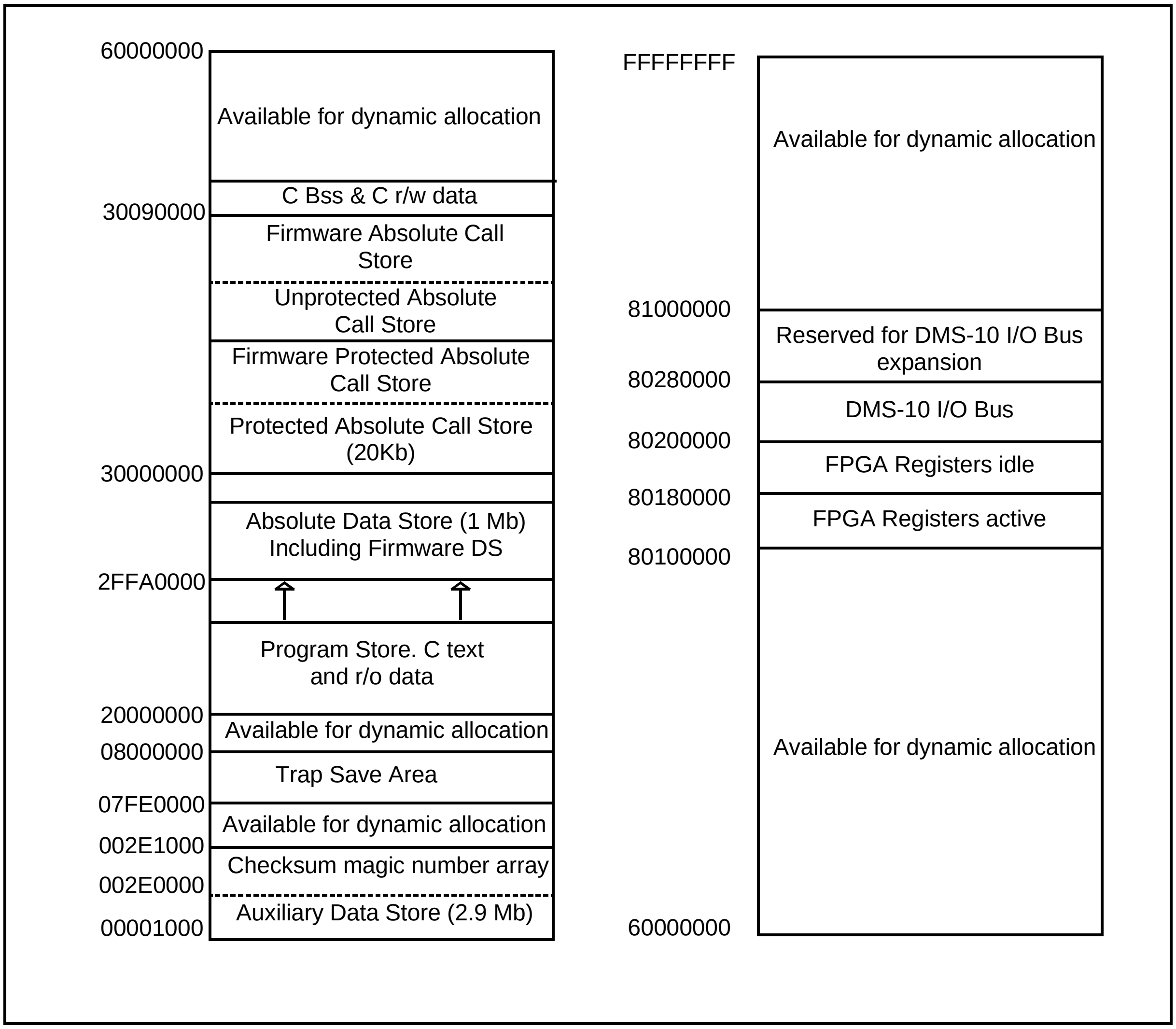


Figure 2-3 shows the DMS-10 telephony system virtual memory allocation. The virtual memory map allows 4 gigabytes of available addressing for the telephony system, a larger memory address range than the 128 Mb DRAM of available physical memory.

Figure 2-3: 600-Series Virtual Memory Map



Protected Call Store

System Processor Protected Call Store (PCS) is not write protected. PCS contents are protected over an initialization.

Unprotected Call Store

System Processor Unprotected Call Store (UCS) is dynamic unprotected memory that is released during an initialization.

Data Store

The Real Time Operating System (RTOS) determines the starting address of each memory parcel allocated for Data Store.

Auxiliary Data Store

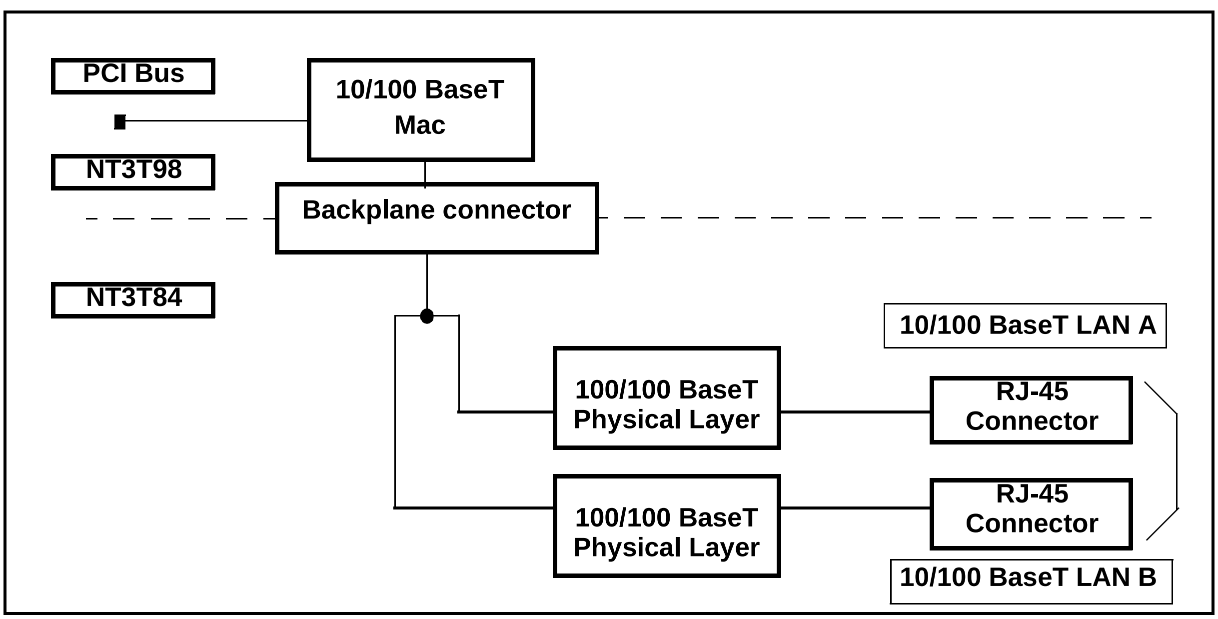
In order to exist over a reload, System Processor Auxiliary Data Store (ADS) addressing is hidden from the RTOS and is the only memory segment that retains checksums.

Ethernet Controller

The Ethernet Controller is a single-chip, full-duplex, dual speed 10/100BaseT Media Access Controller (MAC). The controller interfaces to the processor through a 25 MHz PCI bus and the PCI bridge. It provides an IEEE 802.3 compliant data interface for connecting, through backplane pins, to two 10/100BaseT RJ45 jacks that reside on the NT3T84 paddleboard. This configuration provides access to either of two redundant Ethernet LANs. Redundant Ethernet access to each NT3T98 allows the DMS-10 to be decoupled from LAN faults and to switch to a backup LAN without having to switch processors. Since both redundant LANs can be connected to both NT3T98s, a processor switchover does not require a switch to the other LAN.

The Ethernet Controller has DMA access into main memory through the PCI bus and PCI bridge. Unlike main memory that is copied from the active to the inactive CPU, writes to the buffers in main memory by the MAC through the PCI bridge are not copied. Figure 2-4 shows a block diagram representation of the 600-Series Ethernet Controller.

Figure 2-4: 600-Series 10/100BaseT Ethernet Interface



Input/output system configuration

The I/O system provides the loading and storage of program data, office data, and administrative, maintenance and test overlay programs into system memory. The I/O system also enables the DMS-10 CPU (System Processor) to communicate with devices both internal and external to the switch.

I/O system components

The main I/O system components are circuit packs that interface with I/O devices. These circuit packs are described in the following paragraphs.

Magnetic Tape Controller (NT3T10) The NT3T10 pack functions as a component of the Automatic Message Accounting (AMA) system. It is the hardware interface for communications between the CPU and 9-track 800 bpi magnetic tape units (MTUs) or Billing Media Converters (BMCs) for the purpose of billing data collection.

Data Link Controller (NT3T50) The NT3T50 pack is used to provide ports for connection to external data equipment (both analog and digital transmission devices) that are used in DMS-10 Cluster configurations for the purpose of office operations data collection.

Dual Serial Data Interface (NT3T80) The NT3T80 pack provides ports for connection to I/O equipment such as local and remote terminals. The NT3T80 pack can connect to a modem on site that, in turn, connects to another modem and terminal at a remote location.

Input/Output Interface pack (NT3T90) The NT3T90 pack provides an interface between the CPU and the AMA disk drives in the 9-track 1600-bpi AMA configuration.

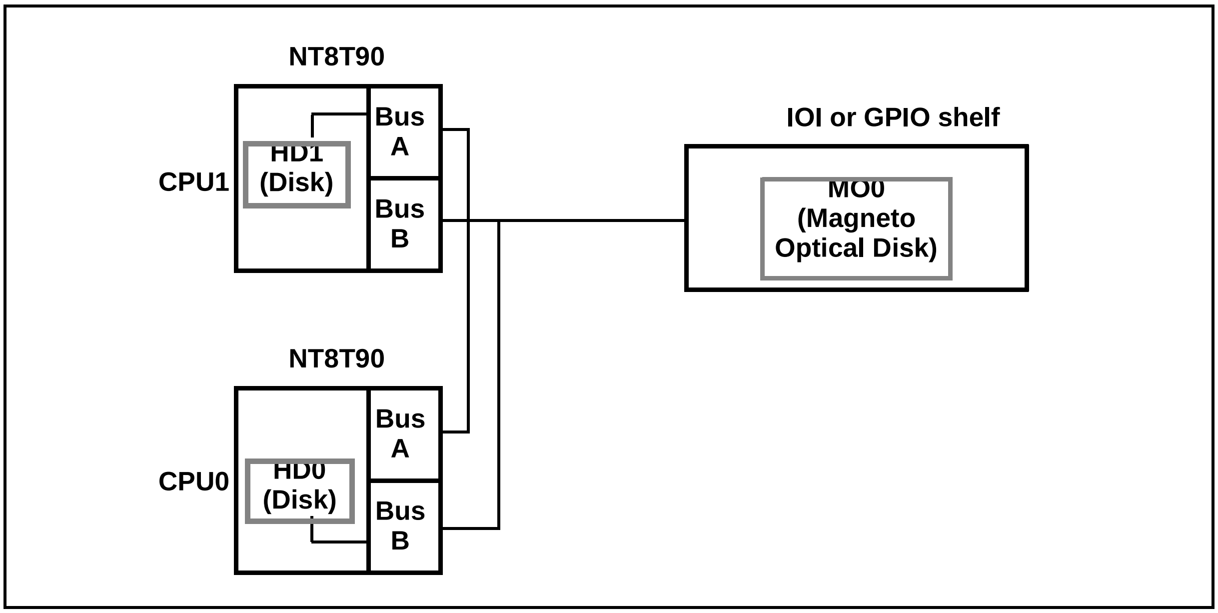
Dual Integrated Modem (NT3T93) The NT3T93 pack provides a direct interface between the DMS-10 switch and external, remote data terminals without the need of vendor-supplied modems located on-site. This pack is totally self-contained and is used in place of the Dual SDI/modem arrangement used for remote TTY access.

SCSI Bus I/O and Disk Drive pack (NT8T90) The NT8T90 (family code BA or higher) provides intelligent control of two ANSI-standard Small Computer Systems Interface (SCSI) buses that connect the CPU to the disk drive resident on the NT8T90 (see “System Bus Architecture,” below). The NT8T90 also provides the interface between the CPU and the magneto-optical drive, which is used for initial loading of office data and for storage of the data after loading has been completed. Two NT8T90 packs are provisioned in the DMS-10 system to provide two separate device busses.

IOI system operation during switch initialization

When the switch is initialized, the NT8T90 probes both SCSI buses to determine what I/O devices are present. Each device that is found is then mapped to a logical device number, starting from 0 (zero). The probing sequence starts with Bus “A” beginning at SCSI ID 0 and proceeds through SCSI ID 6. The probe then moves to Bus “B”, again starting at SCSI ID 0, and proceeds through SCSI ID 6 on that bus. Subsequent Overlay device references are made, however, according to device type and probing sequence identification rather than by Bus. These device types include the “HD” (hard drive) and the “MO” (magneto-optical drive). The IOI system configuration shown in Figure 2-5 illustrates the physical position and logical identification provided to the HD and MO device types and their connection to busses A and B.

Figure 2-5: IOI system configuration showing the HD and MO device types

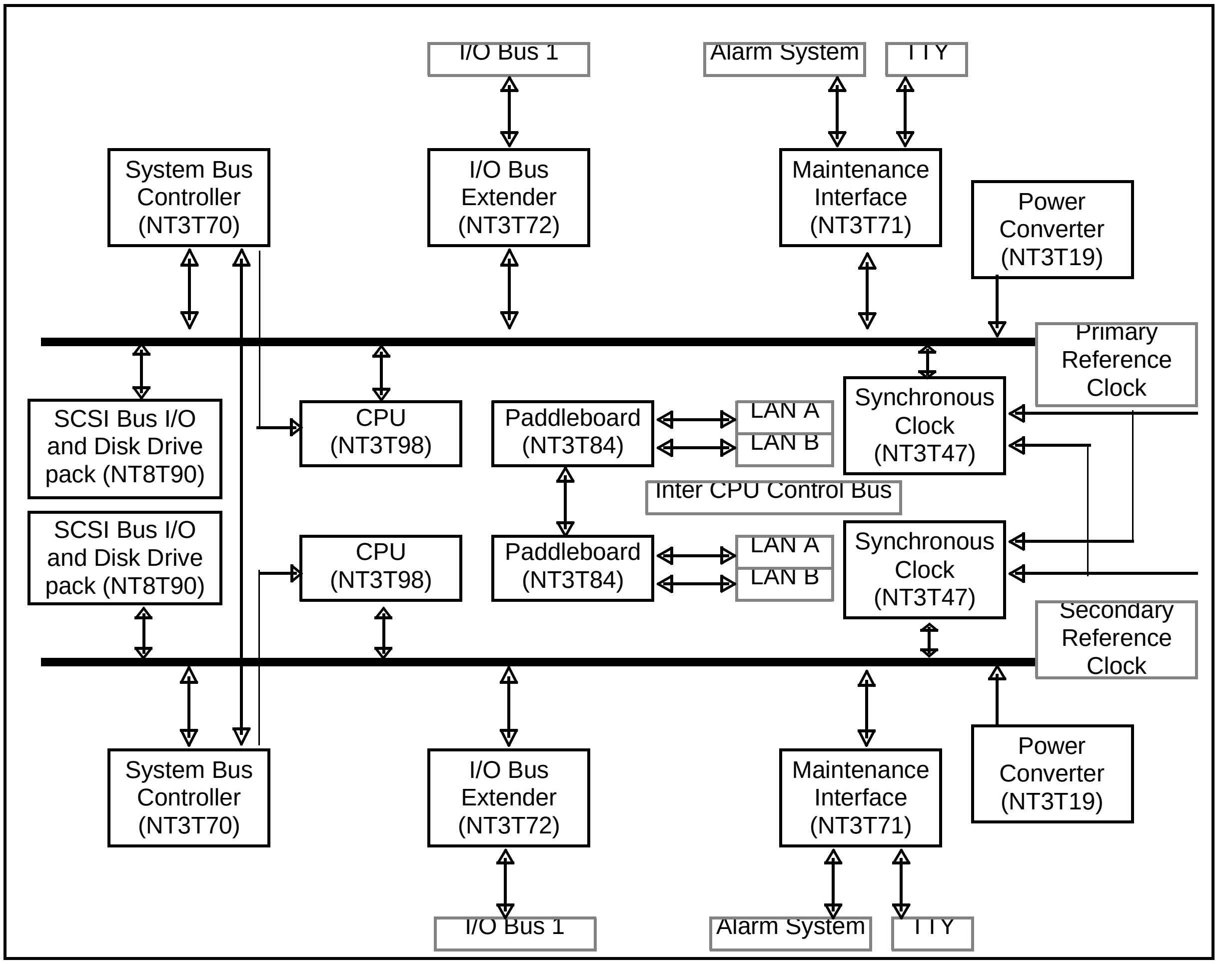


System bus architecture

The system bus architecture for the control equipment (that is, CPUs, memory systems, and I/O equipment) is organized around two major buses: the CPU system bus and the I/O bus. The CPU system bus handles intra-CPU communication and connects the CPUs to the memories. The I/O bus handles all communications between the CPUs and the network equipment.

Figure 2-6 illustrates the system bus architecture for control equipment. Each CPU incorporates a System Bus Controller pack that monitors the state of the CPUs. The System Bus Controller pack also automatically selects the optimal control and I/O bus configurations when a fault is discovered by the system or the system is recovering from software-invoked testing. Buses can also be configured manually for system software reload or testing.

Figure 2-6: 600-Series System Bus Architecture



CPU system bus

The CPU system bus provides an interface for address, data, and control signals within the NT3T98 System Processor pack. It is a high-speed bus that operates asynchronously using data, addresses and control signals. The CPU system buses of the two CPUs are connected by way of an inter-CPU cable. The I/O Bus Extender pack provides the interface between the high-speed CPU system bus and the slower I/O bus.

In addition to the NT3T98 and NT3T72 packs, the following Control shelf circuit packs interface with the control shelf bus:

- Input/Output Interface, which provides CPU system bus access for the primary IOI device (NT8T90 hard disk)
- Maintenance Interface, which provides a data interface to the alarm system and an SDI port for modem application

- Synchronous Clock, which synchronizes the Stratum 3 system clock to an 8 kHz reference signal
- System Bus Controller, which (in addition to the duties listed above) uses the clock signal generated by the Synchronous Clock pack to provide signals required by the system

Inter-CPU bus

The Inter-CPU bus provides the connection between the two CPU System buses. It is required for updating the backup memory system, checking the inactive real-time clock, and maintaining the standby synchronization unit. The Inter-CPU bus may be disabled to allow one-bus (independent) operation of the CPUs or to isolate CPU faults.

I/O bus

The I/O bus extends the control shelf bus to the network equipment and the GPIO shelf. It consists of a multiplexed address and data bus that carries read/write signals, interrupt signals, and clock signals. All signal lines are buffered by differential drivers and receivers on the I/O Bus Extender packs.

There are two identical I/O buses, each controlled by one CPU. This arrangement provides a redundant signal path to the Network for use in the event of an I/O bus failure. The active I/O bus is on the same shelf as the active CPU and is selected by the System Bus Controller packs on the Control shelves.

One I/O Bus Extender pack is provisioned on each Control shelf, two on each Network shelf, and two on each half of a GPIO shelf. The pack on each Control shelf is connected to one of the two packs on each Network shelf and to one of the two packs on each half of a GPIO shelf, thereby providing both CPUs with full access to all Network shelves and the GPIO shelf. This interconnecting configuration keeps the system operational during a fault and simplifies fault isolation.

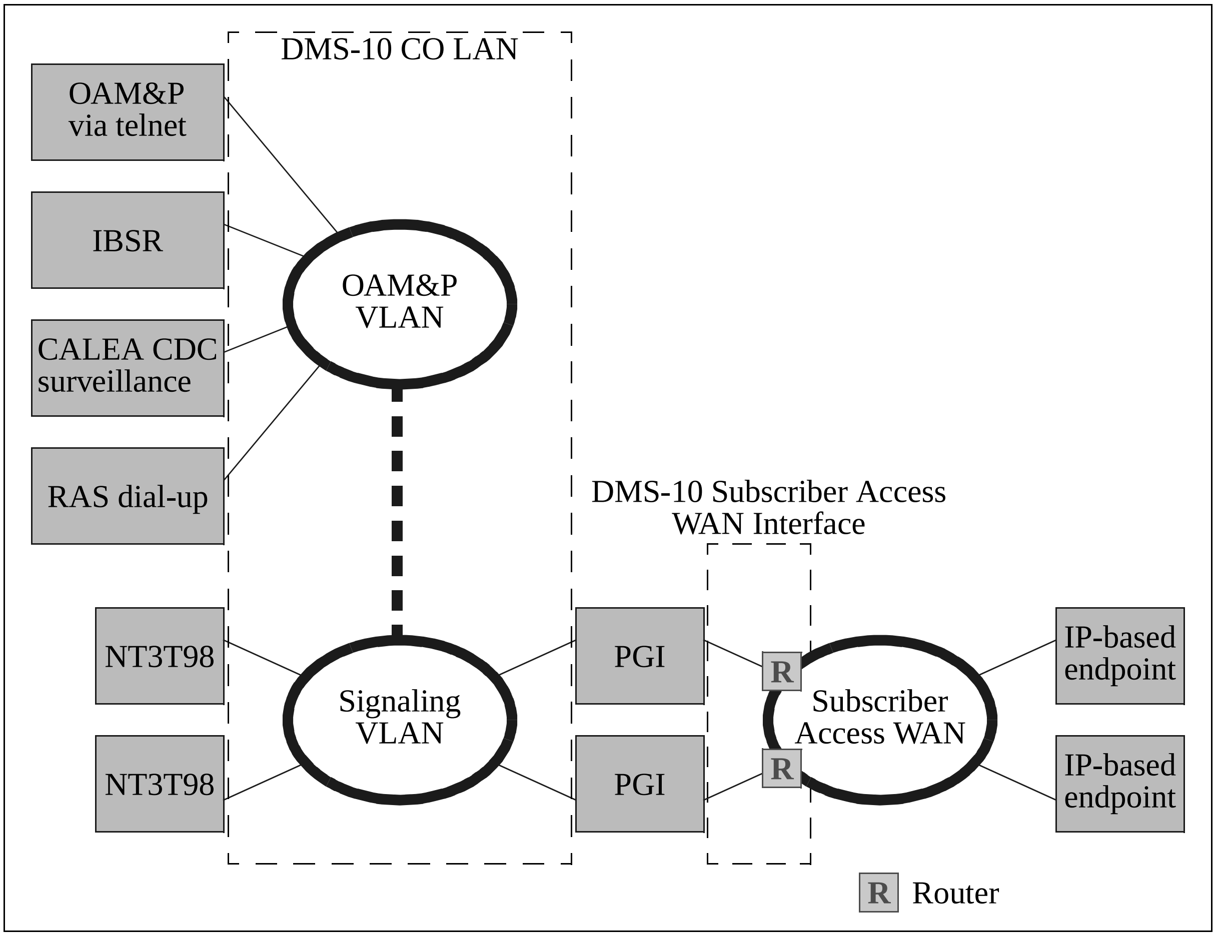
Ethernet Central Office Local Area Network (CO LAN)

The IP network architecture for a VoIP equipped 600-Series DMS-10 is shown in "DMS-10 CO LAN Architecture" on page 2-12. This diagram is used to show the IP sub-networks that make up the 600-Series DMS-10 CO LAN. Each of these sub-networks may be considered to be VLANs (virtual LANs).

The existing 500-Series DMS-10 CO LAN infrastructure will be relocated off of a new Ethernet Switch. This will be referred to as the *OAM&P VLAN* through the remainder of this document. OAM&P traffic is low priority and will have its throughput limited at the ingress port to the Ethernet Switch.

The *Signaling VLAN* is the means of signaling between the System Processor pack (NT3T98) and the PGIs. The Signaling VLAN must be highly robust and fault tolerant because it is used as an integral part of the DMS-10. If the Signaling VLAN were to fail, all lines served by PGIs would experience a service outage.

Figure 2-7: DMS-10 CO LAN Architecture



Network equipment

Two network configurations are supported by the 600-Series DMS-10 switch: the “DMS-10 Classic Network” and the “DMS-10 North American Expanded Network” (DMS-10EN). The DMS-10EN is introduced in Generic 502.

DMS-10 Classic Network

The DMS-10 Classic Network equipment provides the switching, scanning and signaling interface between the CPU and the line and trunk circuits and up to 512 channels for service circuits (for example, tone senders). It provides 4608 channels to the line and trunk interface equipment. Each channel can carry voice, data, or signaling information at a rate of up to 64 kbit/s. The high traffic-carrying capacity of the digital network loops provides flexibility in the assignment of line and trunk interface equipment.

The network equipment consists of up to two network modules and a Power and Cooling Module housed in a Common Equipment (CE) bay. For a full-size DMS-10 switch, the network modules, each of which contains two Network shelves, are provisioned in the CE-1 bay. In three-bay configurations for 2,560 lines or less, the network equipment is provisioned in the same CE bay as the control equipment (that is, the CE-3 bay), and the network function is performed within two CPU/Network shelves.

A Network shelf or CPU/Network shelf typically contains Network packs, interface packs (DS-30A Interface, Multiplex Loop Interface), and service packs (Conference, Universal Tone Receiver, Tone and Digit Sender). A Network shelf may also contain general-purpose input/output (I/O) packs such as Data Link Controller, Magnetic Tape Controller, and Input/Output Interface packs. For detailed information on network hardware, refer to the NTP entitled *Equipment Identification* (297-3601-150).

Network interconnection

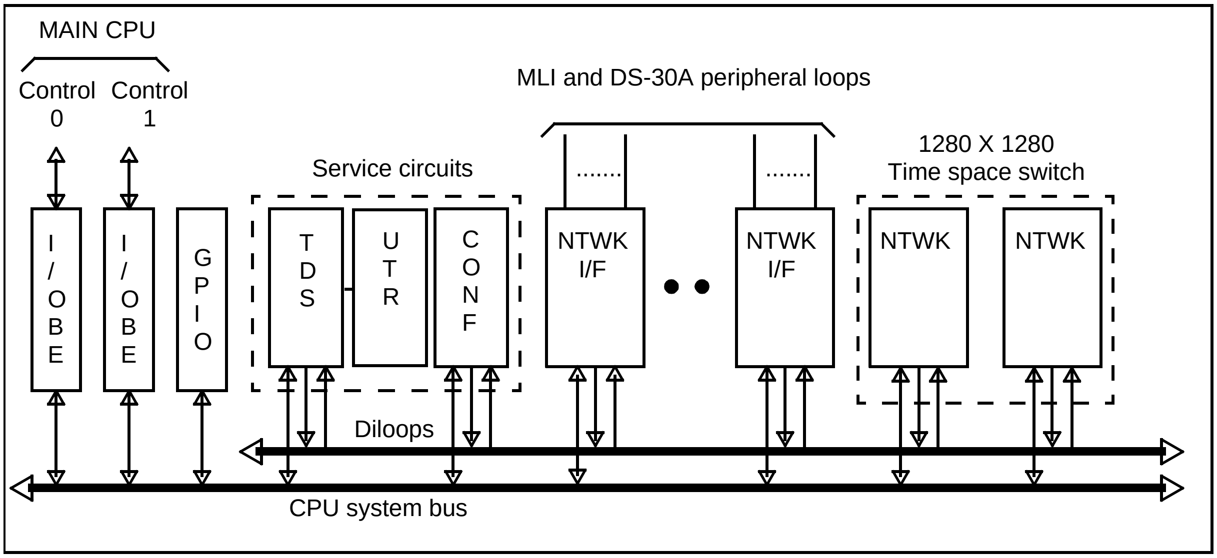
The Network or CPU/Network shelves are interconnected by modular cables that carry balanced 5.12 Mb/s serial pulse code modulation (PCM) signals between the shelves and the Network packs. The circuit packs on each Network shelf are also interconnected with 5.12 Mb/s diloops.

When PCM data are received by a Network or network interface pack, they are demultiplexed by a custom LSI Formatter circuit. This device demultiplexes the diloops and converts the serial data to parallel so that the packs can perform their functions. A similar procedure is used for the output data. The formatter converts the parallel data on the pack to multiplexed serial data, which is transmitted in a balanced differential form by network interconnection cables. This interconnection eliminates the need for junctoring and provides numerous possible paths in the Network by bit interleaving the diloops.

The network is connected to line and trunk equipment on the peripheral side by multiplexed loops and on the network side by diloops. Network interface packs provide the connection to peripheral equipment (PE) and subscriber carrier equipment (SCE) through peripheral multiplexed loops and to line concentrating equipment (LCE) through DS-30A multiplexed loops. Figure 2-8 presents an overview of the Network shelf architecture.

Each Network shelf can support 36 peripheral loops, each of which is divided into 32 channels (timeslots). The peripheral loops are paired to provide multiple access to PE, SCE, and LCE.

Figure 2-8: Network system architecture



Network packs

Network packs perform the primary time and space switching in the network. There are two Network packs per Network shelf and one Network pack per CPU/Network shelf, each of which controls 10 of the 20 diloops of PCM data that interface that Network shelf.

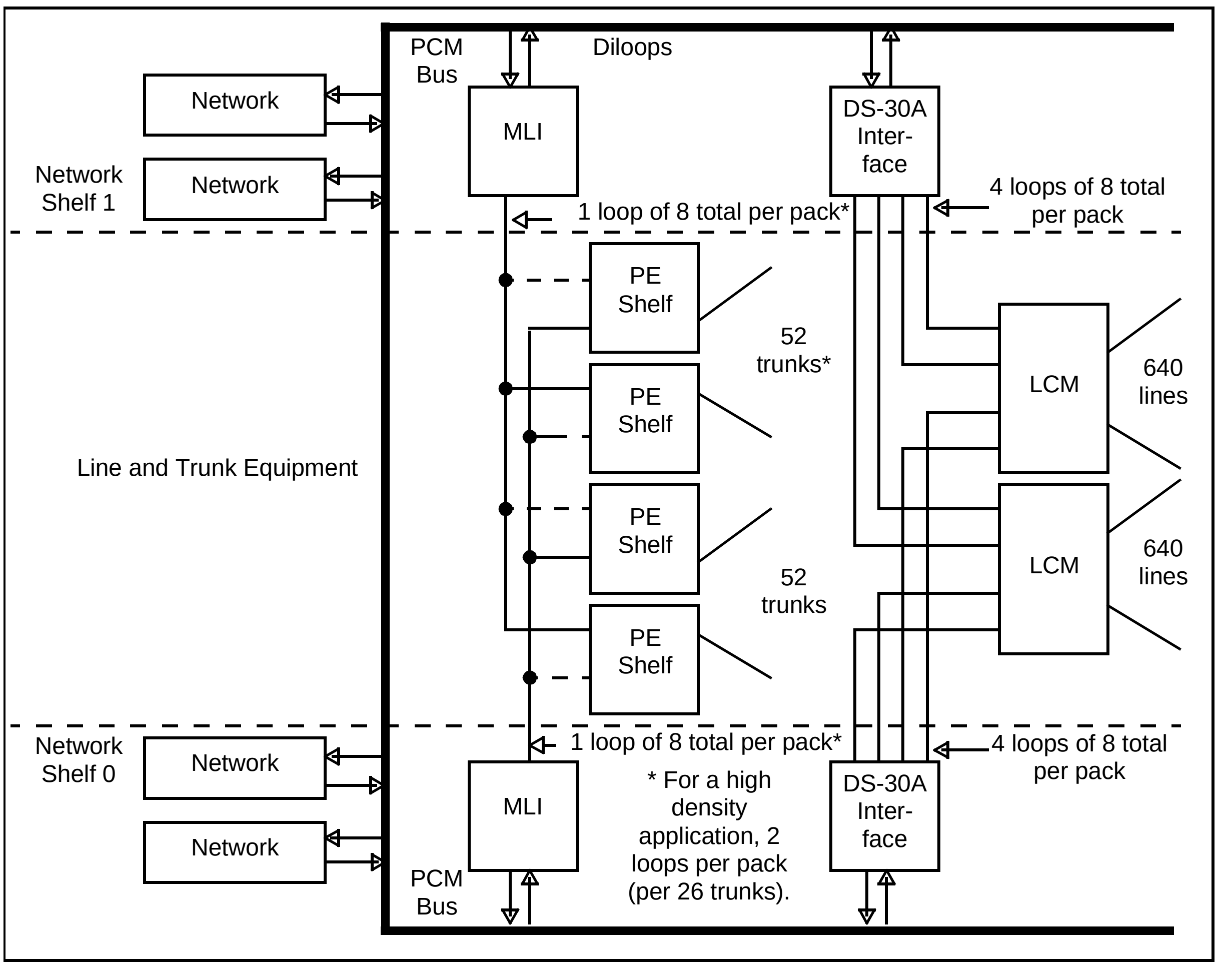
The connectivity is such that any channel on any diloop can be switched to any other channel of the 20 diloops. All traffic in the network is routed through any one of the 1280 x 1280 switches. In the event that a network pack fails, calls can still be placed at a reduced-peak traffic capacity.

Network interfaces

Network interface packs connect and switch the PCM data from the network to the associated line and trunk equipment. They also provide a signaling interface between the line or trunk circuits and the CPU. The two types of network interface packs are: the Multiplex Loop Interface (MLI) and the DS-30A Interface (DS-30A). Up to five of these packs can be configured on a Network shelf. Each pack interfaces eight peripheral loops and terminates two diloops, except the fifth pack, which operates at one-half channel capacity. Each pack contains a 256 x 256 non-blocking time and space switch between the peripheral loops and the diloops, which in turn interface the 1280 x 1280 time switches of the Network packs.

Multiplex Loop Interface (MLI) MLI packs provide an interface between the DMS-10 Network and the PE. Each MLI provides eight peripheral multiplex loops and interfaces them with two or four network diloops. Each multiplexed loop provides 30 timeslots for speech transmission and two timeslots for signaling. For high-density trunking requirements, one primary multiplexed loop can be provisioned for each PE shelf of 26 analog trunks or for a single DCM of 24 digital trunks. Each trunk is thereby assured of a path to the network under normal operating conditions (see Figure 2-9). Alternatively, for low-density trunking requirements, one primary multiplexed loop can be provisioned for two PE shelves. In either case, should a multiplexed loop or MLI pack fail, an alternate loop from another MLI pack will take over traffic handling for the shelf, but at half the normal capacity.

Figure 2-9: Network interface (low density trunking configuration)



DS-30A Interface (DS-30A) DS-30A packs provide an interface between the network and the LCE and SCE. Each DS-30A provides eight DS-30A peripheral multiplex loops, and interfaces them with two or four Network diloops. Each loop is paired with another; one provides 32 timeslots for speech transmission while the other provides 30 timeslots for speech transmission, one timeslot for signaling, and one timeslot unused. Four or six DS-30A loops are provisioned for each 640-line LCM.

Service circuits

The network also provides access for the following service circuits: Conference, Tone and Digit Sender (TDS), and Universal Tone Receiver (UTR) packs.

Conference The Conference pack can accommodate up to 10 simultaneous three-way conferences.

Tone and Digit Sender (TDS) The TDS generates all call progress tones and multifrequency (MF) digits that are sent over trunks and subscriber lines.

Universal Tone Receiver (UTR) The UTR receives digital multifrequency tones from network DS-60 loops (via the TDS) for up to 31 channels simultaneously. It then digitally filters the tones for the appropriate signaling set, decodes the filtered outputs, and outputs the decoded results.

Service pack interface with network The service packs interface with the network differently than Network packs. The service packs, situated on the CPU System bus, share half of four diloops with the fifth network interface pack on each shelf. In order to ensure full service-circuit availability to the switching network at all times, only four of the eight peripheral multiplexed loops on the fifth network interface pack are generally used. Up to four service packs (that is, Conference and/or TDS) reside on each Network shelf.

The time-space switch within the TDS allows it to receive or drive any of the 128 channels in the pool. This architecture allows a great deal of flexibility in the allocation of the service channels and the functions for which they may be used.

Network loops

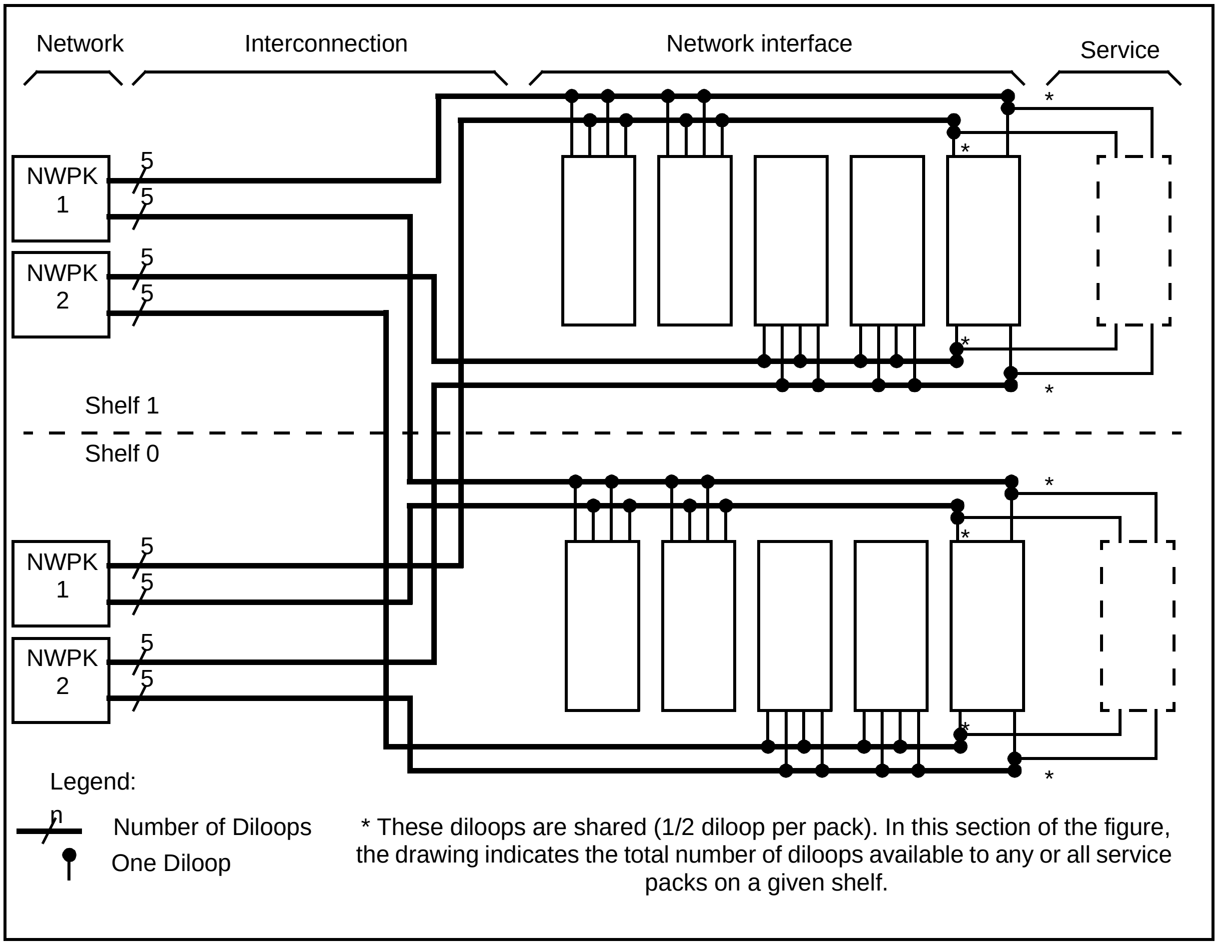
When determining total loop capacity per Network shelf, it is necessary to look at the total number of loops provided by the interface packs, determined according to traffic loading, and the service packs. Each of the four interface packs that can be configured provides eight multiplex loops to the line and trunk equipment and four diloops to the Network pack. The fifth pack provides four multiplex loops and two diloops. Therefore, the interface packs on a Network shelf provide a total of 36 multiplex loops.

This loop configuration provides a total capacity of 40 multiplex loops and 20 diloops per Network shelf. Of the 20 diloops, 18 are interface diloops and 2 are service diloops. If the maximum Network provisioning exists (that is, two Network modules), the loop configuration provides a total of 160 multiplex loops.

Network configurations

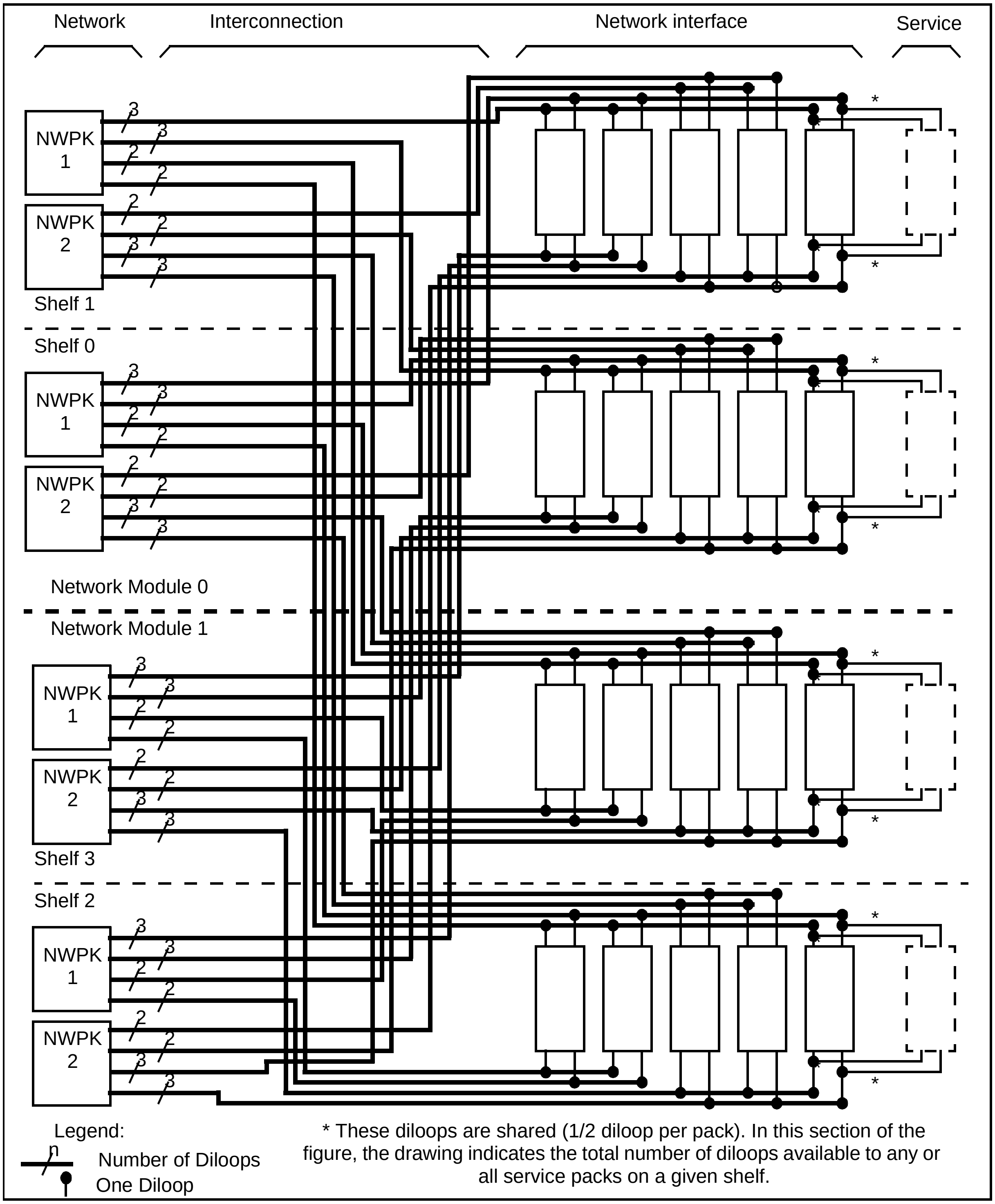
A system consisting of a single network module consists of two Network packs per shelf. The network is interconnected by 40 diloops which are capable of providing service to about 6,400 lines plus associated trunks and service circuits. Figure 2-10 shows the shelf interconnection of a system consisting of a single network module.

Figure 2-10: Interconnection of standard two-shelf network system



A system consisting of two network modules also requires two Network packs per shelf. The network system is interconnected by 80 diloops or 160 multiplexed loops, which are capable of providing service to approximately 12,800 lines plus associated trunks and service circuits. The four-shelf network has a different scheme for distributing links across the Network packs: a diloop from each Network shelf is available to each network interface pack or service circuit block in the Network shelf. Figure 2-11 shows the shelf interconnection of a system consisting of two network modules.

Figure 2-11: Interconnection of four-shelf network system



The three-bay configuration consists of one network module (that is, two CPU/ Network shelves). Each CPU/Network shelf houses two interface packs (one MLI and one DS-30A) and up to four service packs. Hence, the total loop capacity per CPU/ Network shelf is 16 multiplex loops and 8 diloops, or 32 multiplex loops and 16 diloops per network module.

DMS-10 North American Expanded Network (DMS-10EN)

The DMS-10EN enhances DMS-10 switch operation by expanding the number of peripheral loops in the switch, increasing the switch's line capacity, providing a non-blocking central switching network, and improving reliability and performance of the switching network. The DMS-10EN also preserves the DMS-10 switch's compactness and its suitability to existing products and markets. Specifically, the DMS-10EN:

- switches each call through dual central network planes, thus providing greater reliability for switched calls than the DMS-10 Classic Network
- connects to existing peripheral equipment
- increases the number of peripheral loops per network interface pack, thereby reducing the number of network interface packs required
- eliminates the need for separate service network interface packs by integrating the service functions performed by these packs into one pack
- through a reduced circuit pack portfolio, reduces the number of circuit pack spares required for DMS-10 switch maintenance
- incorporates cable and paddleboard functions into backplanes, thus reducing the number of cables and paddleboards required
- assimilates digital signaling processing technology into service channels

DMS-10EN architecture

The DMS-10EN is modular in structure to allow easy incremental growth of network capacity and interfaces to equipment such as Line Concentrating Modules (LCM), remote line units (such as the RLCM or OPAC), and trunking modules (such as the DSI).

The networking function is performed by the Computer Network Interface (CNI) module, a module consisting of two shelves of equipment that span a single backplane. The two CNI shelves in the module support up to 320 peripheral loops. The CNI module is housed in a J1T92, CE-01 bay. For a description of the CNI module and the J1T92 family of CE-01 bays, see NTP 297-3601-150, *Equipment Identification*.

On the CNI shelf, the NT8T04 Network Interface pack and the NT8T06 Central Network pack provide the network interface and network switching elements. From two through five NT8T04 packs can be provisioned on each CNI shelf. Two NT8T06 packs are provisioned on each CNI shelf.

NT8T04 The NT8T04 Network Interface pack serves as the interface to both the Multiplex Loop Interface (MLI) and DS-30A Interface (DS-30A) families of DMS-10 peripherals. A single NT8T04 can support only one application, either MLI or DS-30A, at a time. Each NT8T04 provides up to 32 peripheral loops (PELP). Thus, each CNI shelf can provide up to 160 PELPs. Each NT8T04 is mated with an NT8T04 provisioned in the same slot on the other CNI shelf, for sparing purposes.

The NT8T04 can also provide up to 128 channels of tone, receiver, and conference services. The circuitry that provides these services consists of two separate digital signal processors (DSP), called Global Tone Services banks (GTSB). Each GTSB provides 64 service channels. The GTSBs perform the following functions:

- DTMF digit sending and reception
- Multi-frequency (MF) sending and reception
- providing call processing tones
- calling number/name delivery to customer premises equipment (CPE)
- 3-way conference call management
- dial-pulse (DP) sending
- coin services management

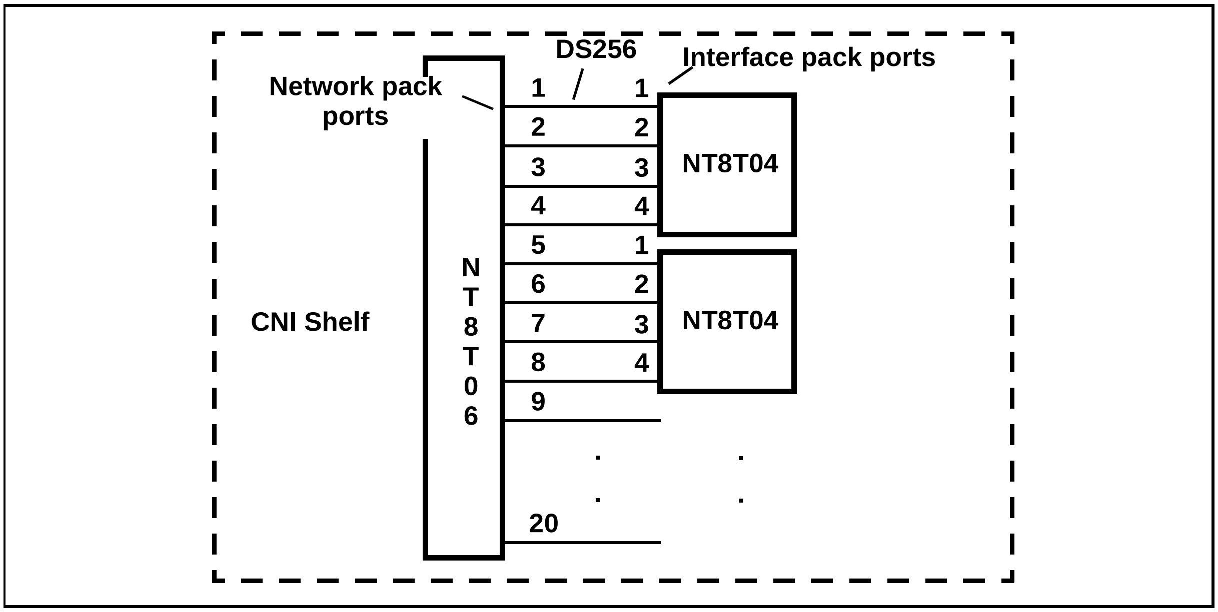
Any GTSB on any NT8T04 pack can serve any peripheral in the system. For example, if an LCMC connected to NT8T04 located in slot 12 needs a tone, another NT8T04 pack, in any slot on any shelf, can provide the tone. When the GTSB circuitry on an NT8T04 is activated, the maximum number of peripheral loops that can be served by the NT8T04 is reduced from 32 to 28.

NT8T06 The NT8T06 Central Network pack performs the switching in the DMS-10EN. The NT8T06 provides a 20,480 X 5120 non-blocking switch matrix which can connect any peripheral GTS channel on its CNI shelf to any other peripheral or GTS channel in the system.

Network interconnection

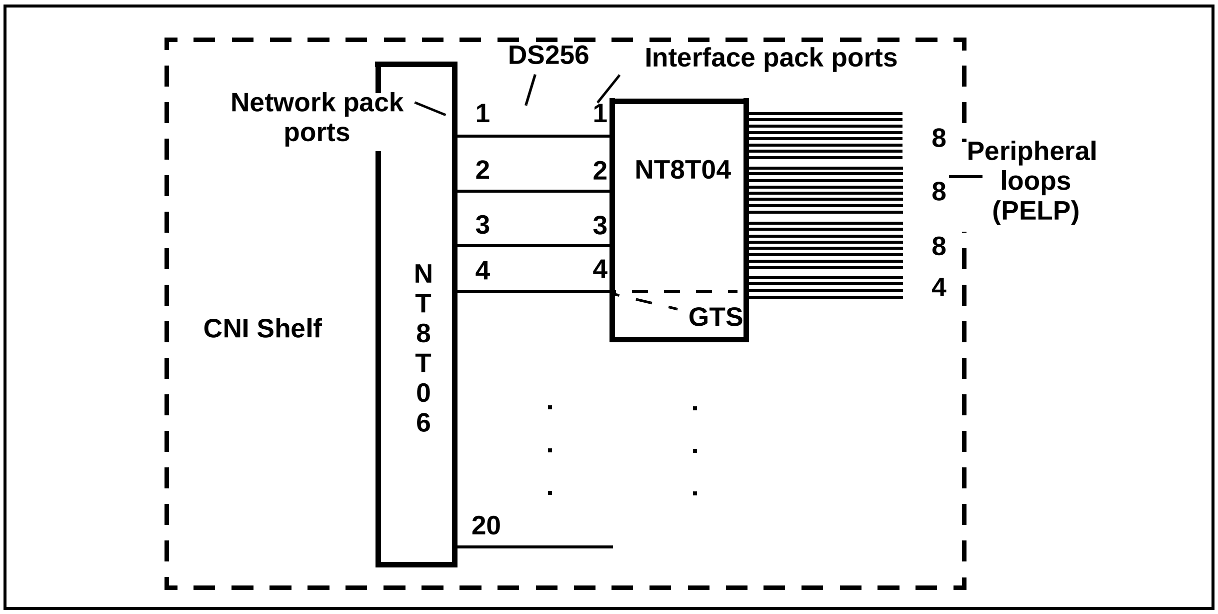
Figure 2-12 illustrates the connection between the NT8T06 Central Network pack and the NT8T04 Network Interface pack on a CNI shelf. Each NT8T04 pack is connected to each NT8T06 through four DS256 loops. Each DS256 loop has 256 channels. Each NT8T06 pack can connect with up to five NT8T04 packs on the same CNI shelf. Thus, each NT8T06 pack has 20 network pack ports available for connection to the NT8T04 packs and each NT8T04 pack has four interface pack ports available for connection to the NT8T06 pack.

Figure 2-12: Interconnection of NT8T06 and NT8T04 packs



Each DS256 loop is mapped to a specific set of peripheral loops on an NT8T04 pack. If GTSB is not activated on an NT8T04, each of the four DS256 loops is mapped to a group of eight peripheral loops (PELP). If GTSB is activated on an NT8T04, three of the DS256 loops are each mapped to a group of eight peripheral loops and the remaining DS256 loop is split across a set of four peripheral loops and the GTS, as shown in Figure 2-13.

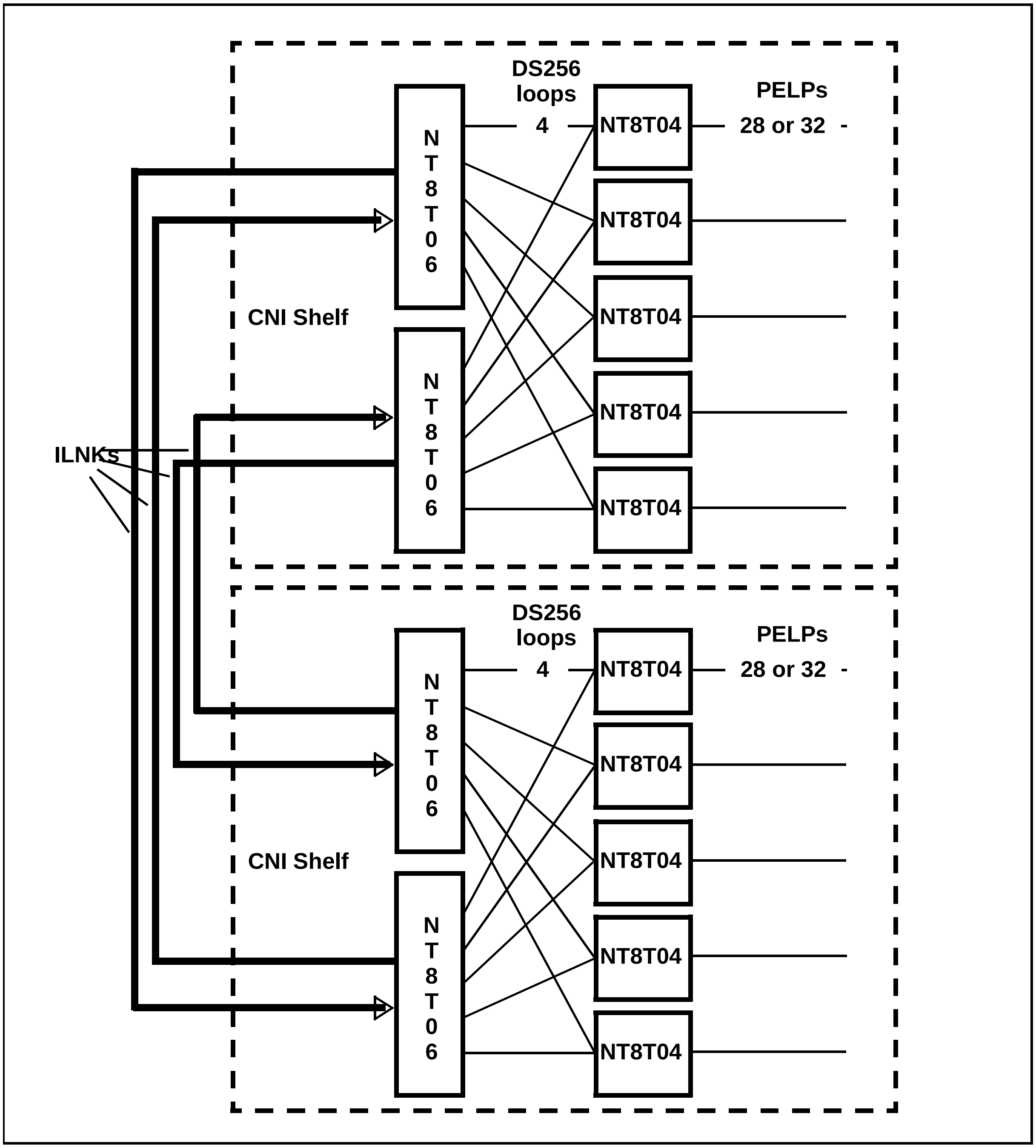
Figure 2-13: Relationship of DS256 loops to peripheral loops with GTSB activated on NT8T04



Inter-shelf connection

CNI shelves are inter-connected through STM-4 links (ILNK). The ILNKs connect the NT8T06 packs on one CNI shelf to the NT8T06 packs on the other CNI shelf in a CNI module. CNI inter-connection is shown in Figure 2-14.

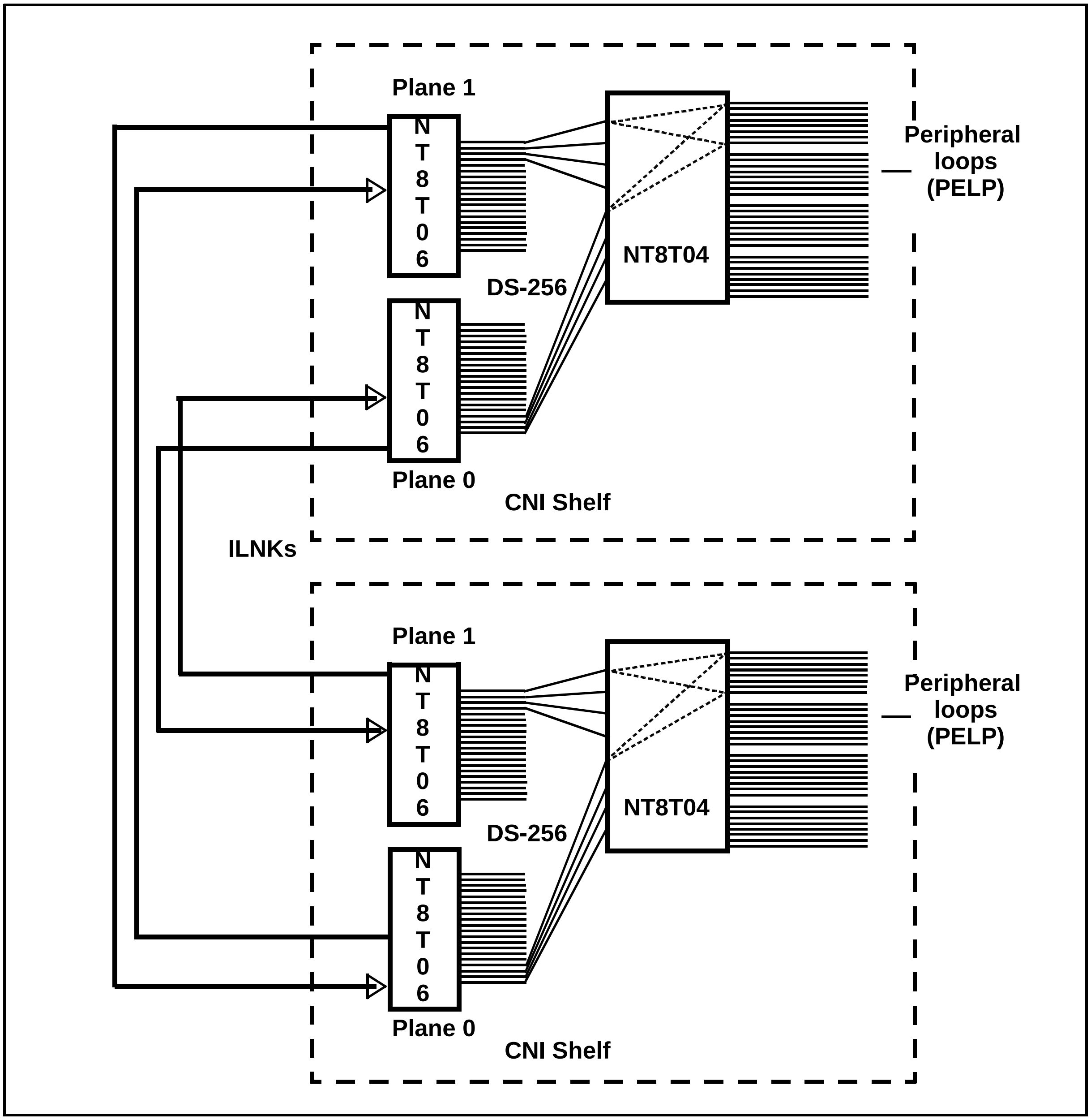
Figure 2-14: CNI Intershelf Connection



Dual-plane architecture

The DMS-10EN operates in a dual-plane network plane architecture. Each network connection between two NT8T04 packs is duplicated in the central network, one connection in each of two planes. The two network planes are numbered 0 and 1. One of the two NT8T06 packs on a CNI shelf is a member of network plane 0, the other NT8T06 pack is a member of network plane 1. The interconnection of the NT8T04 and NT8T06 packs in the dual-plane network architecture is shown in Figure 2-15.

Figure 2-15: Interconnection of NT8T04 Packs in the DMS-10EN Dual-plane Architecture



The channels on the DS-256 loop are in fixed relationship to the channels on the peripheral loops. After a peripheral timeslot for the source terminal and the destination terminal is determined to be available, the network connection between the terminals is guaranteed. Thus, network blocking will not occur.

The DMS-10EN provides hot-standby equipment redundancy as each call is switched simultaneously in parallel on both planes. Each peripheral loop is connected to both network planes. The NT8T04 pack transmits the Pulse Code Modulation (PCM) to both planes and determines which PCM to transmit to the peripheral loops. The NT8T04 can also choose to receive a single channel of PCM either on plane 0 or on plane 1.

Because the system has hot-standby capability, a single NT8T06 pack fault will not result in service degradation since the connection is also present in the mate network plane on the other NT8T06 on the shelf. If, however, both NT8T06 packs on a shelf fail, all connections on the network shelf are lost. And, if there is no peripheral loop sparing capability, the peripheral loops on the shelf become unavailable.

For a description of the pack fill for a CNI shelf, see NTP 297-3601-150, *Equipment Identification*.

DMS-10EN configuration

The CNI module is housed in a J1T92 CE-1 bay. In addition to the CNI module, the bay houses a Power and Cooling Module, up to two GPIO shelves, and an optional DCI shelf or Messaging shelf. In a typical DMS-10EN configuration, a J1T93 CE-3 Common Equipment frame houses digital trunks and CCS-7 equipment, and a PE-01 frame provides power distribution and metallic maintenance facilities. The total number of frames provisioned depends on the quantities of lines and trunks required.

For a description of the frames used in the DMS-10EN network configuration, see NTP 297-3601-150, *Equipment Identification*.

Installed DMS-10 base equivalent configurations The following configurations are examples of equivalent configurations of installed DMS-10 Classic Network equipment and DMS-10EN network equipment.

LCC configurations An equivalent configuration of DMS-10EN network equipment to a Large Cluster Controller (LCC) configuration does not exist since the LCC does not contain network equipment.

One- and Two-bay DMS-10 switch configurations The One- and Two-bay configurations do not support the expanded network. Thus, these configurations must be upgraded to a standard DMS-10EN configuration.

Standard DMS-10 switch configurations There is no change in equipment footprint when a standard DMS-10 switch network is re-configured as a DMS-10EN network. The J1T92 CE-1 frame supplements the existing J1T30 CE-1 frame. The existing CE-3 frame is retained for the existing alarm and ringing equipment, but is re-configured to accommodate digital trunks, CCS-7 equipment, or GPIO equipment.

Standard compact DMS-10 switch configurations The equipment footprint changes when a standard compact DMS-10 switch network is re-configured as a DMS-10EN network. The J1T92 CE-1 frame supplements the existing J1T30 CE-1 frame. The existing CE-3 frame is retained for the existing alarm and ringing equipment, but is re-configured to accommodate digital trunks, CCS-7 equipment, or GPIO equipment.

EXP compact DMS-10 switch configurations There is no change in equipment footprint when an EXP compact DMS-10 switch network is re-configured as a DMS-10EN network. The J1T92 CE-1 frame supplements the existing J1T30 CE-1 frame. The existing CE-3 frame is retained for the existing alarm and ringing equipment, but is re-configured to accommodate digital trunks, CCS-7 equipment, or GPIO equipment.

DMS-10M switch configurations The DMS-10M equipment footprint increases when the DMS-10M is re-configured as a DMS-10EN network - the entire DMS-10M module is replaced. The equivalent configuration consists of a J1T92 CE-1 frame, a CE-3 frame to house used for alarm and ringing equipment, digital trunks, and CCS-7 equipment, a PE-01 frame for MLI-based digital and analog trunks, maintenance, recorded announcements, and power distribution, and LCE frames to house subscriber lines.

Peripheral equipment

Peripheral equipment (PE) provides the circuitry to interface the digital signals of the multiplexed loops to the transmission/signaling facilities of lines and analog/digital trunks. The PE configuration and architecture are discussed below.

PE configuration

Lines, trunks, and test trunks can be provisioned as part of PE. PE shelves and a Bay Supervisory Panel (BSP) are mounted in a PE bay.

Also mounted in PE bays are:

- Digital Carrier Modules (DCMs), which provide the capability to connect the DMS-10 switch directly to 1.544 or 2.048 Mb/s digital lines
- Remote Equipment Modules (REMs), which provide an extension of a pair of multiplexed loops to remotely located peripheral equipment, or connection to remotely located control, network, and peripheral equipment when the Emergency Stand Alone (REM/ESA) option is provided
- Subscriber Carrier Modules (SCMs), which interface with DMS-1 Remote Concentrator Terminals

PE shelves

Each Dual PE shelf, Dual PE Trunk shelf, or Dual PE/PMS shelf operates from its own power supply. In the event a converter fails on one shelf, that shelf will be powered by the converter on the mate shelf.

PE packs

Line and trunk packs contain the circuitry to interface the digital signals of the multiplex loop with the signaling transmission of lines and trunks. For detailed information on line and trunk packs, see the NTP entitled *Circuit Interfaces for Lines, Trunks, and Test Trunks* (297-3601-184).

PE control

The Peripheral Shelf Controller 1 (PSC1) pack is the interface between the Network and the PE circuit packs. It provides the control capability to:

- select one multiplexed loop to be made active and the other to be made standby
- compensates PE circuit packs against loss of voltage or logic signals
- activate other maintenance relays on PE packs; that is, control which (if any) line or trunk on a PE shelf is connected to a maintenance bus
- control the connection of the shelf maintenance buses to the frame buses
- provide enable/disable capability for PE shelf signaling

The Peripheral Shelf Converter 2 (PSC2) pack contains the dc-to-dc conversion circuitry from -48 V dc to ±10, ±6, +8, and +48 V dc for the other PE packs. In addition, maintenance relays for connection of the PE shelf and frame maintenance buses are provided.

Receiver packs

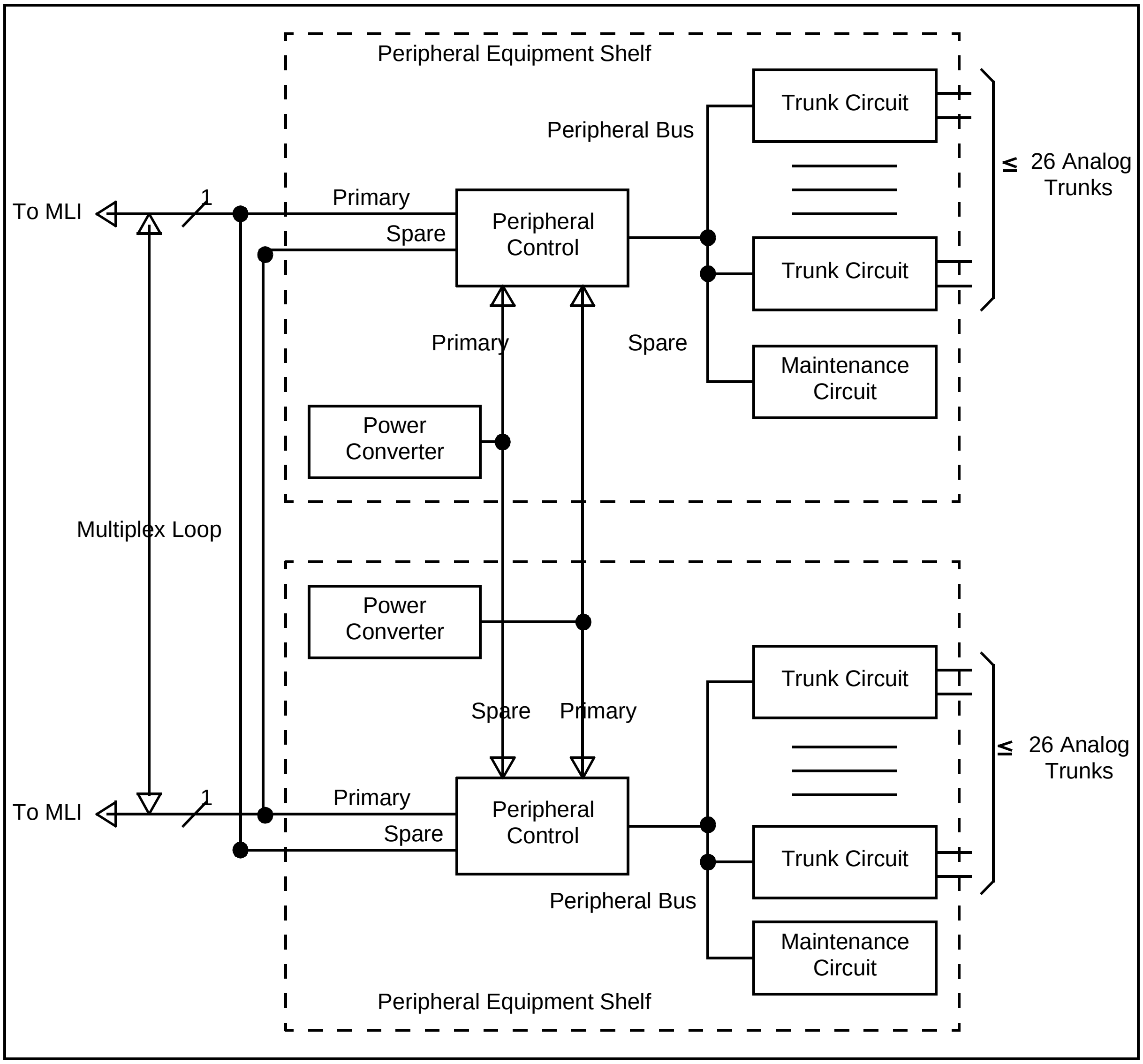
Two types of receiver packs can be configured as part of PE: the Digitone Receiver (DTR) pack and the Multifrequency Receiver (MFR) pack. The DTR pack contains two circuits, each of which decodes Digitone signaling frequency pairs, that is, one of 697, 770, 852, or 941 Hz (low group) and one of 1209, 1336, 1477, or 1633 Hz (high group). Two digital connections can be made to the pack, one to receive Digitone signals from the connected circuit and one to receive tones from the Tone and Digit Sender (TDS) (that is, the dial tone sent to the original subscriber). The MFR pack provides circuitry to decode standard two-out-of-six multifrequency signals on incoming trunks.

PE architecture

The PE architecture for paired PE shelves is illustrated in Figure 2-16. The scanning and signal distribution performed by the network and PE hardware provide communication between the CPU and the PE.

Two levels of scanning operate asynchronously. The PSC1 in each PE shelf scans the lines and trunks on its shelf, looking for changes of state. The MLI pack (NT4T04), or Network Interface pack (NT8T04), scans the PSC1 packs associated with the network module. When a change of state is detected, the address of the PSC1 and PE pack is retrieved serially and buffered in the MLI pack (NT4T05 or NT8T04). The CPU is notified by means of an interrupt and retrieves the message by way of the parallel CPU bus. The message is placed in an input message buffer in Call Store.

Figure 2-16: Paired peripheral equipment shelves



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Digital Carrier Module (DCM)

The DCM comprises the following circuit packs: Carrier Interface (NT2T32), Signaling Converter (NT2T31), and Network Interface (NT2T30). DCMs are housed on Digital Carrier shelves located in PE bays. A single Digital Carrier shelf can accommodate up to six DCMs, with one peripheral loop required per DCM.

The DCM provides the capability to connect the DMS-10 switch directly to a 1.544 Mb/s digital trunk (DS-1 span line), thereby eliminating the need for channel banks and analog trunk circuits. The DCM can also serve as the DMS-10 system clock synchronization reference source. Additional information about the DCM can be found in NTP 297-3601-150, *Equipment Identification*.

Digital Signal Interface (DSI)

The Digital Signal Interface (DSI) is a digital facility interface that performs the functions of the Digital Carrier Module (DCM) and Subscriber Remote Interface (SRI) packs. It provides clear-channel connectivity for Integrated Service Digital Network (ISDN) using a single interface.

Each DSI module provides two 24-channel DS-1 spans, running at 1.544 Mbps. A DSI module comprises the following circuit packs: Span Interface Controller (NT4T24) and DS-1 Interface pack (NT6X50). DSI modules are housed on Digital Carrier Interface (DCI) shelves located in CE-1, CE-2, CE-3, or CE-4 bays, both for ease of installation and for increased reliability resulting from dual power feeds by way of the NT3T19AE Power Converters. A single Digital Carrier Interface shelf can accommodate up to 10 DSI modules, with two DS-1 links supported per module. A DSI module may be used either as a digital trunk interface or as a remote interface, although the module cannot be used for both types of interface at the same time. For more information about the DSI module packs and Digital Carrier Interface shelf, see NTP 297-3601-150, *Equipment Identification*.

DSI as a digital trunk interface

When functioning as a digital trunk interface, a DSI module supports two types of configuration: simplex and duplex. In the simplex configuration, shown in Figure 2-17, the DSI module is connected to the DMS-10 network through 2 mux loops that reside on the same Multiplex Loop Interface (MLI) packs (NT4T05 or NT8T04). In the duplex configuration, shown in Figure 2-18, the DSI module is connected to the DMS-10 network through 4 mux loops (2 loops per DSI link); the two loops of each DSI link reside on MLI packs provisioned on separate Network shelves.

Figure 2-17: DSI module provisioned as a Digital Trunk Interface (Simplex mode)

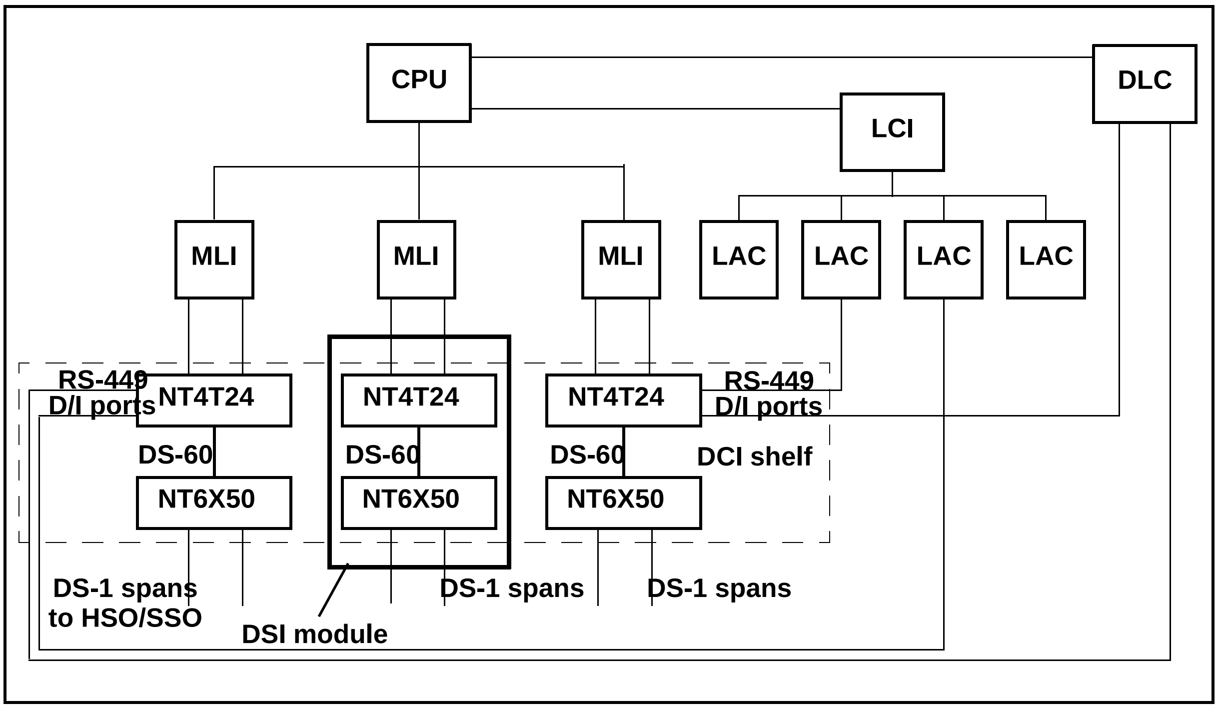
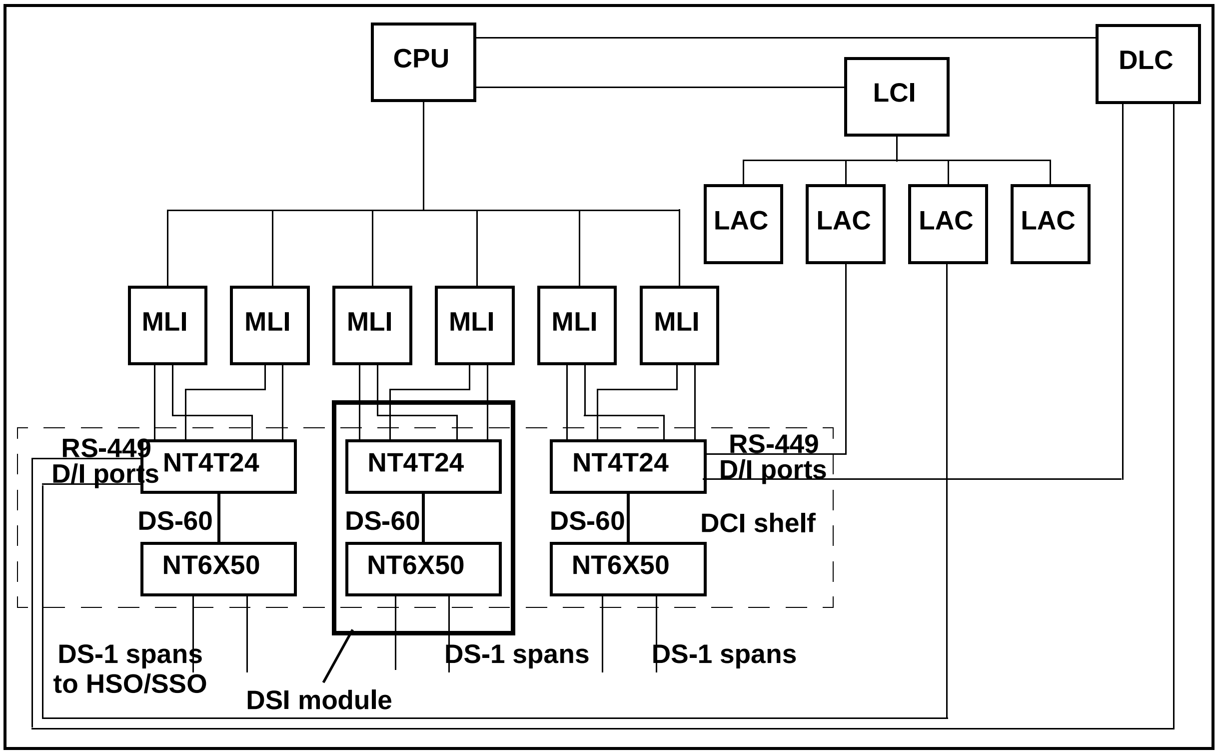


Figure 2-18: DSI module provisioned as a Digital Trunk Interface (Duplex mode)



To simplify engineering of Common Channel Signaling (CCS7) and Satellite Switching Office (SSO) networks, each DSI module offers two RS-449 data ports, providing software-assignable drop/insert channels operating at either 56- or 64-kbps. The two data channels may both be assigned to one span, providing CCS7 and HSO/SSO connectivity, as determined by the telco. For CCS7 signaling, a channel is connected to an NT4T20 LAN Application Controller (LAC) pack. For HSO/SSO data links, the channel is connected to a Data Link Controller (NT3T50) pack.

The following capabilities are provided by the DSI when functioning as a digital trunk interface at 56 kbps:

- DP, MF, or ISUP signaling
- SuperFrame (SF) or Extended SuperFrame (ESF) framing, for compatibility with the evolving trunk network
- Robbed Bit signaling: capability of supporting continuous signaling; extraction and insertion of the a- and b-bits from appropriate frames both AMI and B8ZS lining coding formats.
- zero code suppression (ZCS) for compatibility with existing repeaters and spans
- automatic span restoral capability after transient span problems

- generation of the following alarms: bipolar violations exceeding designated thresholds (BPV), loss of frame alignment (FA), remote fault (RALM), slips, and cyclic redundancy check (CRC) if ESF is used
- channel loopback capabilities for maintenance and testing
- timing reference for office synchronization

The following capabilities are provided by the DSI when functioning as a digital trunk interface at 64 kbps:

- ISUP signaling
- SuperFrame (SF) or Extended SuperFrame (ESF) framing, for compatibility with the evolving trunk network
- bipolar 8-bit zero suppression (B8ZS), for clear channel capability
- generation of the following alarms: bipolar violations exceeding designated thresholds (BPV), loss of frame alignment (FA), remote fault (RALM), slips, and CRC if ESF is used
- channel loopback capabilities for maintenance and testing
- timing reference for office synchronization

The DSI digital trunk interface can coexist with DCMs within an office. The DMS-10 switch supports digital trunks connected to DCM-24 modules as well as DSI modules. The DSI and DCM modules cannot, however, be provisioned on the same shelf. DSI links for digital trunk interface and DSI links for remote interface can exist on the same shelf if they are located in separate DSI modules.

The following limitations apply to the DSI when ESF is used:

- DMS-10 supports only reporting of remote alarms over the Facility Data Link (FDL)
- c- and d-bits are ignored for ESF

Sparing In the duplex mode configuration, a dual path to the NT4T24 provides redundant network interface connections. In this configuration, two Multiplex Loop Interface (MLI) links are configured per span rather than one. One of the paths is always active while the mate path is held in standby mode pending a software-controlled request to make the inactive path active. Should maintenance that requires a switch in paths be necessary, stable (answered) calls are re-switched if a path is available. Conditions under which sparing occurs are shown in TP 5210, in NTP 297-3601-511, *Maintenance and Test Manual*.

Office synchronization The DSI extracts the 8-kHz reference supplied to the NT3T47 Synchronous Clock pack from the incoming first span on the module. The DSI also filters the clock reference received from the network interface pack and ensures that the digital signal transmitted on the connected span complies with the appropriate synchronization specifications for jitter. A secondary clock reference is extracted by another DSI module. Office synchronization references can also remain on the DCM. In the event that both clock references are lost, the DMS-10 switch can operate in *clock holdover* mode. In this mode, the last synchronized clock frequency is maintained until synchronization is re-acquired. For additional information about office synchronization, refer to “System Clock Synchronization,” in this section.

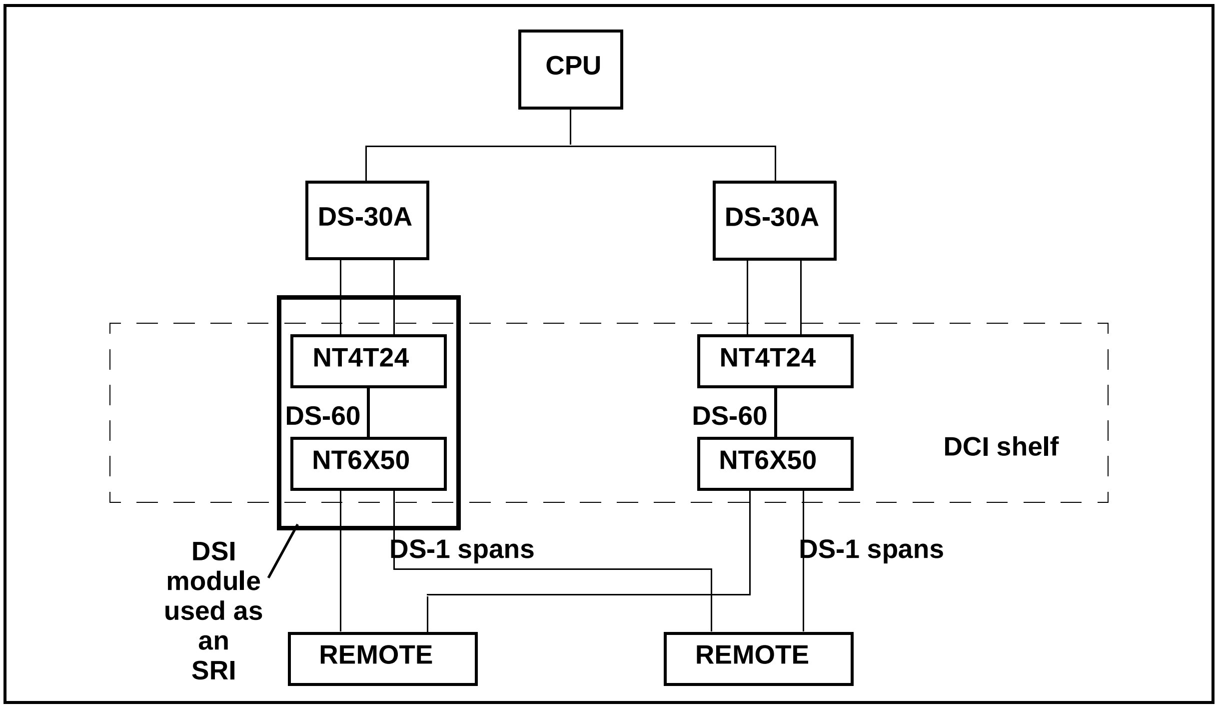
DSI as a remote interface

The DSI configured as a remote interface is shown in Figure 2-19. The following capabilities are provided by the DSI when functioning as a remote interface:

- SuperFrame (SF) framing for compatibility with all existing DMS-10 remotes
- zero code suppression (ZCS)
- local loop-around of all DS-30 channels for better isolation of span faults
- span alarms for bipolar violations exceeding designated thresholds (BPV), loss of frame alignment (FA), remote fault (RALM) and slips

Both 56 kbps and 64 kbps transmission rates are supported.

Figure 2-19: DSI module provisioned as a remote interface



For remote interface applications, each DSI module is connected to the DMS-10 network through DS-30A loops. DSI modules used for trunking and future remote applications are packaged in Digital Carrier Interface (DCI) shelves located in available CE-1, CE-2, CE-3, or CE-4 bays to assure redundant power distribution to the NT3T19AE Power Converters. Existing DCI shelves with older power systems providing remote interfaces through the NT4T09 Small Remote Interface (SRI) can be equipped to support DSI modules only for remotes.

> ***Note:*** *The DSI functioning as an SRI in the J1T80A-1 shelf (which resides in a PE bay) receives power for both NT3T19 packs from the 48V "A" feed or from the 48V "B" feed. Unlike the J1T80A-2 shelf, if the J1T80A-1's single 48V supply is lost, power to all modules on the shelf is lost. Another important difference between the J1T80A-2 and the J1T80A-1 is that the +5V bus to the backplane is not redundant to the DSI modules (functioning as an SRI). If a single NT3T19 fails, one-half of the J1T80A-1DSI modules (functioning as an SRI) will fail.*

DSI as an ISDN PRI interface

The DSI can be configured as an ISDN PRI interface. In this application, the DSI is connected on its C-side with two DS-30A loops from an NT4T04 or NT8T04 pack, and is connected on its P-side with two T1 spans that provide 48 channels to Class II equipment such as a PBX. Only an AD or later version of the NT4T24 card in a DSI module supports the ISDN PRI application. For additional information about the DSI acting as an ISDN PRI interface, see the section entitled, “Integrated Services Digital Network” in this NTP.

Remote Equipment Module

The Remote Equipment Module (REM) permits PE to be remotely located by extending multiplex loops over DS-1 carrier lines from a host DMS-10 system. Although signaling in the system is effective to approximately 70 miles (112 km), speech impairment limits the distance between the host system and the remote system to approximately 40 miles (64 km).

REM configuration

A fully configured REM consists of two pairs of multiplex loops (four loops) that serve eight remote PE shelves (two PE bays with four shelves per bay). Each multiplex loop is interfaced to a DS-1 carrier by the Office Carrier Module (OCM) at the host location and the Remote Carrier Module (RCM) at the remote location. The minimum REM configuration consists of one-half the hardware of the fully configured REM, or one pair of multiplex loops serving four remote PE shelves located in a single PE bay.

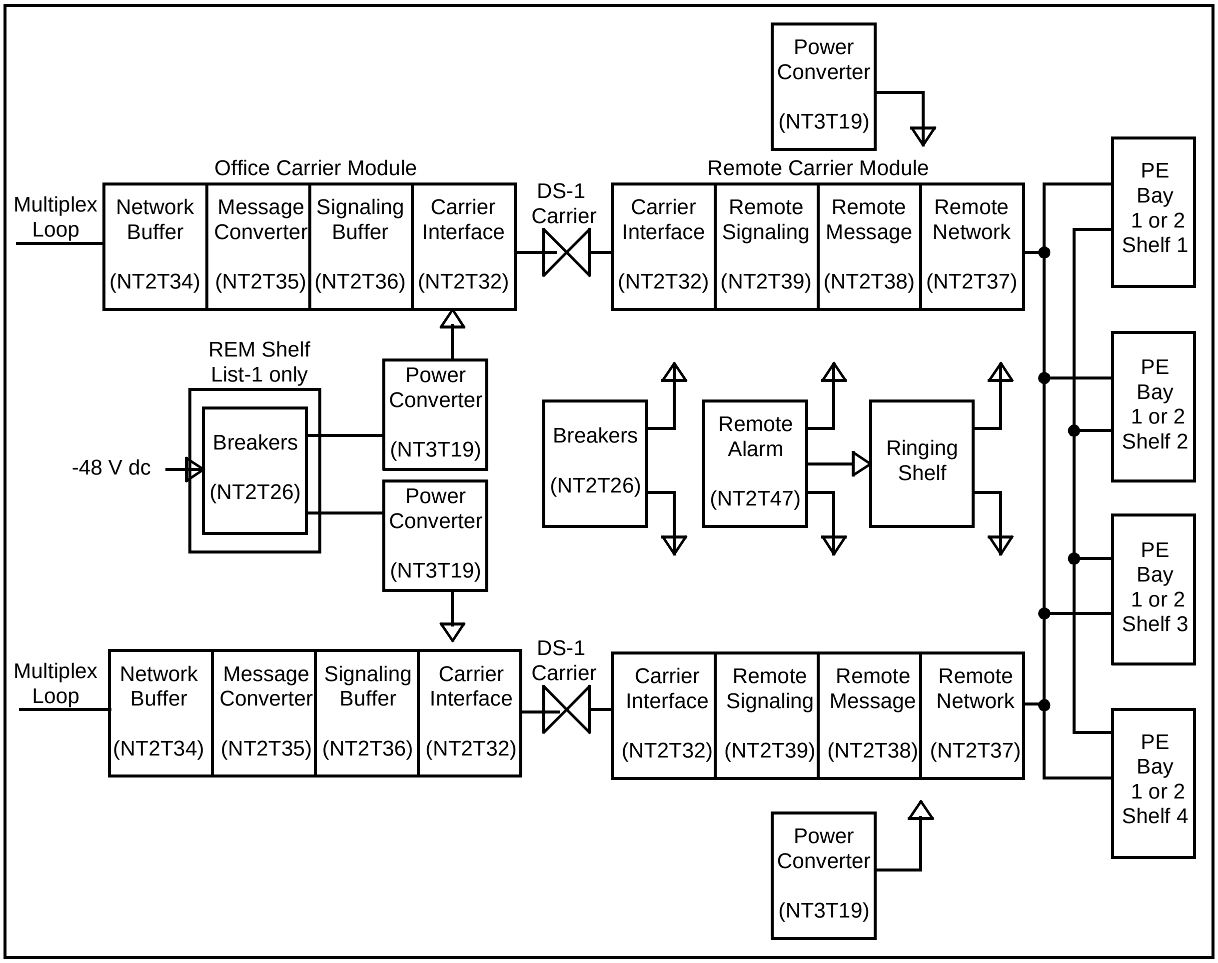
Figure 2-20 illustrates this minimum REM configuration of one pair of multiplex loops serving up to 224 ports (subscriber lines) on four PE shelves, with each loop in the pair serving up to 112 ports on two shelves. If one loop in the pair fails anywhere on its path, the mate loop serves, at a reduced capacity, the four shelves.

The OCM consists of four circuit packs: Carrier Interface (NT2T32), Network Buffer (NT2T34), Message Converter (NT2T35), and Signaling Buffer (NT2T36). In addition, one or two 5/12 V Converter packs and a circuit breaker pack are required on an OCM shelf. A fully configured REM consists of four OCMs at the host site, while the minimum configuration comprises two OCMs.

The RCM consists of four circuit packs: Carrier Interface (NT2T32), Remote Network (NT2T37), Remote Message (NT2T38), and Remote Signaling (NT2T39). In addition, one Remote Alarm pack (NT2T47) and one or two 5/12 V Converter packs and a circuit breaker pack are required on an RCM shelf. A fully configured REM consists of four RCMs at the remote site, while the minimum configuration comprises two RCMs.

The REM configuration requires that both the PE bay and power equipment at the remote site meet DMS-10 switch power specifications. Also, depending on operating company requirements, several REMs may be located at one remote site, with only one Alarm and Ringing Module required for all the REM bays at the same location.

Figure 2-20: REM system block diagram (minimum configuration)



REM architecture

The REM converts the 30 speech timeslots of the DMS-10 switch to the 24 timeslots of the carrier, with 6 timeslots in each network loop permanently busied. The remaining 24 timeslots are assigned on a one-to-one basis to the associated carrier channels. Timeslot switching does not take place in the REM.

Network signaling on the multiplex loops occurs in timeslots 0 and 16. In the REM, these network signaling messages are converted into carrier signaling messages and transmitted over the A and B bits of the carrier. The A and B bits are the least significant bits, and they occur every sixth frame in all channels. A complete 48-bit signaling message can be transmitted by the carrier during each 1.5-ms interval. This message consists of 40 message bits plus an 8-bit checksum.

When the error rate of the carrier becomes too high, error correction is required for the signaling messages. Detection of a received faulty checksum requires the retransmittal of the last carrier messages until they are received correctly.

Message handling

Outgoing messages from the multiplex loop usually occur less frequently than once every 1.5 ms. However, messages can occur in bursts; therefore, the OCM contains a buffer that can store up to 64 signaling messages before they are transmitted on the carrier. If the buffer overflows, a maintenance message is generated.

Incoming messages from the remote end are retrieved by a scan circuit at the RCM. If the carrier line associated with incoming messages is busy, the remote scanning stops until the line becomes free again; thus, for incoming messages, little buffering is needed.

The OCM also contains a circuit that detects a change in terminal address on any of the timeslots from the multiplex loop. If such a change occurs and signaling messages are not waiting in the buffer, an update message is transmitted to the remote connection memory. This memory generates the terminal addresses in each timeslot for the remote peripheral circuits. Remote connection memory update messages are only transmitted when signaling messages are not waiting in the message buffer. Thus, excessive delays for signaling messages are avoided.

Dual Peripheral Control pack

Each REM uses two carrier lines that, after conversion to 2.048 MHz, are connected to the same Peripheral Control pack. Since there are jitter and delay differences between the two carrier lines, the Peripheral Control pack must handle two nonsynchronized loops. For this reason, only the Dual Peripheral shelf can be used with the REM.

Subscriber carrier module

The Subscriber Carrier Module (SCM) reduces the hardware requirements when a DMS-10 system is connected to a DMS-1 system.

SCM configuration

The SCM consists of an SCM shelf mounted in a DMS-10 Peripheral Equipment bay and is connected by two DS-1 type transmission lines to the Remote Concentrator Terminals (RCTs) of a DMS-1. Refer to Figure 2-21. One SCM interfaces with up to four RCT in series. The SCM interfaces with the DMS-10 network equipment by means of two multiplex loops. One loop goes from each Time Switch pack of the SCM to the corresponding MLI pack (NT4T05 or NT8T04) on the two shelves of a network module. A maximum of 16 SCMs may be equipped in a single DMS-10 switch.

The SCM shelf contains up to 15 circuit packs: one Circuit Breaker (NT2T26), two 5/12 V Converters (NT3T19), two Time Switches (NT2T50), two System Processors (NT2T51), two B-Word Processors (NT2T52), two A-Bit Processors (NT2T53), two Digroups (NT2T54), and if equipped with the protection switching option, one 1-For-N Protection Switch (NT2T55) and one Protection Switch Failsafe (NT2T56). Each pack location must contain the correct type of circuit pack. Circuit pack locations are not flexible in the SCM. Refer to Figure 2-22 for a block diagram of the SCM.

Remote concentrator terminal

The RCT acts as a remote switch to concentrate up to 251 subscriber lines onto 48 digital transmission channels. These transmission channels are carried to the SCM over two working DS-1 transmission lines of 24 channels each. For a complete description of the RCT, refer to the NTP entitled, *Remote Concentrator Terminal* (363-2011-102).

Reliability

To enhance reliability, most transmission and call processing blocks in the SCM are duplicated. Normal call processing and transmission can continue if one block in a pair experiences a failure. If one Time Switch should fail, the other can handle calls from any RCT subscriber loop with total call handling capacity reduced by 37.5%. Should one digroup pack fail, the other can handle traffic for any subscriber on any of the four RCT with a total traffic capacity reduction of up to 50%, since only half as many channels are available.

Connectors

Connectors on the SCM include an Option Connector, DS-1 Line Connector, Ringing Connector, Multiplex Loop Connector, Power Connector, and Ground Terminal. These are located on a panel recessed at the right-hand side of the shelf.

Figure 2-21: SCM serving distributed RCTs

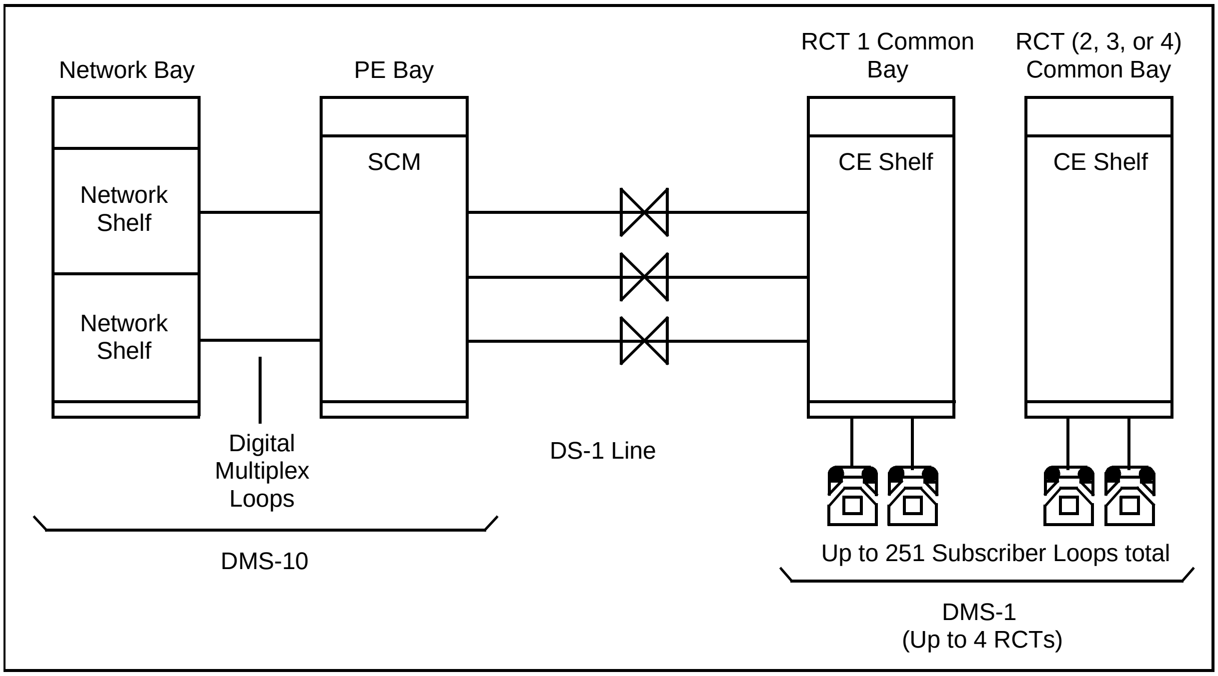
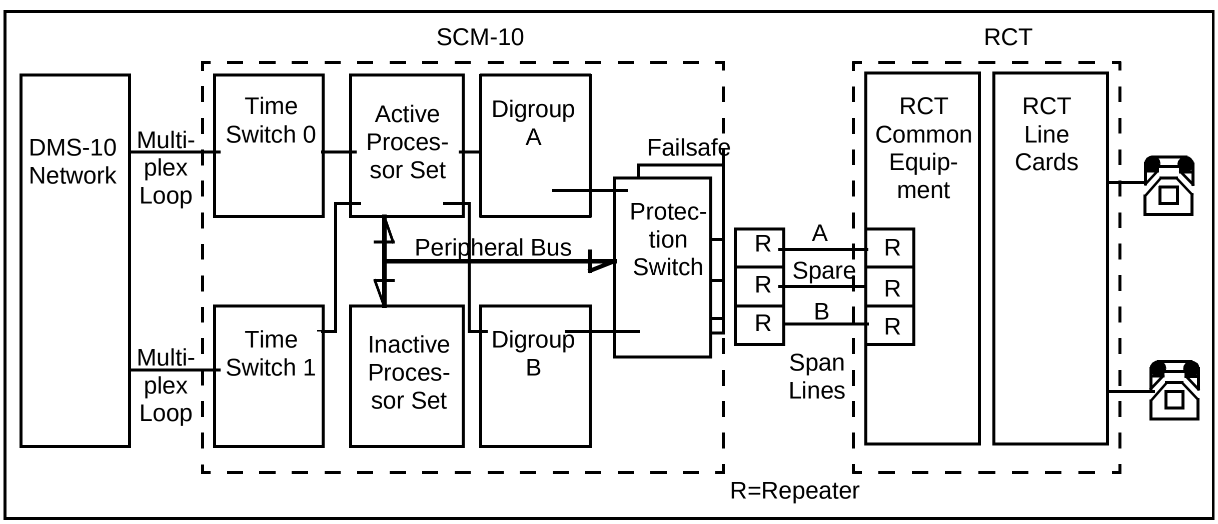


Figure 2-22: SCM block diagram



Protection switching option

The optional 1-for-N Protection Switch enables either digroup pack to switch away from its normal transmission line and onto the spare, that is, protection, line. This switching is done automatically when a fault on an active line is detected, or manually by a command from the TTY using the SCM overlay. Several SCMs and their associated RCTs can share a protection line as long as the SCMs are colocated at the base, and the RCTs are colocated at the remote site.

Line Concentrating Equipment

Line Concentrating Equipment (LCE) provides the circuitry to interface the digital signals of the 2.56 Mb/s of the multiplex DS-30A loops to the transmission/signaling facilities of LCE subscriber lines. The LCE configuration and architecture are discussed below. For detailed information on LCE hardware, refer to the NTPs entitled *Equipment Identification* (297-3601-150) and *Circuit Interfaces for Lines, Trunks, and Test Trunks* (297-3601-184).

LCE configuration

An LCE bay consists of up to two Line Concentrating Modules (LCMs; NT6X04) and, at the top of the bay, two Ringing Generators (NT6X30), one for each LCM. Each LCM is composed of two Line Concentrating Array (LCA) shelves (NT6X0401). Each LCA shelf contains a Power Converter (NT6X53), an LCM Processor (NT6X51), a Digroup Control (NT6X52), and up to five pullout Line Drawers (NT6X05). Each Line Drawer contains a Bus Interface Circuit (BIC) card (NT6X54) and up to 64 line cards: standard type A (NT6X17AA/AC), world line card type A (NT6X17BA), standard type B (NT6X18AA), world line card type B (NT6X18BA), and Type B +48 V Coin (NT6X18AB), P-phone line card (NT6X21), Data line card (NT6X71), as well as the optional +48 V Power Converter (NT6X23).

An LCE that supports ISDN also contains one pullout ISDN line drawer (NT6X05DA) per shelf. Each drawer contains up to 28 BRI ISDN line cards (NTBX27), one ISDN Drawer Controller (IDC), one Point-of-use Power Supply (PUPS).

An LCE that supports the 1-Meg Modem Service feature contains standard POTS line drawers (NT6X05), each of which, in turn, houses a Data-enhanced BIC card (NTEX54) and up to 16 Data-enhanced Digital Subscriber Line (xDSL) cards (NTEX17) or a combination of xDSL and regular line cards.

Ringing Generator pack

The Ringing Generator pack contains circuitry that generates ringing, automatic number identification (ANI), and coin-control voltages for one LCA shelf in each of two LCMs. Should one of the Ringing Generator packs fail, its associated LCM Processor and Digroup Control packs are taken indirectly out of service, and the processor and control packs on the mate shelves service all lines in the LCE frame. The remaining Ringing Generator then provides ringing for all lines in the frame.

The cadence of ringing, ringing frequency and amplitude, and dc offsets of ringing voltages can be preset to meet Bell Canada, Bell USA, and Rural Electrification Administration (REA) requirements. For settings, see the NTP entitled *DIP Switch Settings for Printed Circuit Packs* (297-3601-316).

Power Converter pack

The Power Converter pack contains the dc-to-dc conversion circuitry for converting the -48 V dc office battery supply to regulated dc outputs at +5 V and +15 V for the LCM Processor, Digroup Control, BIC, and line circuit cards residing in the LCA shelf in which it is located. The Power Converter pack also performs switching of ringing and ANI/coin-control voltages for the line circuit cards in its LCA shelf.

LCM Processor pack

The LCM Processor pack provides an interface between the LCE and the DMS-10 network by performing scanning, ringing control, DMS-X message handling, and low-level processing and control functions for the Digroup Control pack.

Digroup Control pack

The Digroup Control pack acts as an interface between the incoming DS-30A links from the DMS-10 network and the LCM line drawers. Under control of the LCM Processor pack, it provides time-switch capability for connecting line cards in an LCA shelf with channels on DS-30A links associated with the LCA shelf.

Bus Interface Circuit card

The BIC card provides an interface between two 32-channel digroups and the 64 line circuit cards in an LCM line drawer. Functionally, the BIC card is divided into two similar parts, called scan chips.

Line circuit cards

Line circuit cards contain the circuitry to interface the digital signals of the DS-30A loop with the signaling transmission of subscriber lines. For detailed information about line circuit cards, see the NTP entitled *Circuit Interfaces for Lines, Trunks, and Test Trunks* (297-3601-184).

ISDN line circuit cards

ISDN line circuit cards provide an interface to the two-wire ISDN U-loop.

ISDN drawer controller

The IDC card is responsible for maintaining each ISDN loop in the drawer, and also communicating with each terminal on the loops. The IDC controls line card and loop maintenance, and all layer 1 and layer 2 functions. Functionally, the IDC card performs a similar purpose as the BIC card, but for ISDN line cards only.

LCE architecture

The scanning and signal distribution performed by the LCE and the DMS-10 network allow communication between the LCE and the CPU. LCE signaling uses a proprietary, message-based protocol called DMS-X. DMS-X signaling is performed in timeslot 1 of the 2.56 Mb/s PCM bit stream and is a compelled protocol in which each device continually sends its state. Figure 2-23 illustrates the LCE architecture.

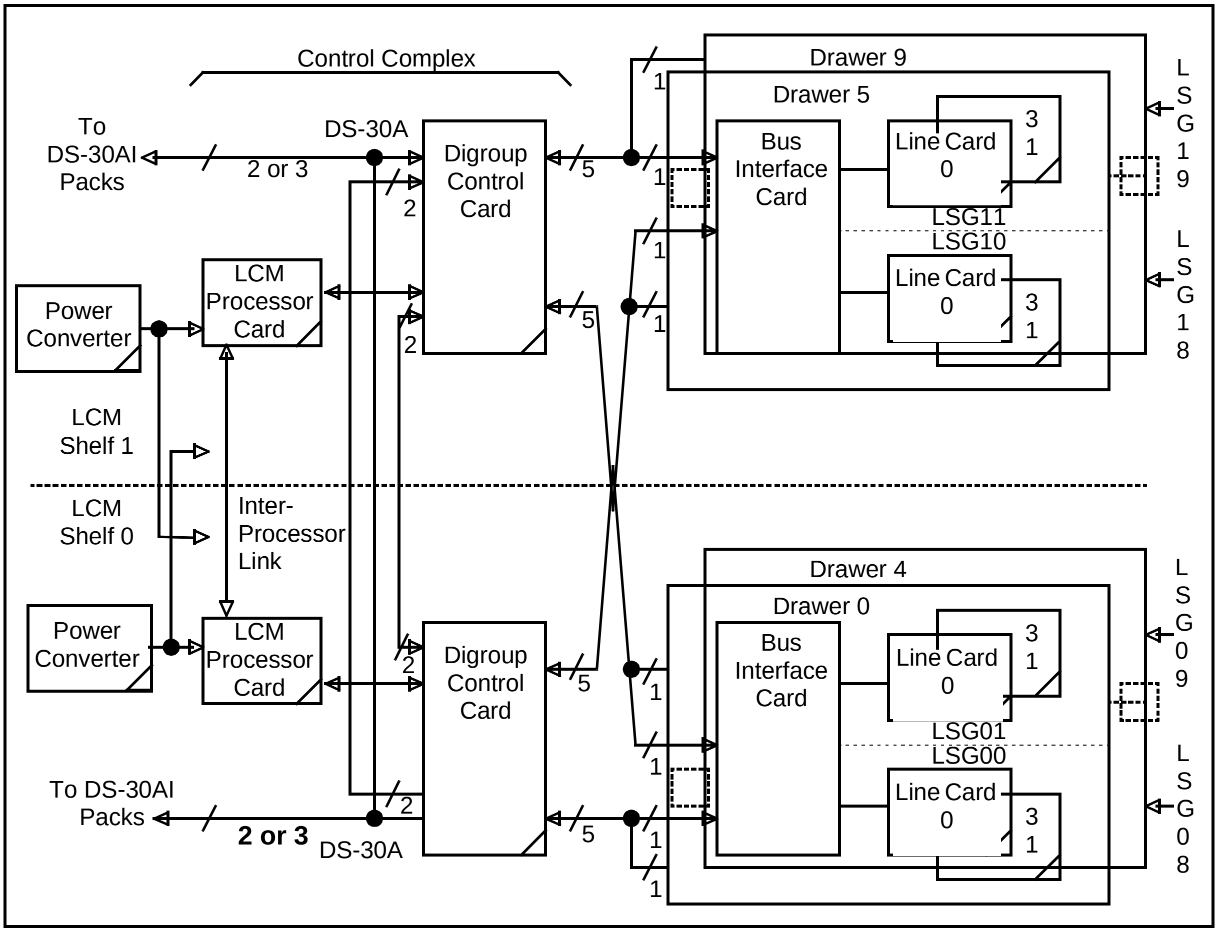
Each LCM is provided with a minimum of four DS-30A multiplex loops. Up to six loops can be provided for each LCM. Signaling is accomplished over the first channel of the first DS-30A loop on each LCA shelf using DMS-X protocol.

The initial level of scanning takes place in the BIC card located in each LCM drawer. The BIC card consists of two identical units, each of which contains a scan chip that performs scanning on one of the two line subgroups (32 cards) in the LCM drawer. When a scan chip detects a change of state in one of the line cards in its subgroup, it generates a message that is passed, through an output buffer and over a serial data link, to the LCM Processor pack on its LCA shelf.

The main functions of the scan chip are: to multiplex/demultiplex a 32-channel, 2.56 Mb/s PCM link onto 32 line circuit card buses, to receive control messages (and responses) to line circuit cards and store such messages until they can be output in channels 0 or 16, and to scan the 32 line circuit cards in its subgroup for changes in state (a message is stored whenever a change-of-state is detected).

The LCM Processor processes BIC messages and will do low-level processing, such as digit collection and timing on- and off-hooks. It then forms this message into DMS-X format in order to signal the DMS-10 CPU. The Digroup Control pack, in turn, passes the necessary DMS-X signaling over the DS-30A loop to the DS-30A Interface pack (NT4T04 or NT8T04) resident on the Network or CNI shelf associated with the loop. The DS-30A Interface pack passes data to the CPU over the I/O bus. The data is then placed in an input message buffer in Call Store.

Figure 2-23: Functional block diagram of LCM



LCM redundancy

LCMs operate in a dual shelf mode. The duplicated processors on each shelf control one-half (320) of the subscriber line cards within an LCM. In the event of a failure in one of the processors, a switchover occurs and the mate processor takes over control of the complete LCM. This switchover occurs without interruption to existing calls in the talking or ringing state.

The same switchover capability applies to the LCM power converters. If one power converter fails, the remaining power converter can perform the following tasks:

- supply power to all 20 LSGs
- distribute ringing, automatic number identification (ANI), and coin control voltages to all 20 LSGs. One of the two ringing generators located in the host interface equipment supplies the coin control voltage.

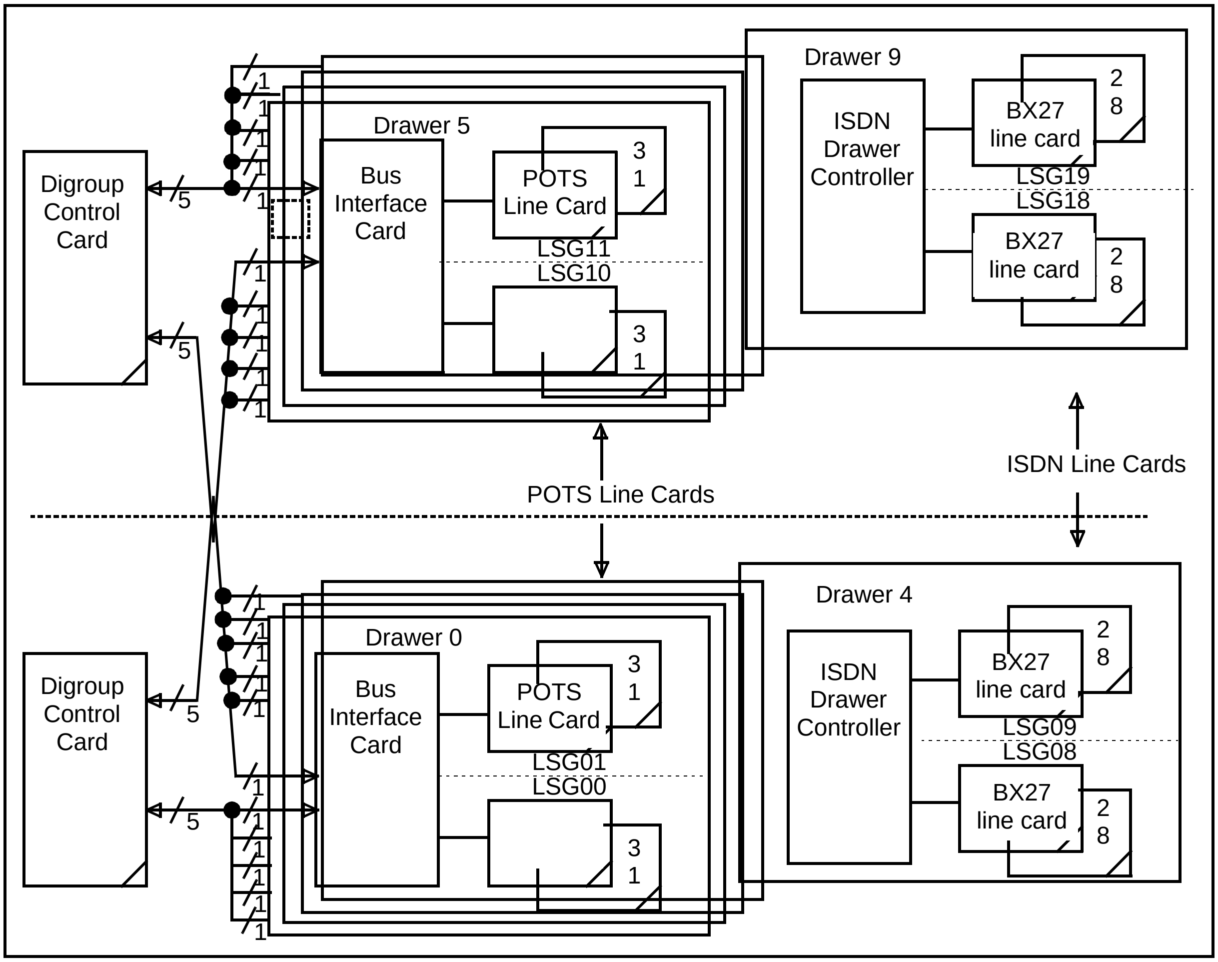
ISDN configuration

An LCE ISDN configuration requires an ISDN line drawer (NT6X05DA), up to 28 BRI ISDN line cards (NTBX27), an ISDN Drawer Controller (NT6X54DA), and a Point of Use Power Supply (NTBX71AA). The ISDN Drawer Controller (IDC), like a BIC card, provides an interface between the BRI ISDN line cards and the DMS-10 system. In an LCM, the ISDN line drawer occupies drawer position 4 in LCA0 (shelf 1) and drawer position 9 in LCA1 (shelf 2). The remaining eight LCM line drawers support standard POTS lines.

Each LCM Digroup Card Controller (DCC); two per LCM; concentrates 10 digroups from up to 10 line drawers onto two DS-30A loops. One of these loops is primary, meaning that it carries signaling and PCM channels; the other is secondary, meaning that it only carries PCM channels. One additional primary loop DMS-X channel is allocated for each ISDN drawer. A semipermanent packet mode data Bd-channel may be allocated, when D-packet data service is provisioned, on either the primary or secondary loop. The DS-30A terminates the DMS-X channel from the IDC, and converts between DMS-X signaling and I/O bus signaling to transfer Q.931 messages between the CPU and each ISDN terminal. A Digital Signal Interface (DSI) may be optionally deployed in DMS-10 ISDN offices if the service bearer capability for circuit mode data or packet mode data call types demand 64 kbps clear channel signaling.

The IDC performs multiple tasks. Like the BIC card, in an LCE POTS configuration, the IDC card provides the initial level of scanning for an ISDN drawer. In addition, the IDC also provides IBERT generation and detection, data control for B- and D-channels, and for D-channel packet handling, and LAPD and DMS-X processing. The IDC card uses two dedicated DMS-X channels which are independent of the DMS-X channels connecting the LCM processor and the DS30A. Figure 2-24 illustrates the LCE architecture, with the addition of the maximum two ISDN drawers per LCM.

Figure 2-24: Functional block diagram of LCM with ISDN



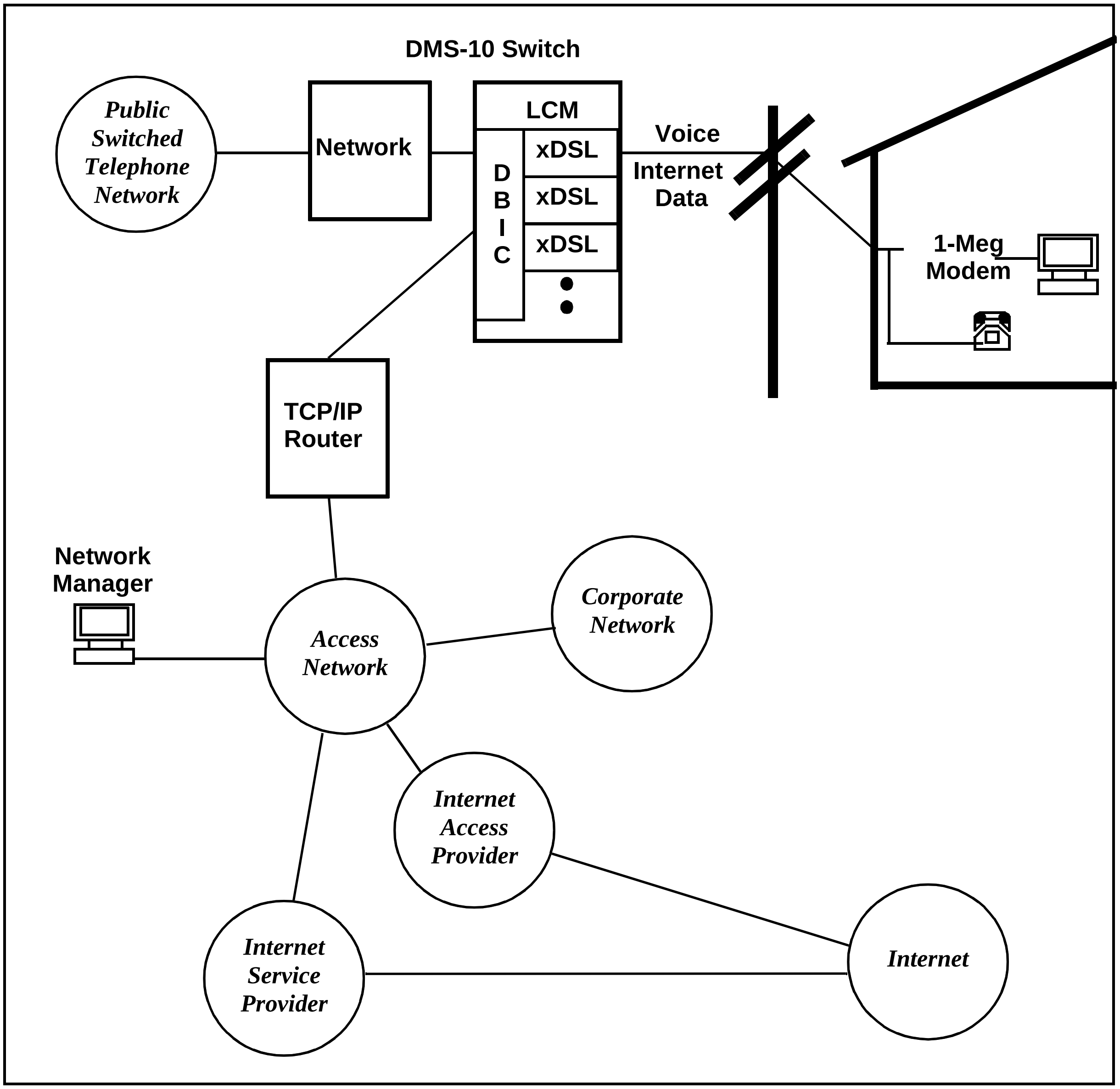
1-Meg Modem Service

The 1-Meg Modem Service feature provides broadband Internet access for the home or small office subscriber, using ADSL (asymmetric digital subscriber line) technology. This access is provided over existing twisted-pair telephone wires. Full POTS functions are maintained.

1-Meg Modem Service feature components

The 1-Meg Modem Service feature requires three basic components: the 1-Meg modem; the xDSL line card; and the DBIC. These components, in turn, connect to the access network, a LAN (local area network) or WAN (wide area network) that connects to the Internet or to a corporate LAN. Figure 2-25 provides an overview of the basic 1-Meg Modem Service feature component configuration.

Figure 2-25: 1-Meg Modem Service feature component configuration



1-Meg modem The 1-Meg modem is located at the customer's premises and connects to the customer's telephone line, extension telephone, and personal computer. This modem provides 10Base-T/100Base-T interface rather than a serial RS232 interface. To the subscriber, this modem appears to operate as a regular voice-band modem.

xDSL The NTEX17 Data-enhanced Digital Subscriber Line card (xDSL) is installed at the central office, or at selected DMS-10 remotes (the operating company should consult their customer service representative for information), in an LCM that terminates the customer's telephone line. This line card provides high-speed data communication with the customer's 1-Meg modem, while also providing full POTS service. The xDSL card is functionally-equivalent to an NT6X17BA line card.

DBIC The NTEX54 Data-enhanced Bus Interface Circuit card (DBIC) provides the concentrating function for the voice and data connections within an LCM. This card also separates voice and data traffic for routing within a packet-switched network (for data) or circuit-switched network (for voice).

Network Manager Nortel's 1-Meg Modem xDSL Element Manager System (xEMS) provides single-point data network management control for all of a service provider's Nortel 1-Meg Modem Service systems, both inside and outside of a serving area. The xEMS operates on the Hewlett-Packard OpenView™ platform, providing graphics-based “point and click” operation, using context-sensitive displays, menus, and pop-up windows to speed system monitoring and trouble-shooting.

1-Meg Modem Service feature component provisioning

An LCM can accommodate 10 line drawers, each of which can be provisioned with one DBIC. A DBIC is installed only in line drawers in which xDSL line cards are provisioned. A mix of regular POTS and xDSL line cards can be provisioned in an LCM.

The Ethernet interfaces that the DBICs provide can connect with a variety of network components, depending on Access Network requirements. For example, a configuration with few xDSL cards in each LCM may not be able to fully utilize a 10Base-T interface. In that case, the 10Base-T lines can be connected to a router by way of a hub. If, instead, a 10Base-T interface is heavily utilized, an Ethernet switch can be used with a high-speed (that is, 100BaseT) connection to a router.

1-Meg Modem Service feature maintenance

Voice Network Maintenance The voice portion of the 1-Meg Modem Service feature is maintained using the existing DMS-10 operations, administration, and maintenance (OAM) system.

Data Network Maintenance Management of the data portion of the 1-Meg Modem Service feature is provided through Nortel's 1-Meg Modem xDSL Element Manager System (xEMS).

Remote Line Concentrating Module

A Remote Line Concentrating Module (RLCM) is a Line Concentrating Module (LCM) remotely located from the base DMS-10 switch. RLCMs may also be provisioned off of Remote Switching Centers (RSC-S) connected to the base DMS-10 switch. The RLCM supports both Intraswitching and ESA.

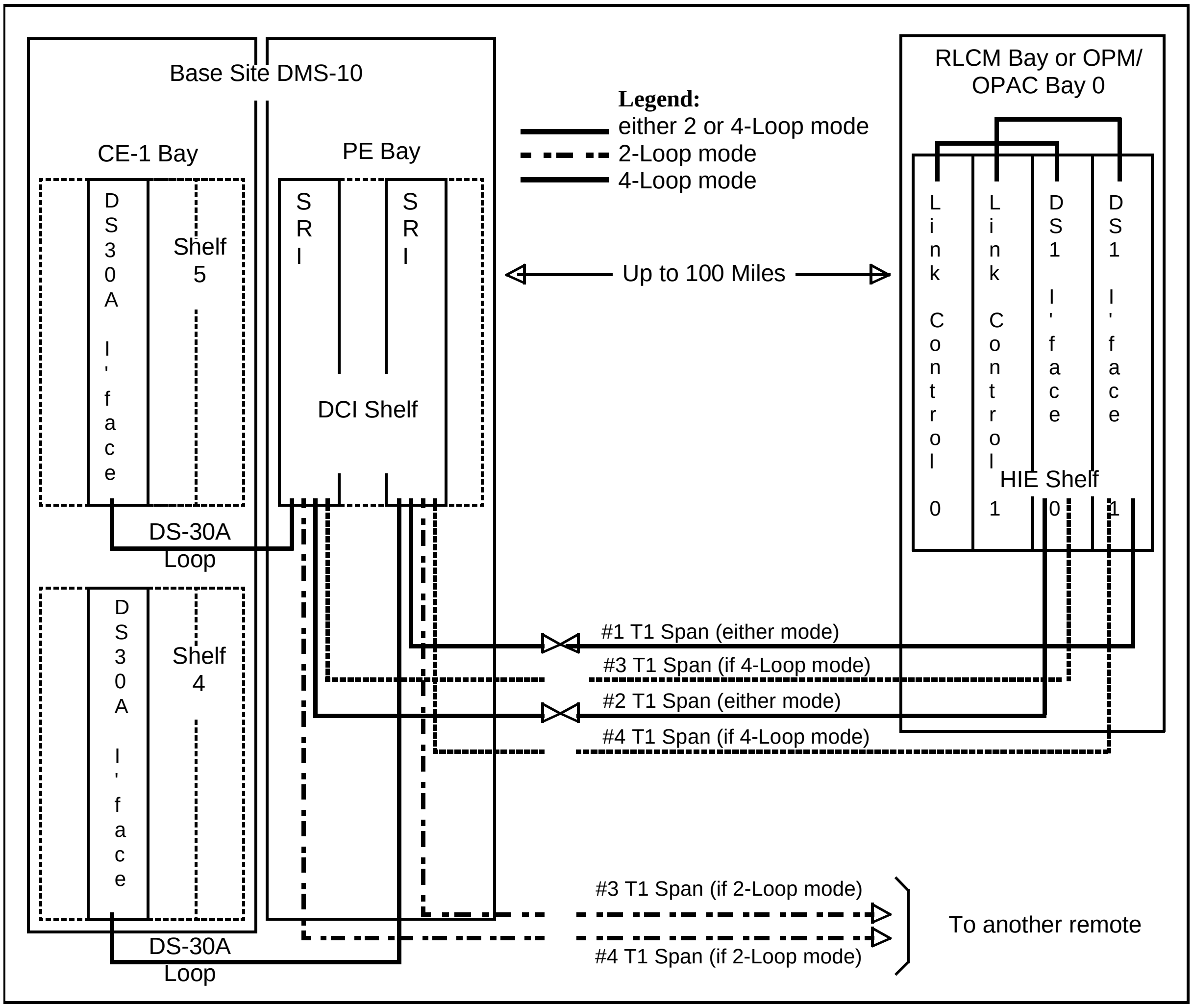
The RLCMs are housed in an RLCM bay, NT6X14, in an Outside Plant Module (an OPM cabinet, NT8X01), or in an Outside Plant Access Cabinet (OPAC, NTRX60). Each of these configurations is discussed briefly below. For detailed hardware information, refer to the NTP entitled *Equipment Identification* (297-3601-150).

A site type (declared in software) is used to identify RLCM, OPM, or OPAC equipment. One to four RLCMs housed in the same location can use the same site mnemonic if they share a single Remote Maintenance Module (RMM) shelf. However, when more than one OPM or OPAC is installed at a single location, a different site mnemonic must be used for each OPM or OPAC cabinet. For procedural details about configuring RLCMs, OPMs, or OPACs, see Overlay CNFG (SITE prompting sequence) in the NTP entitled *Data Modification Manual* (297-3601-311).

Base site/RLCM interface

The interface between the base site DMS-10 switch and the RLCM comprises either 2 or 4 DS-1 (T1) digital span lines. The span lines interface with the DMS-10 network through Subscriber Remote Interface (SRI) packs or Digital Signal Interface (DSI) module packs on the Digital Carrier Interface (DCI) shelf. The span lines interface with the RLCM through the Host Interface Equipment (HIE) shelf. The span lines interface with the network in an RSC-S connected to a DMS-10 switch through DS-1 links. Each span line carries 24 channels, but two channels of the interface are reserved for signalling between the base site and the RLCM. In the 2-loop mode, 46 channels per RLCM are available for voice. In the 4-loop mode, 94 channels per RLCM are available for voice. Figure 2-26 shows both the 2-loop and 4-loop interface modes in an RLCM configuration provisioned off of a DMS-10 switch. Figure 2-26 illustrates the interface between an RLCM and the DMS-10 switch when the RLCM is provisioned off of an RSC-S.

Figure 2-26: DMS-10 interface with an RLCM/OPM/OPAC



Six-loop RLCM

This feature allows the assignment of up to six loop interfaces to an RLCM. The six-loop interface capability requires either four DSI modules, two supporting four loops and the other two supporting one loop each, or six DSI modules, each module supporting two loops. The loop configurations can be changed for an RLCM from two loops to either four loops or six loops. Figure 2-27 illustrates a six-loop configuration with four DSI modules. Figure 2-28 shows a six-loop configuration with six DSI modules.

Figure 2-27: Six-loop interface with an RLCM using four DSI modules

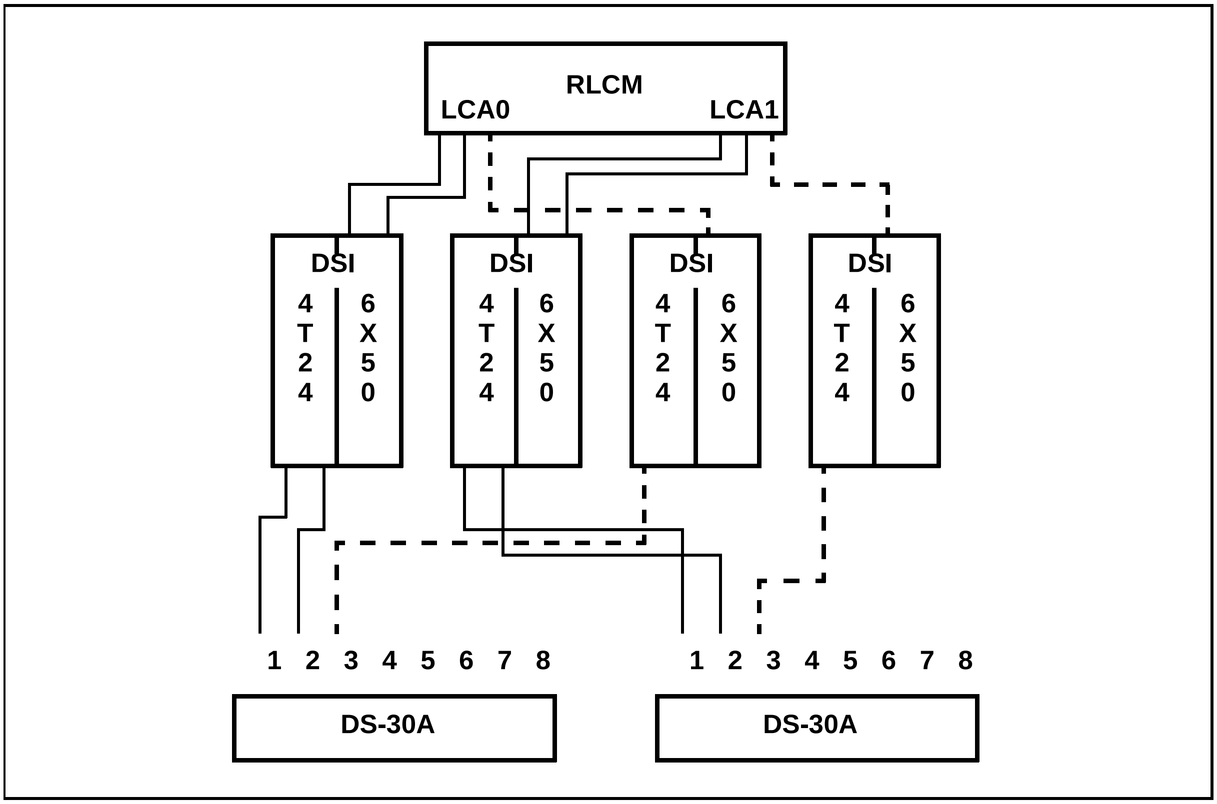
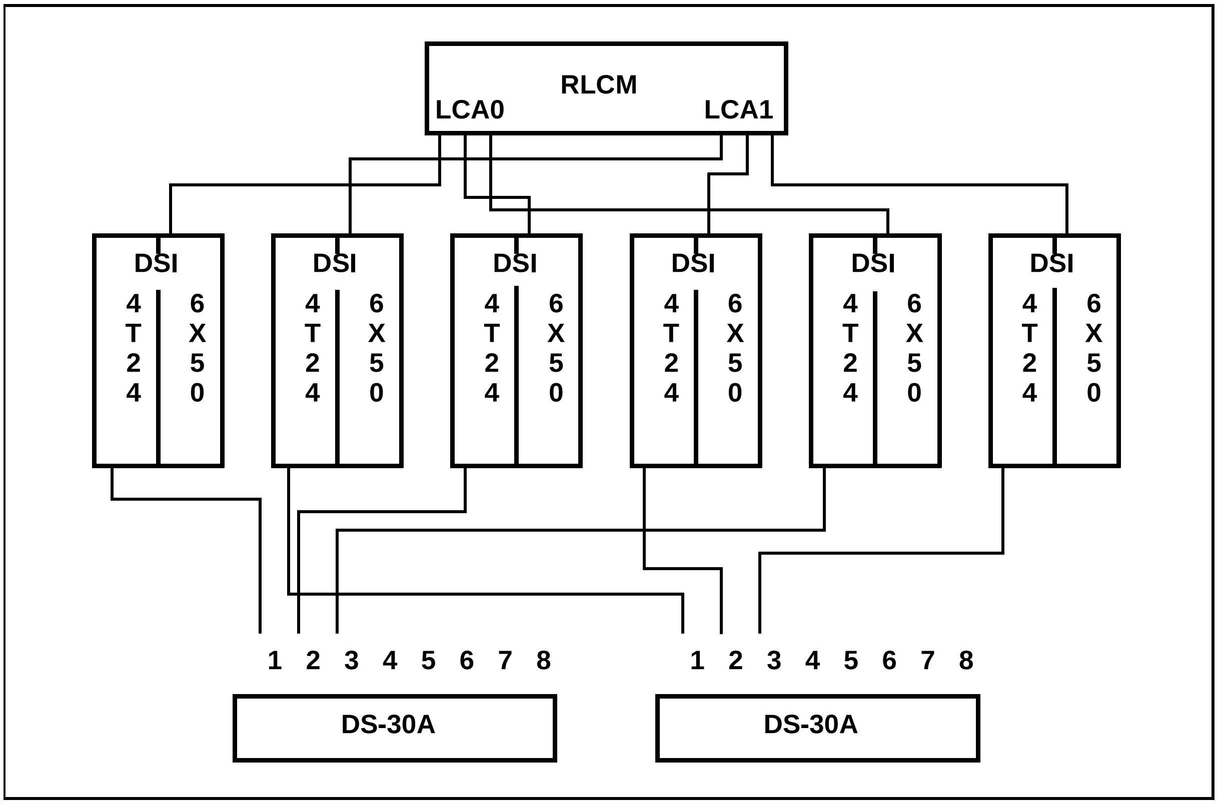


Figure 2-28: Six-loop interface with an RLCM using six DSI modules



RLCM bay configuration

An RLCM configuration consists of a Frame Supervisory Panel (NT6X25) (OPM and RLCM only), A Modular Supervisory Panel (NTRX60) (OPAC only), a Remote Maintenance Module shelf (NT6X13), a Host Interface Equipment shelf (NT6X11), and one LCM (NT6X04).

Supervisory Panels

The Frame Supervisory Panel (FSP) and Modular Supervisory Panel (MSP) house power control and alarm circuits for the RLCM, and talk battery filtering equipment.

Remote Maintenance Module shelf

The Remote Maintenance Module (RMM) can be provisioned in the RLCM bay and in the OPM/OPAC cabinet. The shelf contains the following packs: Miscellaneous Scan Detection (NT0X10), Common Feature Power Converter (NT2X06), Multi-Output Power Converter (NT2X09), LTU-Analog (NT2X10), LTU-Digital (NT2X11), Miscellaneous Signal Distribution (NT2X57), Codec and Tone (NT2X59), Incoming/Outgoing Test Trunk (NT2X90), Metallic Test Access (NT3X09AA/BA), and RMM Control (NT6X74). A Digital 4-Channel Digitone Receiver pack (NT2X48) is required for ESA operation. The RMM provides subscriber line testing capabilities. A single RMM, without the ESA feature, can serve up to four RLCMs but only one OPM or OPAC. In order to provide emergency stand-alone capability, each RLCM, OPM, or OPAC, must have its own RMM.

Host Interface Equipment shelf

The Host Interface Equipment (HIE) provides circuitry to interface the DS-1 links from the RLCM to the DMS-10 switch. This shelf contains the following packs: Power Converter (NT2X70), DS-1 Interface (NT6X50), Ringing Generator (NT6X60), and Link Control Card (NT6X73). The ESA Processor (NT6X45AF), Master Processor Memory (NT6X47AB), and ESA Clock/Tone pack (NT6X75) are required for ESA operation.

Line Concentrating Module

The Line Concentrating Module (LCM) in the RLCM is identical to the LCM in a Line Concentrating Equipment (LCE) bay.

An RLCM that supports ISDN also contains one pullout ISDN line drawer (NT6X05DA) per shelf. Each drawer contains up to 28 BRI ISDN line cards (NTBX27), one ISDN Drawer Controller (IDC), one Point-of-use Power Supply (PUPS).

Digital Carrier Interface shelf

The Digital Carrier Interface (DCI) shelf (J1T80A-1/J1T80A-2,L2) provides the interface required to convert 1.544 Mb/s signals from the DS-1 links of the RLCM to 2.56 Mb/s signals for the DS-30A loops of the DMS-10 Network. The DCI shelf contains two Power Converter packs (NT3T19), up to 10 Subscriber Remote Interface (SRI) packs (NT4T09) or up to 10 Digital Signal Interface (DSI) modules (one NT4T24 and one NT6X50 pack per module), and filler plates.

OPM cabinet configuration

When RLCMs are housed in an OPM cabinet, the RLCM can be placed in an external environment. The OPM cabinet is an all-steel container consisting of two areas: an end-access compartment and a main compartment.

End-access compartment

The end-access compartment is located on the left side of the OPM cabinet and is accessed by a single swinging door. The end-access compartment houses voice frequency equipment, special service equipment, and the MDF.

Main compartment

The main compartment houses the RLCM (the LCM, HIE shelf, and RMM shelf), Battery Control Unit (BCU), ac breakers, and two Environmental Control Units (ECU). It is accessed from the front of the OPM cabinet by a pair of swinging doors, which open 120° and may be locked in the open position. Most of the equipment in the main compartment is housed in a pair of swing-out, doubled-latched, hinged frames. These hinged frames provide access to the rear of the shelves and allow miscellaneous equipment to be located against the back wall of the cabinet.

Each ECU consists of air inlets, filters, and a fan system to maintain acceptable environmental conditions for the RLCM.

A BCU, consisting of a pair of Battery Charge Controllers, up to eight battery “strings,” and a battery backup system with rectifiers, is available. The battery strings are charged on a 24-h cycle that automatically begins at midnight. However, the automatic cycle can be scheduled to run at different hours by changing the software configuration record in Overlay CNFG, prompting sequence OVLY. For additional information, see the NTP entitled *Data Modification Manual* (297-3601-311). For information about the remote battery control diagnostic (Overlay RBCD), see the NTP entitled *Maintenance Diagnostic Input Manual* (297-3601-506). For more information about OPM battery string maintenance, see the NTP entitled *General Maintenance Information* (297-3601-500).

OPM optional equipment

Optional equipment that is available for the OPM-256 includes:

- 320-line upgrade kit (NT8X09AB) which increases the total line capacity of the OPM-256 to 576 lines
- FMT-6 fiber multiplexer: a compact stand-alone multiplexer and 6 Mb/s lightwave transmission system which transports up to four DS1 electrical signals by single mode, or multimode, fiber-optic cable (refer to the *FMT-6 User Guide* (321-3231-290) for more information)
- user-selected channel bank, to provide special-services capability, such as ISDN. The DE-4 enhanced channel bank (J7265AC-1), available from Nortel Networks, is a 48-channel digital carrier terminal used for two-way transmission of voice and data signals over T1, T1C, or T2 compatible carrier systems; this can be used with all classes of switched telephone trunks and special-service voice-frequency applications. For more information, refer to the *DE-4 Enhanced PCM Channel Bank Description* (368-5151-110)

- Model 3704 Digital Remote Test Unit (DRTU), NT0J42AA, which provides the means to make comprehensive tests of metallic loops at an OPM remote location. For more information, refer to the *Digital Remote Test Unit (DRTU) Description and Installation Guide* (662-5021-233) and *Model 3704 Digital Remote Test Unit (DRTU)/Outside Plant Module (OPM) Installation Instructions* (662-5021-235)

OPAC cabinet configuration

An RLCM can also be housed in an OPAC. The OPAC is an insulated, weatherproofed structure constructed primarily of 11-gauge cold-rolled steel. Like the OPM, the OPAC provides a controlled environment for RLCM equipment located at a remote site. The OPAC also provides additional space for transmission or operating company-provided equipment.

Electronics compartment

This compartment is the only section that is environmentally controlled and houses the RLCM (the LCM, HIE shelf, and RMM shelf), the Modular Supervisory Panel (MSP) (NTRX40), Battery Control Unit (BCU), rectifier system (consisting of two or three switch mode rectifiers), environmental controls, fuse panel, ac outlets, and ground bars.

The electronics compartment is accessible through the front and rear cabinet doors. Four 23-inch swing frames hold the equipment shelves and battery strings. Each frame pivots on hinges to swing out and away from each other to allow for cabling, shelf interconnection, and access to the backplane of the equipment shelves or to the batteries at the base of the cabinet. The frames are held in position with a locking latch located at the lower part of the frame.

ac power compartment

The bolt-on ac power compartment is located on the right side of the cabinet. This compartment is designed to distribute ac power from the attached power pedestal (NT7A68), and can be configured as a main service entrance. A cabinet ac compartment-mounted interface panel allows the modular attachment of the ac power pedestal that houses all the elements of an ac service equipment dead front switch. Included with the power pedestal are rectifier-ground fault circuit interrupt (GFCI)/ heater circuit breakers for power distribution, surge protection, and optional emergency generator connection and transfer capabilities.

Termination compartment

The termination compartment is located on the end of the cabinet opposite the ac power pedestal. It is the interface between the electronics equipment and the outside plant cables. Access to the compartment is through a full height single door.

Operating company-provided equipment compartment

The OPAC provides 26 vertical mounting spaces of 23-inch rack in the left rear frame and four vertical mounting spaces of 19-inch rack in the right front frame for operating company-provided equipment. This additional capacity combined with increased power allows flexibility to mount a variety of transmission, special circuit, and test equipment.

Environmental controls

The Heat Exchanger Roof Cooling System (NT7A69DA-FA) option provides a closed-loop cooling system wherein hot air in the electronics compartment circulates through the interior fins of the heat exchanger using forced air movement. The heat flows from the interior fins to the exterior fins, where fans move external air across fins and exhaust the heat externally. Air ventilation is provided from the electronics compartment to the outside to exhaust battery gases.

The Air Induction Roof (NT7A69AA-CA) option controls the OPAC interior temperature through the use of fans, heaters, and insulation. The roof is constructed of noncorrosive materials, and is designed to keep the cabinet free from dust, sand, water, and pests. Two air filters, made from open-cell, polyurethane foam, are located behind hinged filter covers.

Remote Subscriber Line Module

The RSLM shelf, another version of remotely-located LCM, is housed in either an RSLM bay or an Outside Plant Subscriber Module (OPSM). The RSLM supports both Intraswitching and ESA, and can be provisioned off of an RSC-S. For detailed hardware information, refer to the NTP entitled *Equipment Identification* (297-3601-150).

When more than one RSLM shelf is located at a site, the same site mnemonic can apply to all RSLM shelves at that site. Up to 32 RSLM shelves may be co-located and up to 32 sites may be defined.

Base site/RSLM interface

The interface between the base site DMS-10 switch and the RSLM consists of 2 DS-1 (T1) digital span lines. The RSLM interfaces with the DMS-10 or an RSC-S network in the same manner as the RLCM.

RSLM bay configuration

When an RSLM shelf is housed in an RSLM bay, the configuration consists of a Frame Supervisory Panel (J9Y75A-1 or J9Y76A-1) and either one RSLM Type A shelf (J9Y74A-1), which can serve up to 256 subscriber lines, or one or two RSLM Type B shelves (J9Y07A-1), each of which can serve up to 192 subscriber lines. The two RLSM Type-B shelf configuration is also known as the D-REM (Dual-REM) configuration. Depending upon the configuration, the RSLM bay may serve up to 384 subscriber lines.

An RSLM that supports ISDN also contains one pullout ISDN line drawer (NT6X05DA) per shelf. Each drawer contains up to 28 BRI ISDN line cards (NTBX27), one ISDN Drawer Controller (IDC), one Point-of-use Power Supply (PUPS).

Frame Supervisory Panel (FSP)

The Frame Supervisory Panel (FSP) houses one or two Ringing Generators (depending upon the type of shelf below it), the power control and alarm circuits for the RSLM bay, and test jacks (in J9Y75A-1 only) and talk battery filtering equipment.

Remote Subscriber Line Module (RLSM) shelf.

Both the RSLM Type A shelf and the RSLM Type B shelf house the following equipment: Line Drawers (NT6X05), LCM Power Converter pack (NT6X53), Switching Matrix pack (NT9Y12AB), Remote Maintenance pack (NT9Y13BA), and an RSLM Processor pack (NT9Y14BA), as well as an Emergency Stand-Alone pack (NT9Y15).

The RSLM Type A shelf is configured with one LCM Power Converter pack and may be provisioned with a maximum of four Line Drawers. The RSLM Type B shelf is configured with two LCM Power Converter packs and may be provisioned with a maximum of three Line Drawers.

OPSM cabinet configuration

The OPSM is a self-contained, transportable, outdoor version of an RSLM bay. The OPSM consists of an insulated steel cabinet, fully wired, and equipped with all required electronic circuits, a power system, a battery monitoring system, and an environmental control system which uses forced air circulation.

The OPSM is divided into two compartments: a battery compartment and Main Distribution Frame (MDF) area, accessible through a side door; an equipment compartment, accessible through front and rear doors. The three doors of the cabinet are equipped with locks and air-seal gaskets. Although both compartments can be heated, only the equipment area can be cooled.

Connections to an OPSM consist of 110 V ac or 220 V ac commercial supply, PCM trunk groups (T1 span lines), cables to subscribers, and an optional emergency ac generator. Depending upon the configuration, the OPSM may serve up to 256 subscriber lines.

Battery compartment

The battery compartment contains the Main Distribution frame and the battery strings. The maintenance-free batteries are Yuasa Model NP24-12 (12 batteries, 4 batteries per string).

Equipment compartment

The equipment area contains the Power and Maintenance Module (J9Y03A-1), the FSP, the RSLM shelf, and the Power and Cooling Unit (J9Y04A-1). The Power and

Maintenance Module (PMM) consists of two 12-Amp rectifier/battery chargers (Lorain Flotrol Model #A12F50), a T1 repeater (consisting of two QRY18 Office Repeater packs and one QPP519 Fault Locate/Order Wire Access pack), and a Cabinet Controller pack (NT9Y00) for temperature and battery control. The digital switching equipment in an OPSM consists of a Frame Supervisory Panel (FSP) and an RSLM shelf, Type A or Type B, all three of which are identical to those used in an RSLM bay.

Remote Subscriber Line Equipment

The Remote Subscriber Line Equipment (RSLE) bay is another version of remotely-located LCM. The RSLE supports both Intraswitching and ESA, and can be provisioned off of an RSC-S.

When more than one RSLE bay is located at a site, the same site mnemonic can apply to all RSLE bays at that site. Up to 32 RSLE bays may be co-located and up to 32 sites may be defined.

Base site/RSLE interface

The interface between the base site DMS-10 switch and the RSLE consists of 2 or 4 DS-1 (T1) digital span lines per Dshelf. The RSLE interfaces with the DMS-10 or an RSC-S network in the same manner as the RLCM.

RSLE bay configuration

The RSLE bay uses a standard DMS-10 frame and contains an FSP (J9Y76A-1), one or two RSLE Control shelves (J9Y84A-1), each of which can serve up to 128 subscriber lines, and one or two RSLE Line Drawer shelves (J9Y85A-1), each of which can serve up to 384 subscriber lines. The combination of one RSLE Control shelf and one RSLE Line Drawer shelf is called a Dshelf. Depending upon its configuration, an RSLE bay may serve up to 1024 subscribers.

Frame Supervisory Panel

The Frame Supervisory Panel (FSP) houses two Ringing Generators, the power control and alarm circuits for the RSLE bay, and talk battery filtering equipment.

RSLE Control shelf

The RSLE Control shelf houses the following equipment: Line Drawers (NT6X05), LCM Power Converter pack (NT6X53), Remote Maintenance pack (NT9Y13BA), RSLE Matrix pack (NT9Y16), RSLE Dual Host Interface (DHI) and Clock pack (NT9Y17), RSLE Tone pack (NT9Y18; one for each RSLE Control shelf), ESA pack (NT9Y19; one for each RSLE bay), RSLE Dual Host Interface pack (NT9Y20), and an RSLE Processor pack (NT9Y22).

RSLE Line Drawer shelf

The RSLE Line Drawer shelf houses up to six Line Drawers (NT6X05). Standard LCE line cards are used in the Line Drawers in both the RSLE Control shelf and in the RSLE Line Drawer shelf.

An RSLE that supports ISDN also contains one pullout ISDN line drawer (NT6X05DA) per shelf. Each drawer contains up to 28 BRI ISDN line cards (NTBX27), one ISDN Drawer Controller (IDC), one Point-of-use Power Supply (PUPS).

RLCM/RSLM/RSLE automatic span restoral

The Subscriber Remote Interface (SRI) pack (NT4T09) is the interface between the DMS-10 switch, or RSC-S, and the DS-1 span lines to the DMS-10 switching remotes. Under the control of the automatic span restoral software, the SRI pack monitors the span lines and the remote for fault conditions, including bipolar violations, frame slips and losses, transient synchronization faults, and remote alarms. Fault conditions are reported by way of the SRI pack to designated maintenance terminals.

The maintenance thresholds and out-of-service limits for DS-1 link faults are set through data modification orders (DMO). When a maintenance threshold is reached, a minor alarm is raised. When an out-of-service threshold is reached, the affected DS-1 link is taken out of service and an alarm is raised. If the last signaling link to the remote is lost, a major alarm is raised.

If the link fault was caused by a remote alarm or by transient synchronization errors, the system attempts to return the link to service immediately after the link fault clears. If the link reports excessive failure messages while the system is trying to return it to service, it is left out of service. The system then waits a minimum of five minutes before the automatic restoral software attempts to return the link to service again. This attempt may occur any number of times per day.

If the link fault was caused by bipolar violations, frame slips, or frame losses, the link is monitored during five-minute intervals. If the link fault clears during a monitored interval, the link will be automatically returned to service. The link can be automatically returned to service up to three times each day. If the link goes out-of-service a fourth time in one day, a major alarm is set and no more attempts will be made until the next 0000 hours.

> ***Note:*** *If a signaling link is returned to service automatically, its status will be INS ACTIVE. However, the status of the LCMC that it controls will be INDR INS. The INDR INS status may remain for up to two minutes after the link has been returned to service while the LCMC is being returned to service.*

RLCM/RSLM/RSLE intraswitching

Intraswitching provides more efficient use of both host and remote resources. With this feature, two remote subscribers served by the same controller are connected in an *intra call* and two remote subscribers served by different controllers, in the same remote, are connected in an *inter call*. After either type of connection is established, the DS-1 channels and the DMS-10 or RSC-S network connections are dropped, thus freeing them for switching external calls. If a special tone or hookflash signal is required for an intra-switched call, or if one of the calling parties with Custom Calling Services signals for activation of that feature, connection with the DMS-10 or RSC-S network is resumed and the intra-switched connection is taken down. Once call control is transferred back to the DMS-10 switch or to the RSC-S, the call connection remains in the base switch network. When either calling party subsequently goes on hook, the channels are released and the connection is dropped.

The following are Intraswitching capacities of the DMS-10 switching remotes:

- An RLCM equipped with two DS-1 span lines can accommodate 42 *intra* calls and 39 *inter* calls at one time; an RLCM equipped with four DS-1 span lines can accommodate 30 *intra* calls and 27 *inter* calls at any one time.
- A type A RSLM shelf can handle up to 120 *intra* calls and a type B RSLM shelf can handle up to 90 *intra* calls. An RSLM shelf, type A or type B, can handle up to 30 *inter* calls.
- One RSLE shelf can handle up to 240 *intra* calls or up to 30 *inter* calls. Any combination of *intra* and *inter* calls reduces these maximum capacities. However, an RSLE bay equipped with two RSLE shelves can accommodate a maximum of 180 *inter* calls.

The following restrictions and interactions pertain to the Intraswitching feature in any remote:

- Remote coin lines that initiate calls are always connection through the DMS-10 switch or RSC-S; remote calls to a coin line and remote IBS/EBS subscriber's calls may be either *intra* or *inter* calls.
- When a remote's processor is in the sparing mode, *inter* calls are not possible, but calls that would otherwise be *inter* calls are treated as *intra* calls by the active processor. If the DS-10 span lines are still enabled, the active Digroup Control pack can still use them to provide connections with the DMS-10 switch or RSC-S.

RLCM/RSLM/RSLE Emergency Stand-Alone (ESA) operation

ESA allows intra-switched (line-to-line) POTS calling between subscribers served by the same remote when the remote can no longer communicate with the DMS-10 switch or RSC-S. If the remote's subscribers try to call the operator or other subscribers not connected to the remote when the remote is in ESA mode, the calls are routed to reorder tone. Calls placed to the remote's subscribers from outside the remote are also routed to reorder or busy tones.

Although no subscriber line features or recorded announcements are available when ESA mode is in effect, dial tone, ringback, busy, quiet, and overflow (reorder) tones are provided. In addition, coded frequency, and superimposed ringing are supported, along with ground start and loop start lines. All standard line types (single--arty, two-party, four-party, eight-party, and ten-party) are also supported. However, when ESA mode is in effect, only one HNPA is active for each remote, only a three-to-seven digit dialing plan is supported, and no Custom Calling features, ISDN service, hookflash signaling, conference circuits, or billing are supported. IBS and EBS lines are treated as POTS lines.

The following restrictions and interactions pertain to the ESA feature in any remote:

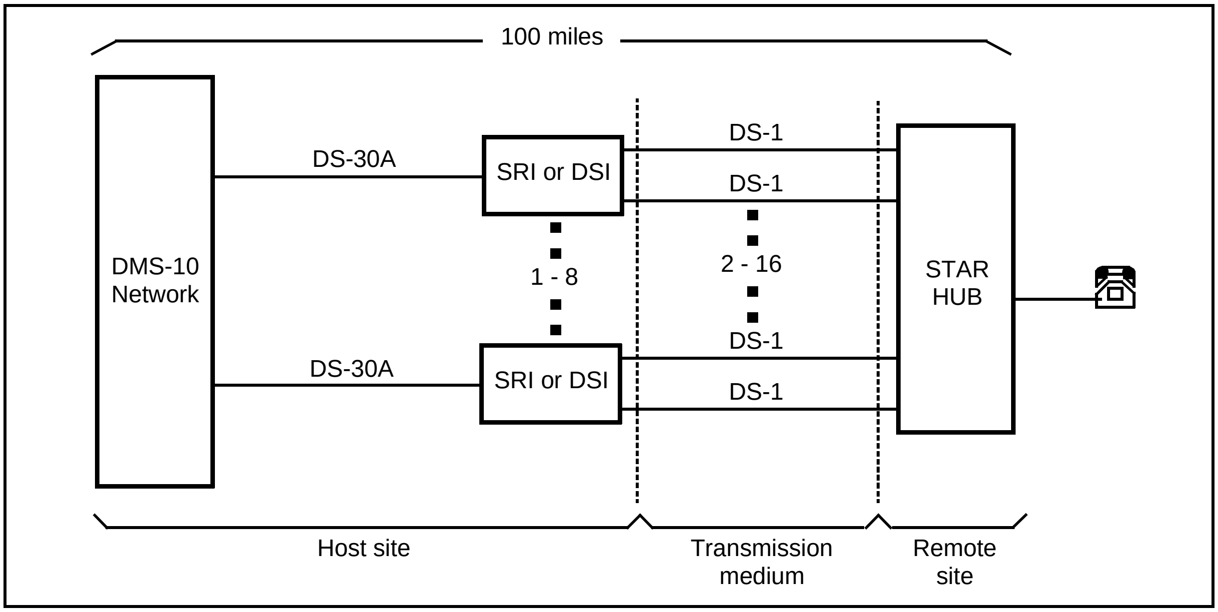
- Only one DN can be assigned the E911 option at a site, suing Overlay DN, for ESA operation. If the DN must be removed, it can be removed only using Overlay DN.
- Remote coin lines operate differently when ESA mode is in effect. For semi-postpay coin lines, the coin is not returned if it is deposited, but the coin is not required for the connection to be mode. For coin, dial tone first and coin, coin first lines, the coin is always returned when the remote is in the ESA mode, but the coin is required for the connection to be made.
- When the remote is in ESA mode, an E911 single-station option provides access to a preselected number for 911 calls. In addition, up to five directory numbers, each seven digits in length, may also be preselected to terminate on the single station assigned the E911 option, or on any other station in the remote. If no numbers have been preselected, the 911 call is automatically routed to the first configurable line card slot in the remote; if a card is not configured in the slot, or if a DN is not assigned to the slot, the subscriber receives fast busy tone (120 IPM).
- ESA translation data must be downloaded from the DMS-10 switch or the RSC-S to the ESA processor when the data has changed at the base site switch. The remote cannot enter the ESA mode until the processor is loaded with translation data.Star Remote system

The Star Remote system provides a remote line concentrating system that supports up to 1152 lines, using standard DMS line cards. The Star Remote system comprises two products - the Star Module and the Star Hub. The Star Hub is available with the DMS-10 switch.

Star Hub

The Star Hub is a remote line concentrating device housed in a Standard DMS-100 Indoor Frame. The line drawers supported include both the standard DMS-10 line drawer, containing up to 64 POTS lines, and the ISDN line drawer, containing up to 28 ISDN BRI lines. As shown in Figure 2-29, the Star Hub can be located up to 100 miles from the host DMS-10 switch and is connected to the DMS-10 switch through a maximum of 16 DS-1 links.

Figure 2-29: Star Hub configuration



In the open standard bay configuration, the Star Hub equipment includes a control shelf, which houses all of the control, power, ringer, and distribution circuitry, and up to three line drawer shelves. The packs located on the Star Hub Control shelf (NTTR8603) include two Remote Controller packs (NTTR77), four LCM Power Converter packs (NT6X53), two Ringing Generator packs (NTTR60), up to six Quad Carrier packs (NTTR87), and two Universal Maintenance packs (NTTR73). The Star Hub Line Drawer shelves (upper, NTTR5020 and lower, NTTR5010) can be provisioned with up to six line drawers. The line cards supported by the Star Hub are listed in Table 2-A. For a more detailed description of this hardware, see NTP 297-3601-150, *Equipment Identification*.

Table 2-A:
Line cards supported by the Star Hub

PEC	Name
NT6X17	Type A Line Card and World Line Card type A
NT6X18	Type B Line Card and World Line Card type B
NT6X21	P-Phone Line Card
NT6X23	+48 V Power Converter Card
NTBX27	2B1Q U-Interface ISDN line card
NT6X71	Data Line Card

Recovery management

Recovery management for the Star Hub is the same as for other DMS-10 products. Since the Star Hub can be located at a remote switch or outside plant where access may be difficult, it supports automatic recovery on low battery (ARLB). Thus, if the Star Hub stops functioning due to an unacceptable voltage supply, it automatically recovers when power returns to an acceptable level.

The Remote Controller pack (NTTR77) and the Universal Maintenance pack (NTTR73) contain 8Mb of FLASH memory. If either of these packs is pulled out from the Star Hub Control shelf, or if the Star Hub is powered down, the packs retain their firmware load and recover automatically when the Star Hub or the packs are returned to service.

ESA for Non-ISDN lInes

Cold ESA entry/exit is supported by the Star Hub. When the Star Hub is in ESA, POTS line calls and PDN calls on MBS lines are supported; ISDN line originations are ignored because ISDN call processing software resides in the host peripheral. The following types of calls are not supported during ESA:

- MADN secondary party calls
- calls made through MBS (P-phone) keys other than the primary DN (key number 1)
- calls made through activation or deactivation of custom calling features
- data line origination and termination calls

Call progress tones supported for other DMS-10 remotes during ESA are supported by the Star Hub. Up to sixteen tones are controlled through the Universal Maintenance pack (NTTR73).

The Star Hub enters ESA when either of the following two conditions exist:

- DS-1 alarms are detected on both C-side message links
- communication with the host peripheral is lost

The Star Hub exits from ESA when both of these conditions no longer exist. Before the Star Hub exits ESA, however, a maximum 30-minute time delay, defined by the telco (in Overlay NET (HUB) prompting sequence in NTP 297-3601-311, *Data Modification Manual*), ensures that DS-1 alarms no longer exist and communication with the host has been completely restored.

Star Hub maintenance

Manual maintenance of the circuit packs provisioned on the Star Hub Control shelf is performed through Overlays DED and NED (see NTP 297-3601-506, *Maintenance Diagnostic Input Manual*).

Line testing for the Star Hub is performed through the Universal Maintenance Pack (NTTR73) and Overlays PED, TLT, and LIT (see NTP 297-3601-506, *Maintenance Diagnostic Input Manual*). The Star Hub supports two forms of line testing: internal testing (line card/loop) and external testing (ITTK). The NTTR73 supplies three wire connection (tip, ring, sleeve) to an external tester and the host maintains the ITTK processing. For additional information, refer to the NTP 297-3601-500, *General Maintenance Information*.

Star Hub synchronization

The Star Hub receives its synchronization clock from the host peripheral through C-side links 0 and 2. The Remote Controller Pack (NTTR77) clock is a Stratum 3 clock and has a holdover of 1 ppm over all temperature ranges.

DMSAccess

The DMSAccess feature enables remote equipment using DMSX protocol to interface the DMS-10 switch by emulating a Remote Line Concentrating Module (RLCM). Emulating an RLCM, or acting as a “virtual RLCM,” enables call processing and administrative maintenance of the remote equipment to be performed by way of the DMS-10 switch.

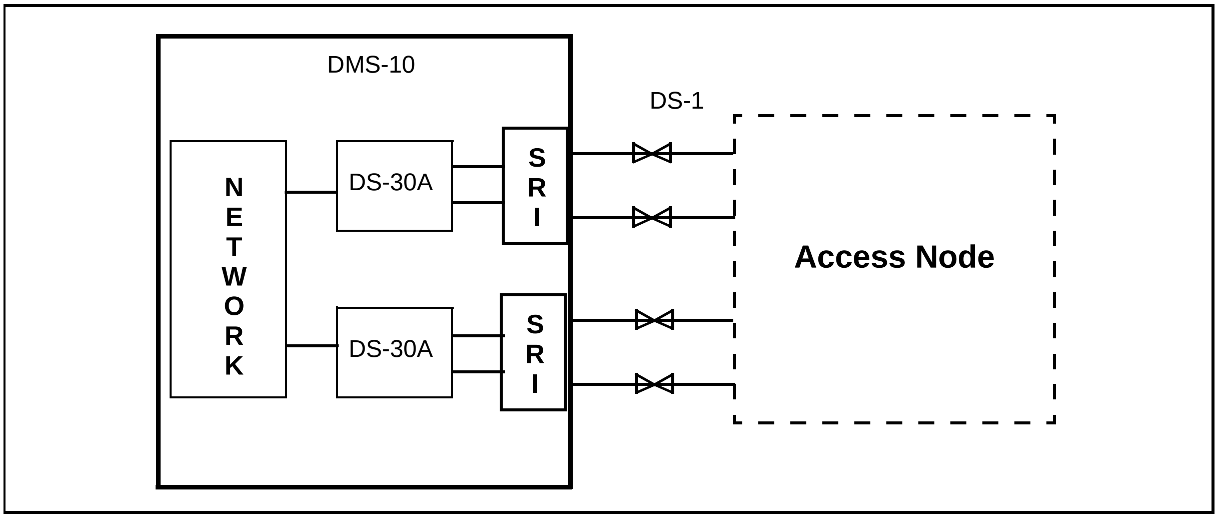
The following paragraphs comprise a high-level description of only the DMSAccess feature. For specific information about the AccessNode or AccessNode Express products, refer to NTP 323-3001-030, *About the AccessNode Library*.

> ***Note:*** *The DMSAccess feature is supported only for generics 411.10 through 502. The DMSAccess feature is not supported for 502.10 and later generics.*

DMS-10 Interface to the AccessNode via DMSAccess

Only the AccessNode interfaces the DMS-10 through the DMSAccess feature. Two versions of the AccessNode are supported: standard AccessNode with Copper Distribution Shelves, and AccessNode Express, which uses distributed Voice Modules. As shown in Figure 2-30, the DMS-10 switch interfaces the AccessNode through either two or four DS-1 links from two Digital Signal Interface (DSI) modules acting as a Subscriber Remote Interface (SRI).

Figure 2-30: DMSAccess configuration - from the DMS-10 switch to the AccessNode



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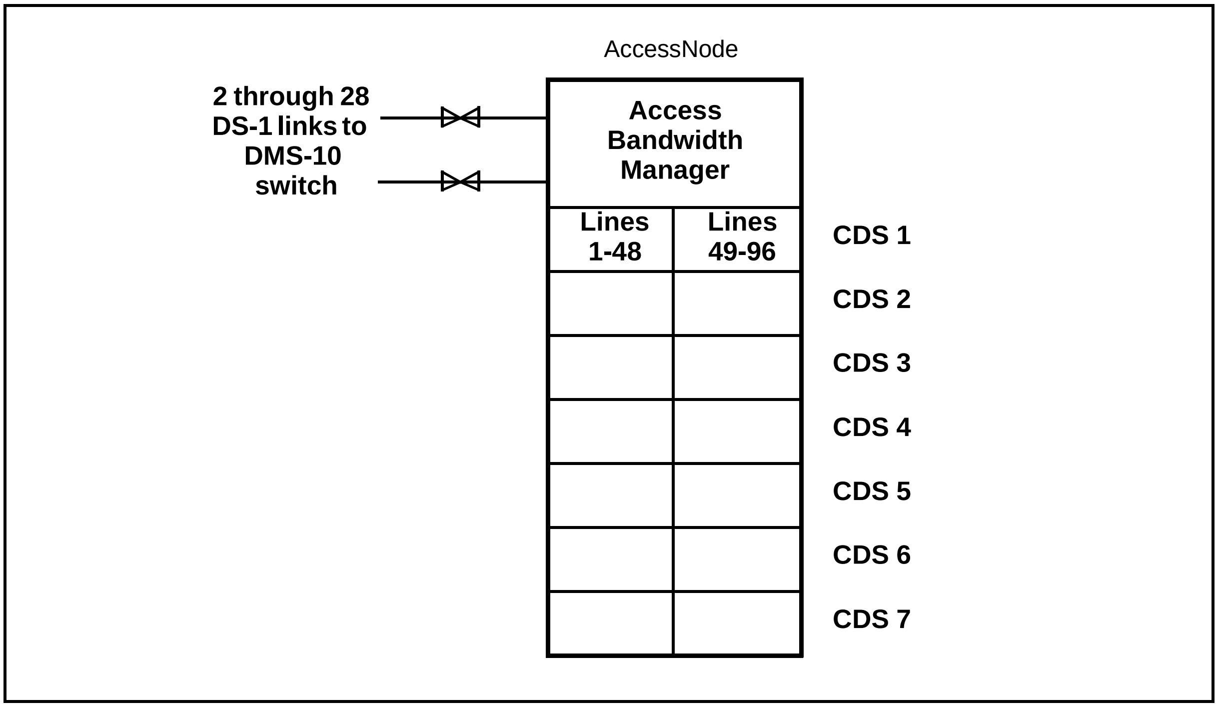
Standard AccessNode Configuration

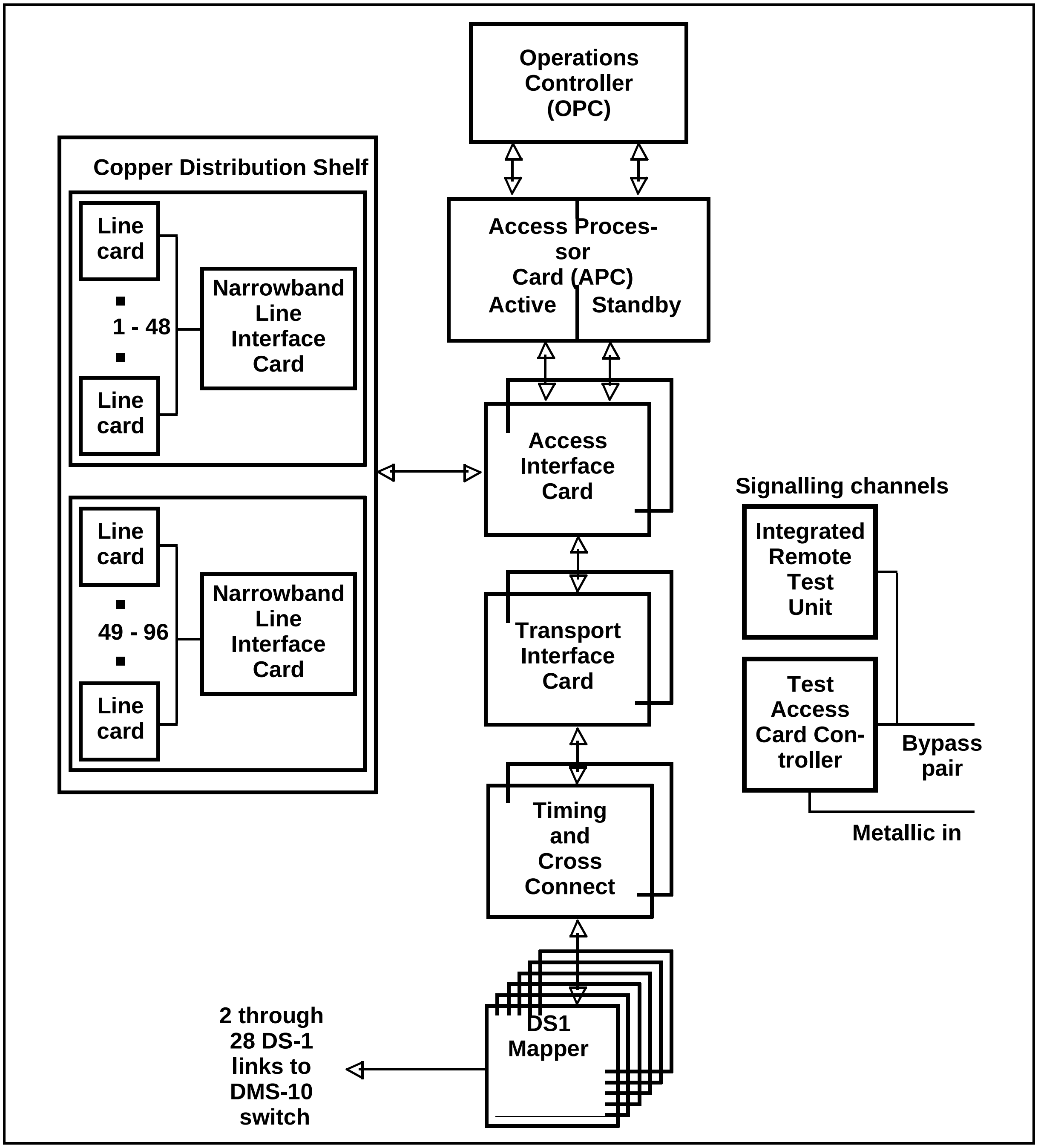
The standard AccessNode configuration, shown in Figure 2-31, consists of an Access Bandwidth Manager (ABM), which interfaces with the DMS-10 switch through a minimum of two and a maximum of 28 DS-1 links, and up to seven Copper Distribution Shelves (CDS), each of which contains two drawers containing 48 line cards each.

Figure 2-31: Standard AccessNode configuration



Access Bandwidth Manager (ABM) The Access Bandwidth Manager (ABM) provides DS0 switching between the host (DMS-10) DS-1 links and the links to the Narrowband Line Interface cards in the standard AccessNode Copper Distribution Shelf (CDS) drawers. The components of the ABM are shown in Figure 2-32.

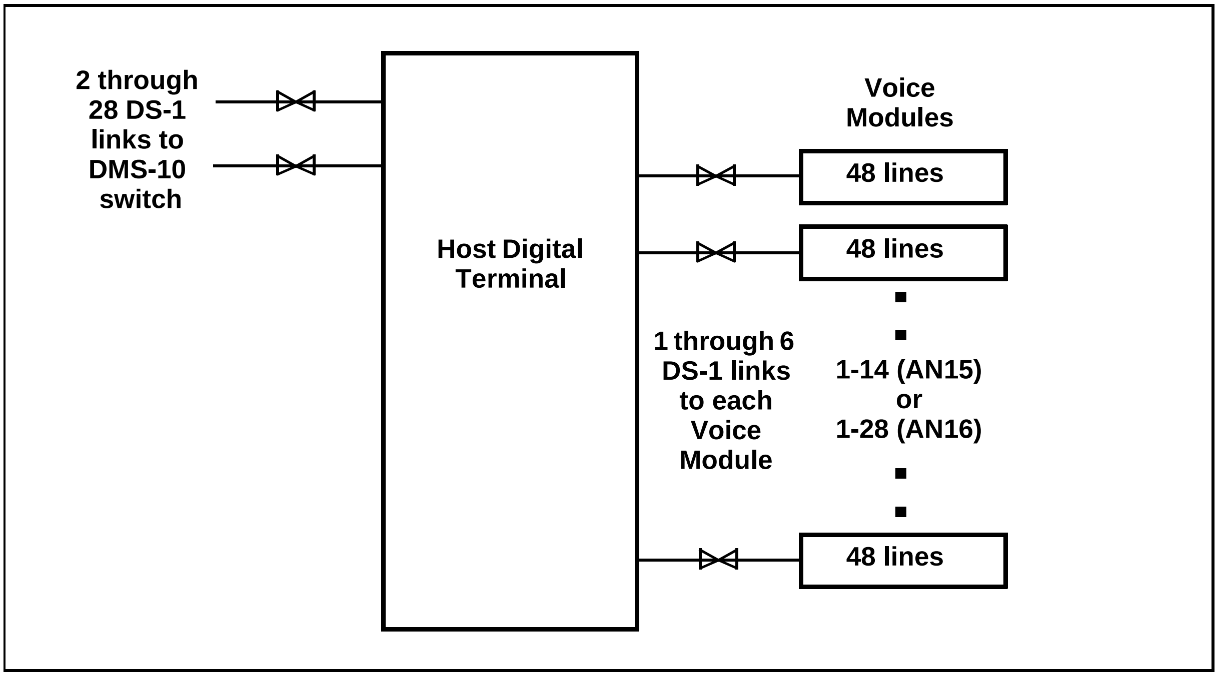
Figure 2-32: Standard AccessNode Access Bandwidth Manager (ABM) Configuration



AccessNode Express Configuration

The AccessNode Express configuration, shown in Figure 2-33, consists of a Host Digital Terminal (HDT), which interfaces with the DMS-10 switch through a minimum of 2 and a maximum of 28 DS-1 links, and from 1 through 14 Voice Modules (VM) for release AN15 and from 1 through 28 VMs for release AN16.

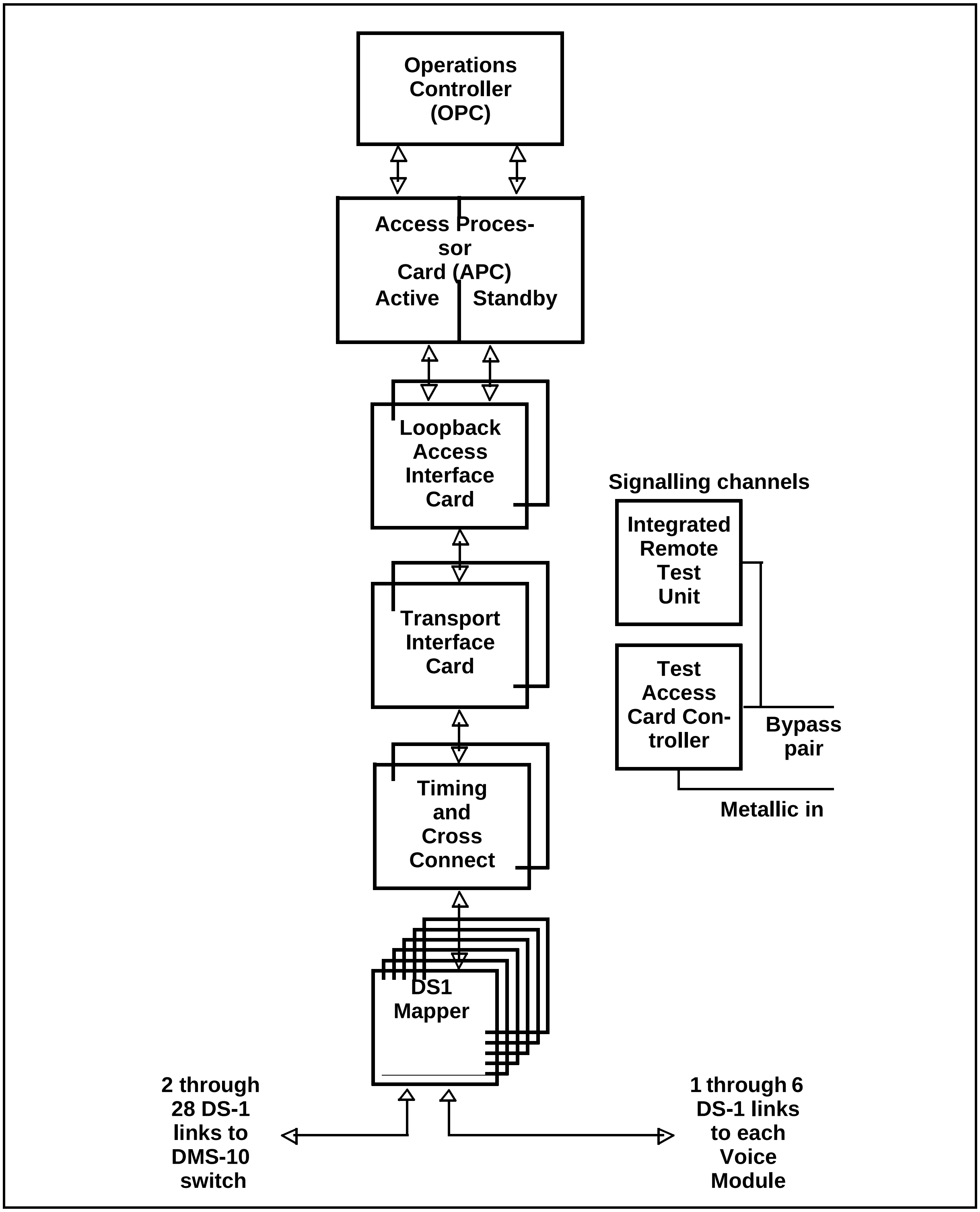
Figure 2-33: AccessNode Express configuration



Voice Module (VM) A Voice Module (VM) consists of from 1 through 6 DS-1 links, a processor, matrix cards, an Integrated Test Unit (ITU), and up to 48 line cards. Each VM can be configured with a maximum of six DS-1 links.

Host Digital Terminal (HDT) The Host Digital Terminal provides DS0 switching between the host (DMS-10) DS-1 links and the Voice Module DS-1 links. The components of the HDT are shown in Figure 2-34.

Figure 2-34: AccessNode Express Host Digital Terminal (HDT) Configuration



Operations Controller The operations controller (OPC) provides operating company personnel interface to the AccessNode for maintenance and administration purposes.

Access Processor The Access Processor card (APC) is the AccessNode's main call processing message processor and performs message conversion from RLCM DMSX to AccessNode format.

Loopback Access Interface Card In the AccessNode Express HDT only, the Loopback Access Interface card (LAIC) provides DS0 switching for 2015 connections and access to DS0 message channels for the APC.

Access Interface Card In the standard AccessNode ABM only, the Access Interface card (AIC) interfaces with the Narrowband Line Interface cards (NLIC) in each drawer of the Copper Distribution Shelves (CDS). Each CDS drawer contains two NLICs, one of which operates in standby mode.

Transport Interface Card The Transport Interface card (TIC) provides conversion between Timing and Cross Connect (TXC) STS-6 links and the APC's V1.5 links.

Timing and Cross Connect The TXC card receives 12 STS-1 links and reformats them into two STS-6 links.

Test Access Card The Test Access card (TAC) provides metallic access for the Integrated Remote Test unit (IRTU) and metallic bypass pairs.

Integrated Remote Test Unit The IRTU performs resistance, voltage and capacitance measurements in conjunction with integrated maintenance functions.

DS-1 Mapper The DS-1 Mapper cards receive 14 DS-1 links, which are reformatted into one half of one STS-1 link. Up to six of the cards can be provisioned, with one of the six used as a spare. This provides a total of 70 DS-1 links that can serve as host or Voice Module links. A minimum of 2 links are required for connection to an AccessNode LCM. In the AccessNode Express configuration, one link is required for connection to each Voice Module.

Equipment Redundancy The APC, LAIC, TIC, TXC, and VM Shelf Processor (SP) each have an active and a standby unit to allow processing to continue after a single card failure. Multiple failures for these circuit packs will, however, result in loss of service for the lines served by the AccessNode. For DS-1 Mappers, a spare card can be switched in to operate for any of the other 5 active cards. If more than one DS-1 Mapper card fails, and if multiple links have been engineered, service capacity will decrease but service will not be lost.

AccessNode VLCM components

The AccessNode, configured on the DMS-10 switch as a Virtual Remote Line Concentrating Module (VLCM), is assigned to a designated AccessNode site. Each AccessNode site can support a maximum of 32 VLCMs. A VLCM consists of a VLCM frame, one VLCM Remote Maintenance Module (RMM) shelf, and a Line Concentrating Module.

VRMM shelf The VLCM RMM (VRMM) shelf provides loop testing and maintenance capabilities for the VLCM. The VRMM is configured with a maximum of four Miscellaneous Scan Detection (NT0X10) packs supporting up to 56 scan points (14 points per pack), a maximum of four Miscellaneous Signal Distribution (NT2X57) packs supporting up to 56 scan points (14 points per pack), and one Metallic Test Access pack (NT3X09) pack.

An integrated remote test unit (IRTU) provisioned at the AccessNode site provides complete LTU (NT2X10/NT2X11) emulation, supporting all of the tests that can be performed on RLCM lines.

VLCM A maximum of 640 lines can be configured per VLCM. AN15 supports one VLCM. AN16 supports up to two VLCMs. The VLCM line cards are configured, logically, in line subgroups (LSG), each of which can contain a maximum of 32 cards. Line equipment supported by the VLCM includes the NT6X17BA (World Line Card type A), NT6X18BA (World Line Card type B), and NT6X21 (P-Phone Line card).

RLCM packs not supported by the VLCM The following packs are not supported by the VLCM:

- non-World Line card versions of the NT6X17 and NT6X18
- ISDN Drawer Controller (IDC) (NT6X54)
- Integrated BERT pack (NT6X99)
- ISDN Line card (NTBX27)
- +48 V Power Converter (NT6X23)
- Incoming/Outgoing Test Trunk (NT2X90)
- Line Card Tester (NT2T80)
- Data Line Card (NT6X71)

AccessNode VLCM subscriber services

Signaling The AccessNode VLCM supports the following types of signaling:

- loop start
- ground start
- coin (loop or ground start, coin first, semi-postpay, dial tone first)

- coded ringing
- P-Phone

Subscriber ringing The AccessNode VLCM supports the following types of subscriber ringing:

- single-party
- teen
- CLASS
- distinctive
- revertive (single-party only)
- immediate

Station options The AccessNode VLCM supports all station options except the following:

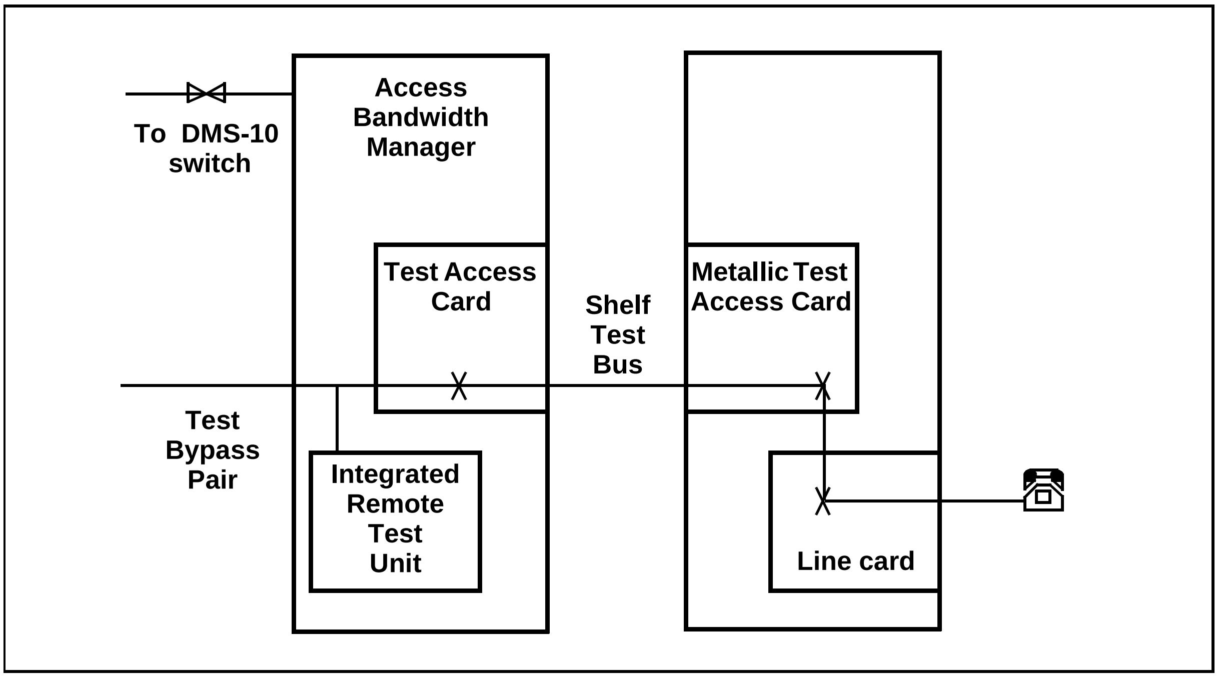
- 10FR
- 8FR
- 4FR
- 4MR
- 2FR
- 2MR
- multiparty distinctive ringing
- SUPV 3W supervision - third-wire control

Since DMSAccess does not support dynamic line padding, the FIXL station option is always assigned to the VLCM lines.

AccessNode Maintenance

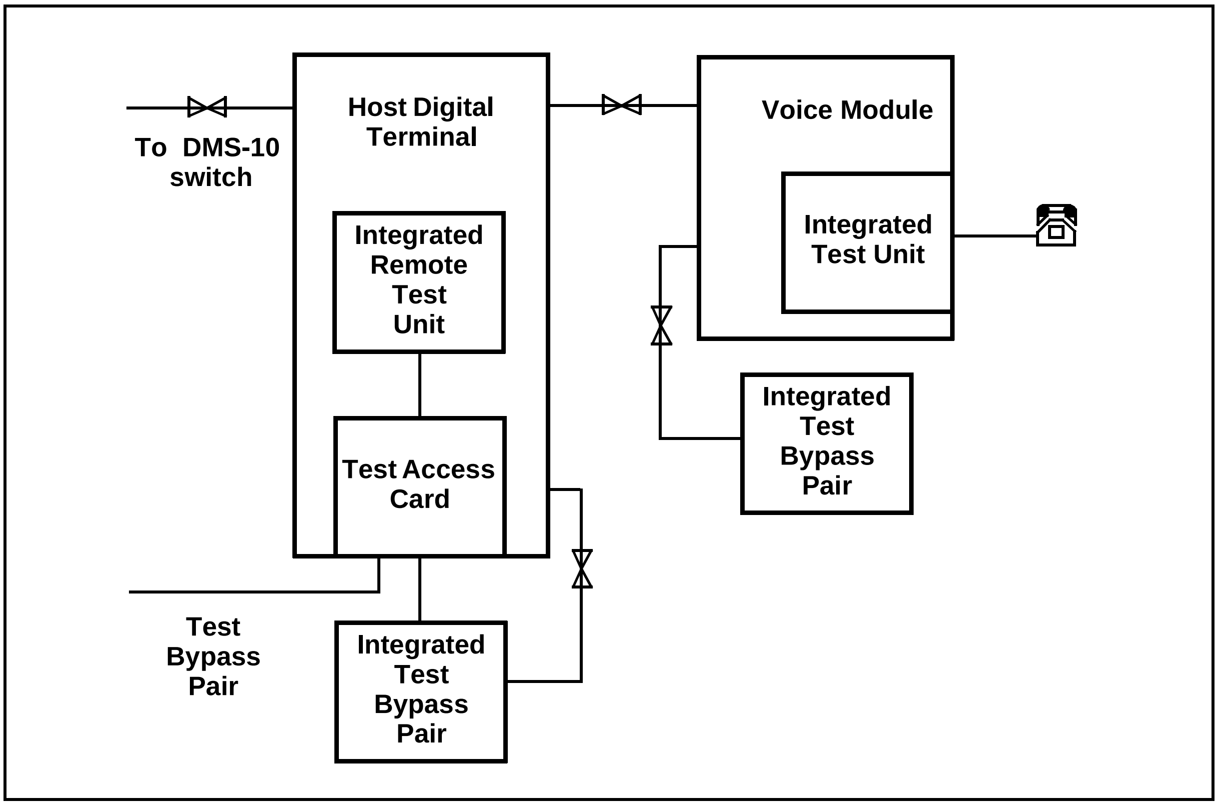
Standard AccessNode metallic access Metallic access for standard AccessNode subscriber lines is provided to the host DMS-10 switch by way of the Test Access card (TAC) provisioned in the Access Bandwidth Manager (ABM). The TAC connects the test bypass pair to the shelf test bus. The shelf test bus is then connected to the drawer test bus through the Metallic Test Access card (MTAC). The drawer test bus can then be connected to any line card in a Copper Distribution Shelf drawer. This connection is shown in Figure 2-35.

Figure 2-35: Standard AccessNode Metallic Testing Access



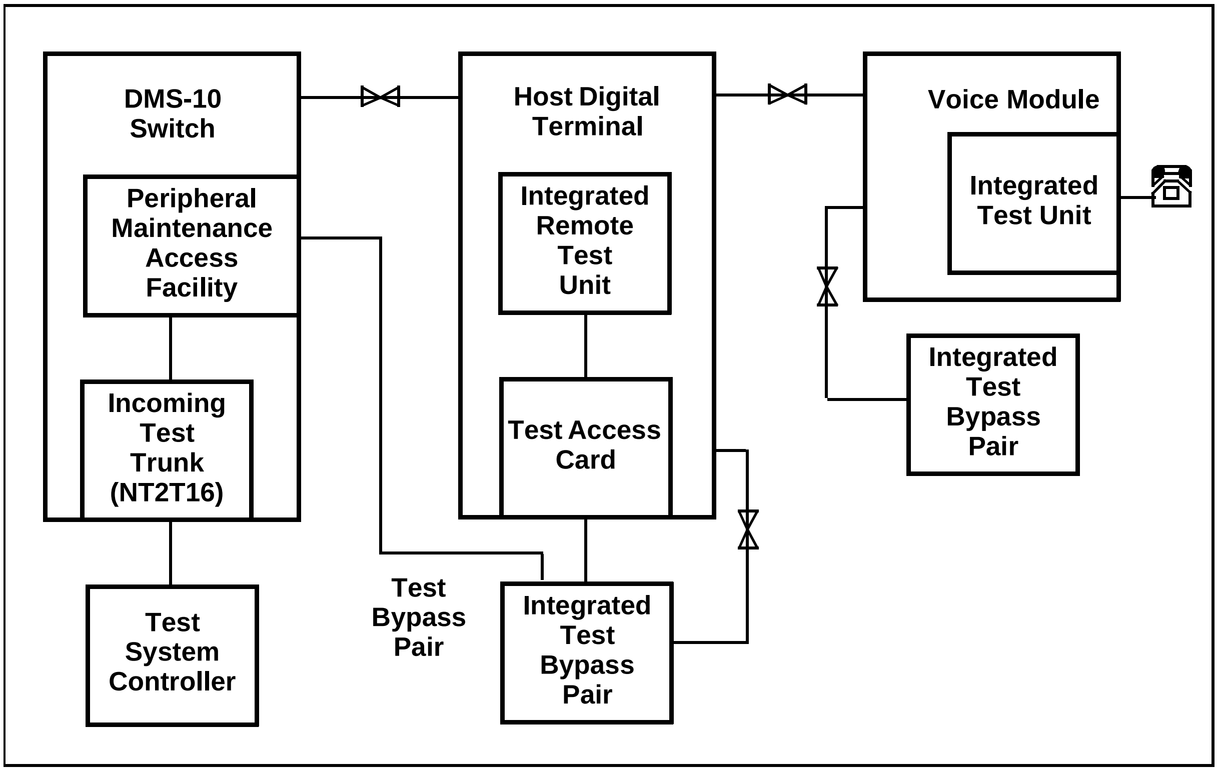
AccessNode Express metallic access Metallic access for AccessNode Express subscriber lines is provided to the host DMS-10 switch by way of the Test Access card (TAC) in the Host Digital Terminal (HDT). Access between the HDT and Voice Modules (VM) is provided by integrated test bypass pair (ITBP) metallic emulators located at the HDT and at each VM. The ITBP units each have a metallic input/output and DS-1 digital input/output. The unit at the HDT communicates with the unit at the VM through two DS0 connections from the DS-1 digital interface. These units are attached to the HDT and VM metallic access bus and DS-1 links. For metallic access, a connection is established between the ITBP DS-1 ports at the HDT and the ITBP DS-1 ports at the VM. The units then replicate both ends of the metallic outputs. This connection is shown in Figure 2-36.

Figure 2-36: AccessNode Express Metallic Testing Access



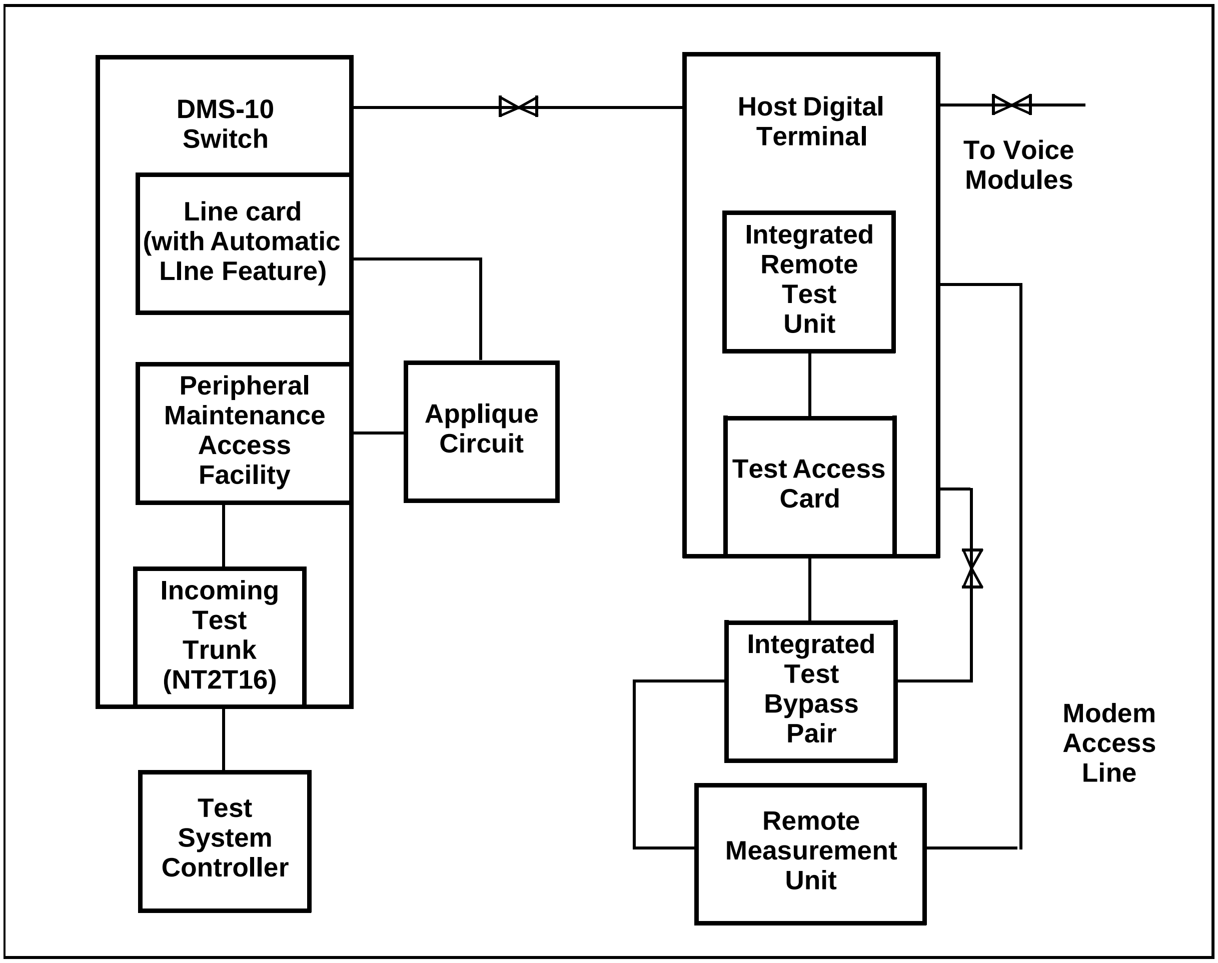
External loop testing for an AccessNode Express can be performed through an Incoming Test Trunk (NT2T16) pack located at the host DMS-10 switch and a metallic path. The metallic connection is provided through the Peripheral Maintenance Access (PMA) facility located at the host DMS-10 switch. The PMA facility connects the metallic bypass pair to the system bus. When external loop testing is required, a metallic connection is established between the HDT's integrated test bypass pair (ITBP) unit and the VM's ITBP unit, as illustrated in Figure 2-37.

Figure 2-37: AccessNode Express External/Internal Loop Test Access through Bypass Pair



External loop testing for an AccessNode Express can also be performed without an actual metallic path. In this testing configuration, the applique circuit and remote measurement unit are provided by a test system vendor. The configuration requires a line configured with the AUT (Automatic Line) feature and a voice channel on the DS-1 link connecting the host DMS-10 switch and the AccessNode Express HDT. This testing access configuration is shown in Figure 2-38.

Figure 2-38: AccessNode Express External/Internal Loop Test Access without Bypass Pair



AccessNode Hardware fault detection and response Because of the difference in the physical structures of the AccessNode and DMS-10 RLCM, detection of and recovery from AccessNode hardware faults is performed at the AccessNode. Alarm logs for the AccessNode faults are maintained by the AccessNode.

Path continuity loop backs are looped back at the AccessNode AIC/LAIC. Path continuity testing is performed at the AccessNode and is transparent to the DMS-10 switch.

DS-1 link maintenance is performed at the AccessNode.

An AccessNode LCM Controller (LCMC) is busied and returned to service, but not tested or downloaded, at the DMS-10 switch. A busy LCMC's calls are handled by its logical mate. If both LCMCs of an AccessNode are busied, service to all of the lines served by the LCMCs is lost.

Failures on DS-1 links connecting an AccessNode Express HDT and a VM, or dual VM shelf processor failures, that render the VM inaccessible, result in all of the line cards in the VM being placed in system-made-busy state. Dual NLIC failures on a CDS shelf in a standard AccessNode also results in all of the line cards on the CDS shelf being placed in system-made-busy state. The AccessNode reports the faults to the host DMS-10 switch which then takes the cards out of service. When the fault has been cleared, the AccessNode sends a message to the DMS-10 switch so that the switch can return the line cards to service.

Audits The following types of audits are performed by the AccessNode on the AccessNode equipment:

- hardware audits - performed on in-service AccessNode line cards
- RMM audits - LTU audits performed by the DMS-10 switch using the existing RMM audit messages
- LCM internal audits

Test lines The following test line types are supported by the AccessNode:

- looparound test line 1
- looparound test line 2
- 100-type test line
- 102-type test line
- 103-type test line
- 105-type test line
- Silent Switchman test line

- trace tone
- dial speed test
- station ringer test

Alarms Customer-assignable VLCM scan points are assigned for the three alarm classes at each AccessNode and AccessNode Express site to report alarm conditions on equipment served by the HDT. When a scan point is set, central office operating company personnel must obtain the actual alarm through the Operations Controller (OPC).

Hazard line testing Hazard line testing on NT6X17 and NT6X18 packs configured in an AccessNode site will not be performed by the DMS-10 switch. AccessNode packs that are determined to be in hazardous state are removed from service by the AccessNode. An LCM overvoltage report message is generated for the hazardous line.

Call Processing Restrictions

ESA is not provided for AccessNode sites. Intraswitching is also not supported by AccessNode sites. In addition, multi-party lines are not supported by AccessNode sites.

Subscriber Carrier Module 10S (SCM-10S)

The SCM-10S provides the circuitry that allows the DMS-10 network to interface with remotely located SLC-96 lines or with S/DMS AccessNode lines configured as a SLC-96. The SCM-10S provides the interface between a Remote Switching Center (RSC-S) connected to a DMS-10 switch and a SLC-96.

SCM-10S configuration

The SCM-10S is housed in an SCE bay (SCE-1), which contains two SCM-10S modules and a Frame Supervisory Panel. In an RSC-S configuration, the SCM-10S is housed in a Cabinetized Remote Switching Center (CRSC). Each SCM-10S consists of a two-shelf unit that provides a digital interface between the DMS-10 network or RSC-S and up to six SLC-96s, or between the DMS-10 network and one or more S/DMS AccessNode Copper Distribution shelves configured as SLC-96s. The SLC-96, located at a remote site, is a four-shelf channel bank that serves as a subscriber loop carrier. By concentrating up to 96 channels and transmitting the digital signals to the DMS-10 switch over DS-1 span lines, the SLC-96 reduces the amount of outside plant equipment necessary to support subscriber lines. The SCM-10S module replaces the central office terminal, thereby eliminating the need for analog line cards and reducing the amount of necessary office space and MDF wiring.

SCM-10S redundancy

The SCM-10S shelves are redundant. One shelf is active, and the other shelf is a "hot standby." The standby shelf takes control of the module if a fault is detected in the active shelf. The SCS Control Complex consists of the following circuit packs: Master Processor (NT6X45), Master Processor Memory (NT6X47), Signal Processor Memory (NT6X46), Signaling Processor (NT6X45), A/B Derived Data Link (NT6X86), Time Switch (NT6X44) and a Message Interface (NT6X43).

Faults in the active shelf are detected by firmware diagnostics. Shelf switchover occurs if faults are detected in the following devices:

- SCS Control Complex
- Power Converter pack (NT2X70)
- DS-30A Peripheral Interface pack (NT8X18)

If the same faults are detected in both shelves (for example, both Power Converter packs are faulty), the entire SCM-10S module is taken out of service.

SCM-10S architecture

Figure 2-39 is a block diagram of the SCM-10S interface to the SLC-96 or S/DMS AccessNode serving as a SLC-96.

Network interface loops

The SCM-10S interfaces to the DMS-10 Network through two or four DS-30A loops. The number of loops affects the traffic-carrying capacity of the SCM-10S.

Up to eight loops (PELP) of each DS-30A pack (NT4T04 or NT8T04) are used for connection to the SCM-10S. Two of the 4 PELPs are used for signaling. All 4 PELPs are used for speech.

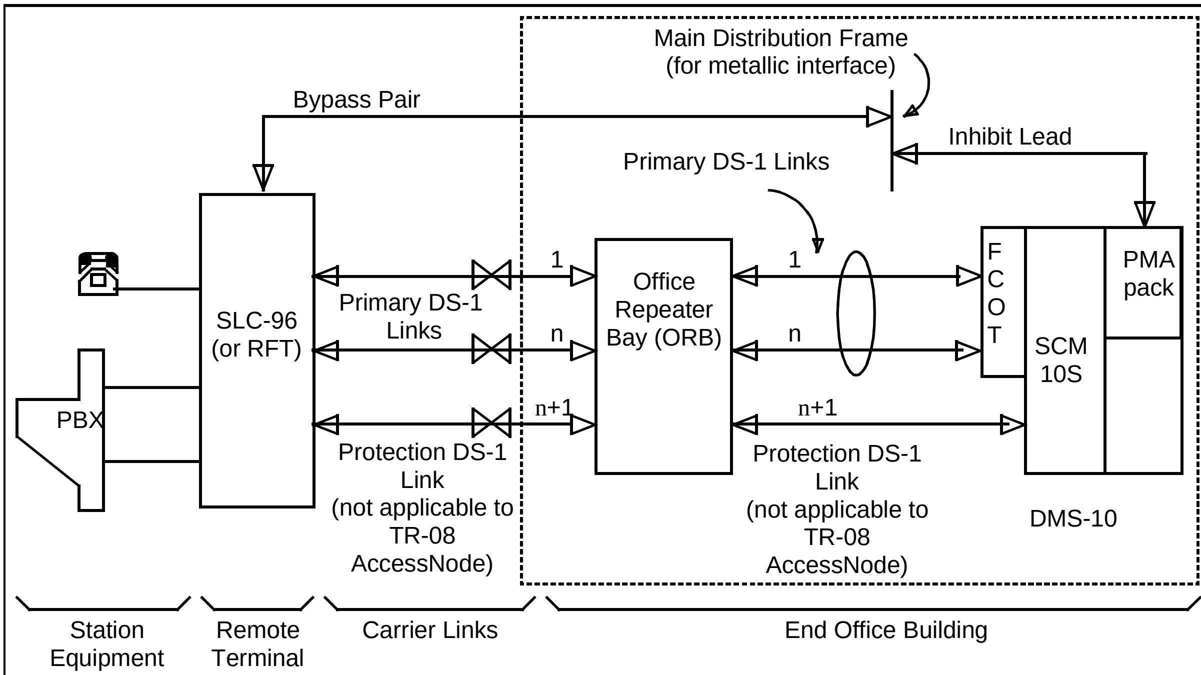
Transmission facilities

Up to five DS-1 Interface packs (NT6X85) may be equipped in an SCM-10S shelf. Each pack provides two DS-1 links and is duplicated on the mate SCM-10S shelf. Therefore, up to 20 DS-1 links connect the SCM-10S module with up to six SLC-96s or connect the SCM-10S with one or more S/DMS AccessNode Copper Distribution shelves configured as SLC-96s. In addition to the two or four primary DS-1 links that connect to a single SLC-96, a loop bypass pair connects the SLC-96 to the MDF at the central office to provide metallic test access at the remote location.

DS-1 link modes

Two DS-1 link configurations, or modes, are supported. The four-shelf SLC-96 is arranged in two shelf groups, AB and CD. Mode I, a non-concentrated configuration, consists of two primary DS-1 links connected to each SLC-96 shelf group. Mode II, a concentrated configuration, consists of one primary DS-1 link connected to each SLC-96 shelf group. For standard and Series-5 SLC-96s, Mode I requires one Line Interface Unit (LIU) per shelf group to accommodate one DS-1 link. For a standard SLC-96, Mode II requires one Time Assignment Unit (TAU) per shelf group to accommodate the 2:1 shelf-to-link ratio. For a Series-5 SLC-96, TAU packs are not used; instead, the Alarm Display Unit (ADU) pack has a switch setting for Mode I or Mode II. Because each shelf group is configured independently, a single SLC-96 may be configured with either or both modes. For the S/DMS AccessNode configured as a SLC-96, only Mode I is available and Narrowband Line Interface cards (NLIC), rather than LIU and TAU packs, are used. Depending on the SLC-96 to DS-1 link configuration, up to six SLC-96s may be supported by an SCM-10S module. Figures 2-40 and 2-41 illustrate Mode I and Mode II configurations for a SLC-96; Figure 2-42 illustrates the S/DMS AccessNode Mode I configuration.

Figure 2-39: SLC-96 (including S/DMS AccessNode configuration) interface to DMS-10 switch



***Notes*:1. The number of primary DS-1 links ranges from 2 to 4, depending on SLC-96 mode and type.**
2. The FCOT applies only to S/DMS AccessNode configurations.

Figure 2-40: Mode I SLC-96

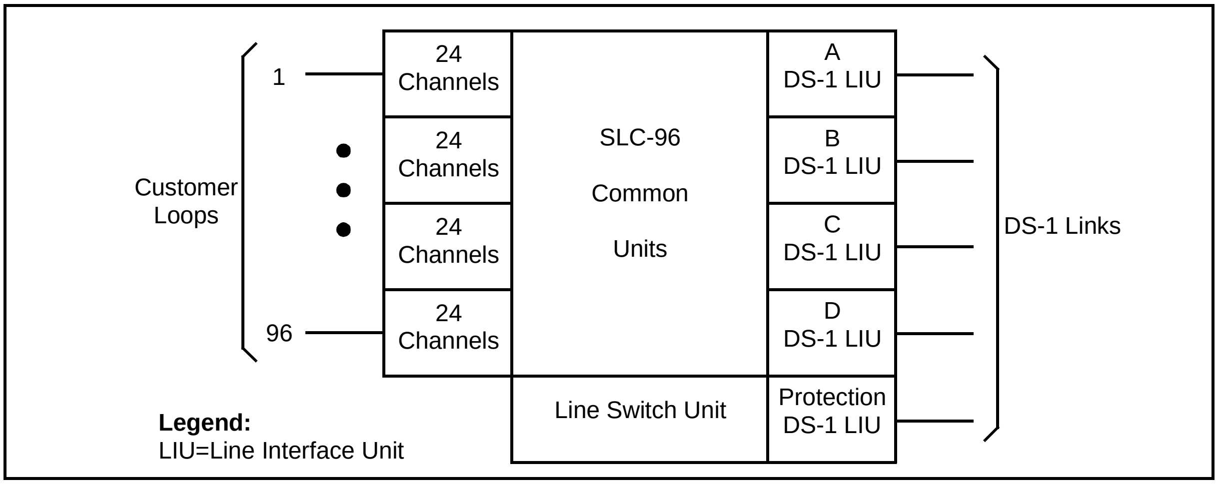


Figure 2-41: Mode II SLC-96

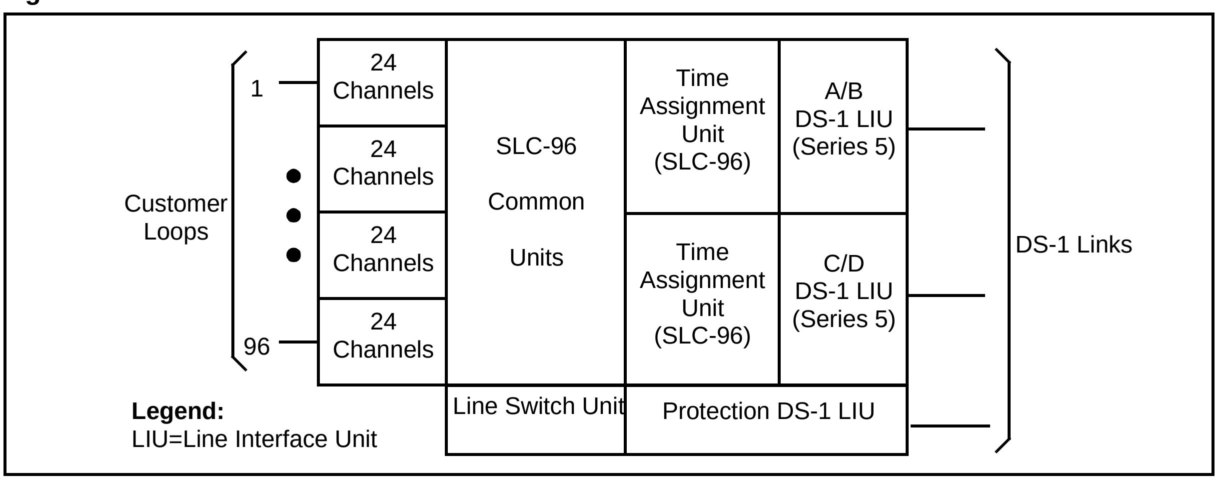
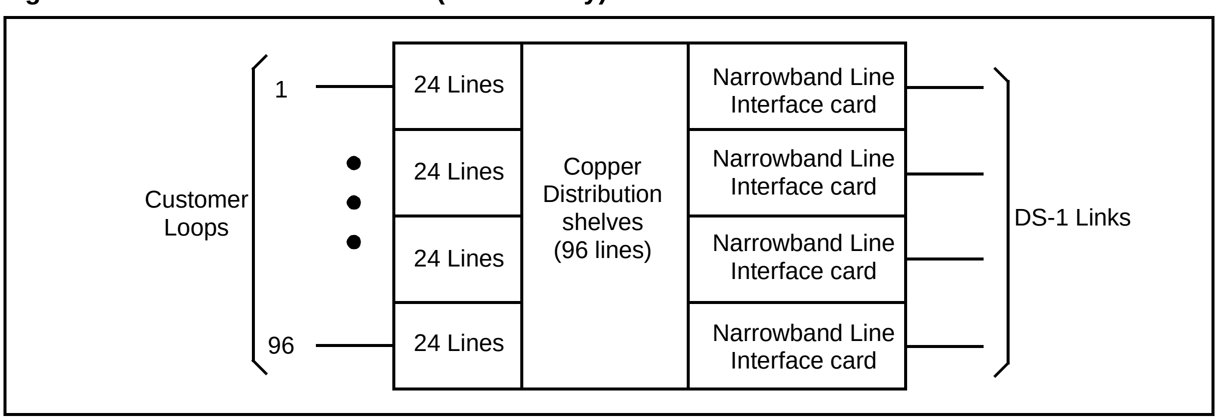


Figure 2-42: S/DMS AccessNode (Mode 1 only)



Subscriber Carrier Module 10U (SCM-10U)

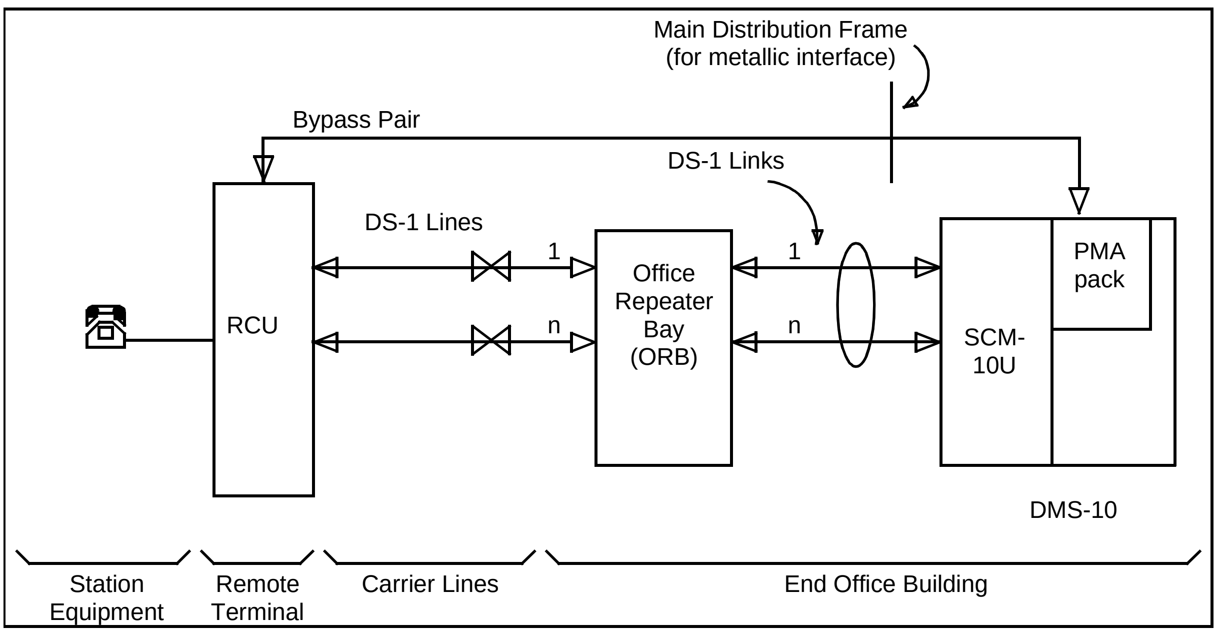
The SCM-10U provides a direct digital interface with a DMS-1 Urban. The DMS-1 Urban (DMS-1U), located at a remote site, is a pair/gain system that supports up to 528 POTS lines.

In a "universal" configuration, the DMS-1U consists of a control terminal (CT), which interfaces with an analog switch at the central office, a remote terminal (RT), which interfaces with subscriber lines, and up to eight DS-1 transmission lines that carry subscriber signals and system control signals between the CT and RT.

When integrated into a DMS-10 system, the SCM-10U replaces the CT. By eliminating the CT, the SCM-10U also eliminates main distribution frame (MDF) activity associated with the CT and analog line circuits, reduces floor space requirements, reduces maintenance and administration requirements, and improves transmission quality. In this configuration, the RT is provisioned with two Message Processor circuit packs to interface the SCM-10U; this version of the RT is known as the Remote Carrier Urban (RCU).

Figure 2-43 is a block diagram of the SCM-10U/RCU configuration.

Figure 2-43: SCM-10U interface to the RCU



SCM-10U configuration

The SCM-10U is housed in an SCE bay, which can accommodate two SCM-10U modules and a Frame Supervisory Panel. Each module comprises two Controller Array shelves (NT6X0201). Each shelf is provisioned with a “control complex” consisting of the following circuit packs: Master Processor (NT6X45), Master Processor Memory (NT6X47), Signal Processor Memory (NT6X46), Signaling Processor (NT6X45), Time Switch (NT6X44), Pad/Ring Interface (NT6X80), Channel Supervision Message (NT6X42), Speech Bus Formatter (NT6X41), and Message Interface and Tone (NT6X69). The shelf is also provisioned with a Power Converter pack (NT2X70), with one DS-30A Interface pack (NT8X18), and with up to five DS-1 Interface packs (NT6X85).

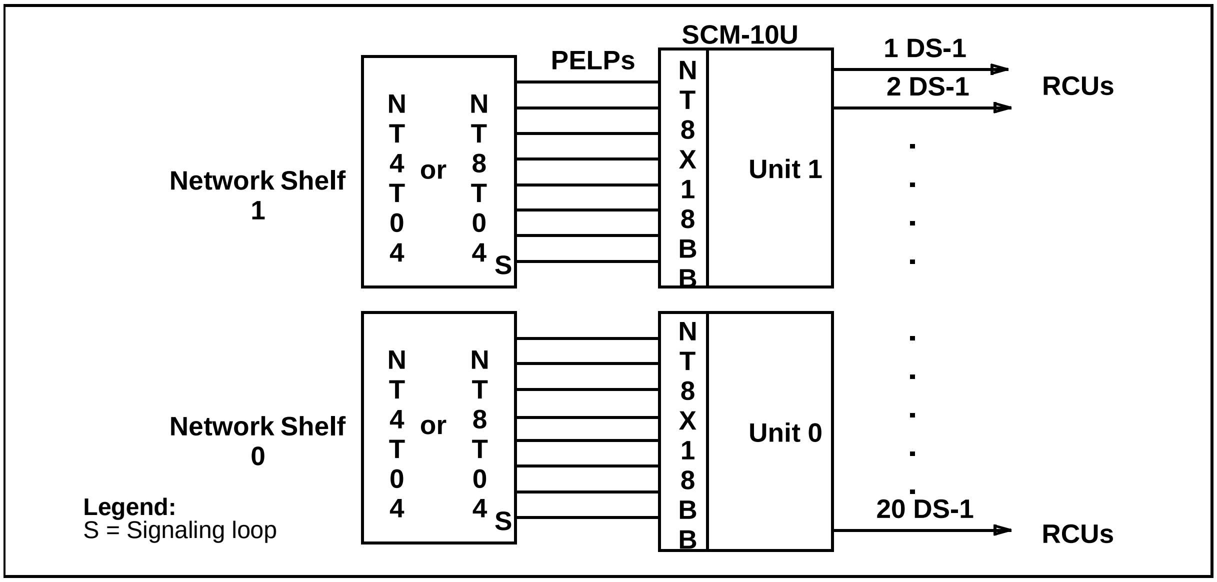
The shelves in each module are redundant. One shelf is active, and the other shelf is a “hot standby.” The standby shelf takes control of the module if a fault is detected in the active shelf. If the same faults are detected in both shelves (for example, both Power Converter packs are faulty), the module is taken out of service.

Network interface loops

The SCM-10U interfaces with the DMS-10 network through DS-30A peripheral equipment loops (PELP). The number of PELPs configured affects the traffic-carrying capacity of the SCM-10U.

Up to eight loops (PELP) of each DS-30A pack (NT4T04 or NT8T04) are used for connection to the SCM-10U. Two of the 16 PELPs are used for signaling. All 16 PELPs are used for speech. This configuration is shown in Figure 2-44.

Figure 2-44: SCM-10U DS-30A expanded configuration



Transmission facilities

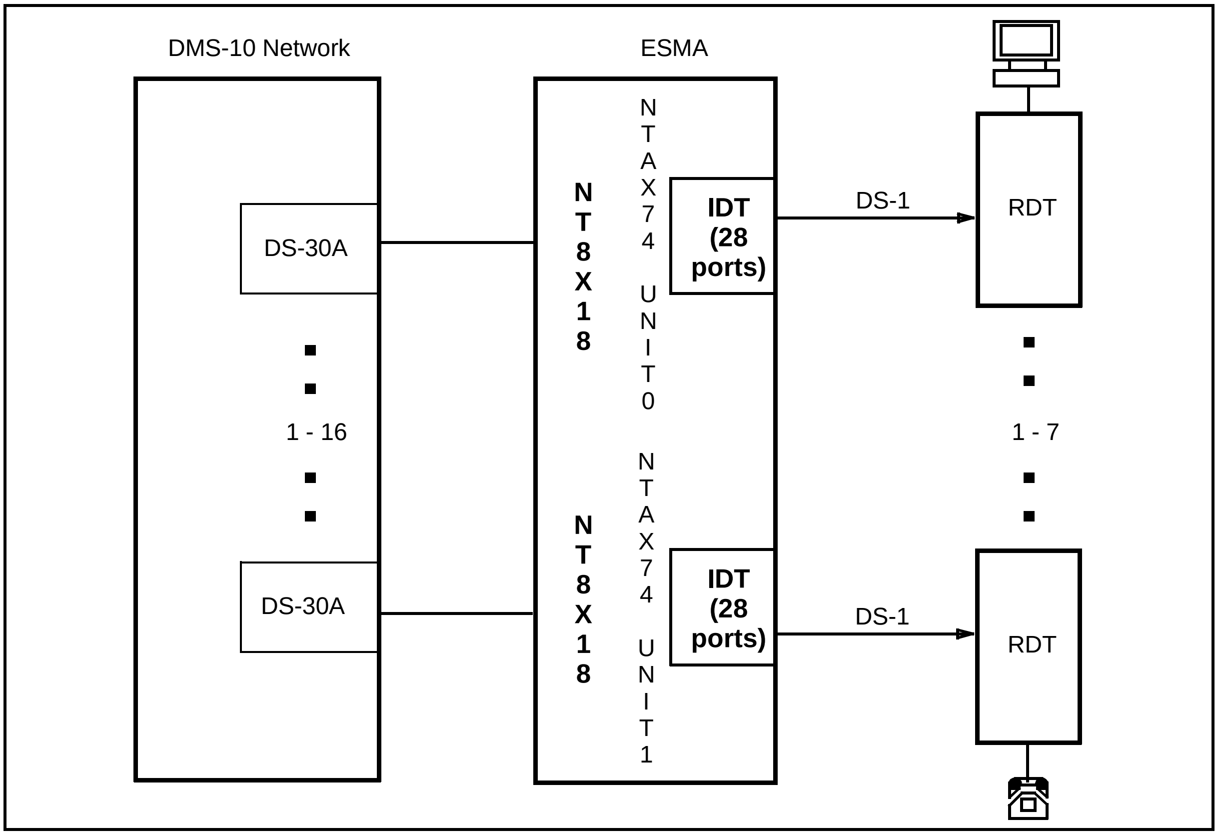
Up to five DS-1 Interface packs (NT6X85) may be equipped in an SCM-10U shelf. Each pack provides two DS-1 links. Therefore, up to 20 DS-1 links connect the SCM-10U module with up to eight RCUs. A loop bypass pair may be connected between the MDF at the central office and the RCUs to provide metallic test access at the remote locations. For more information about metallic test access, see the NTP entitled *General Maintenance Information* (297-3601-500).

Subscriber Carrier Module-10A (SCM-10A)

GR-303 is a generic interface that allows telephone exchanges and remote line equipment of different vendors to be connected together. The SCM-10A feature is, specifically, the interfacing hardware/software that supports the GR-303 interface between the DMS-10 switch and GR-303 compliant access vehicles called “remote digital terminals” (RDT).

Figure 2-45 shows the SCM-10A feature configuration. The major hardware components of the feature are the Enhanced Subscriber Carrier Module Access (ESMA) module, the Integrated Digital Terminal (IDT), and the Remote Digital Terminal (RDT).

Figure 2-45: SCM-10A feature configuration



ESMA

The primary hardware component of the SCM-10A feature is the Enhanced Subscriber Carrier Module Access (ESMA). The ESMA peripheral module is based on the Common Peripheral Module (CPM) hardware technology introduced with the Remote Switching Center-S (RSC-S) product.

The ESMA module provides channel switching, message processing, service circuits, D-channel handlers for ISDN, and DS-1 interfaces to connected GR-303 compliant remote access vehicles. The ESMA software controls the call processing events in an RDT over a GR-303 compliant time-slot management channel (TMC), while managing provisioning, alarms, maintenance, and testing through a separate Embedded Operations Channel (EOC) channel to each RDT. Each module contains a fully redundant control complex, allowing either unit to direct all call processing and ensuring that single failures do not adversely affect call processing. Each ESMA peripheral is connected to the DMS-10 switch network through 2 to 16 DS-30A ports. These ports require the messaging capacity and downloadable firmware capabilities of the NT4T04AM DS-30A Interface pack or of the NT8T04 Network Interface pack.

The ESMA (NTMX8504) module can be located in a standard seven-foot Multivendor Interface Equipment (MVIE) bay (NTQX90AA) or Multivendor Dual Density Equipment (MVDD) bay (NTQX90BA). The module supports up to seven small RDTs (up to 672 lines), 4 medium RDTs (up to 1344 lines), or two large RDTs (up to 2048 lines). In addition, the module capabilities include:

- support of 24 peripheral side (P-side) DS-1 links.

  Note: *When provisioned with an extension shelf support for 48 P-side DS-1 links (up to 28 per RDT) is provided.*

- interface with the DMS-10 switch network through DS-30A links (maximum of 16)
- support of ISDN, POTS, CLASS, coin, and multiparty lines
- support of time-slot management channel (TMC) protocol (used to set up and disconnect calls and connect DS-1 channels to line cards for call processing)
- support of embedded operations channel (EOC) protocol (used to relay maintenance and provisioning requests between the DMS-10 switch and the RDTs
- support of ABCD bits signaling (used to transfer line signaling information from the RDTs to the DMS-10 switch)
- support of Extended Super Frame (ESF) DS-1 protocol (in order to support ABCD bits signaling)
- support of BRI ISDN lines and ISDN features

In an MVIE bay up to two main ESMA shelves and one ESMA extension shelf (two half-shelves, each dedicated to one of the main shelves), configured as two ESMA modules, can be provisioned. Thus, a single ESMA module consists of a main shelf and half of the extension shelf. The extension shelf works in conjunction with the main shelf to support additional DS-1 links and/or Enhanced D-channel handler packs (NTBX02) to accommodate ISDN line requirements. In this configuration, 96 P-side links can be supported (48 DS-1 links per module).

In an MVDD bay up to 4 main ESMA shelves, configured as 4 ESMA modules can be provisioned. In this configuration, 96 P-side links can be supported (24 DS-1 links per module). Because the MVDD bay supports more ESMA modules, a greater number of RDTs may be supported by a single bay of equipment.

The power and alarm reporting capabilities of each bay (MVIE and MVDD) are provided by a Modular Supervisory Panel (MSP). The MSP comprises four modules, including the alarm, breaker, fuse, and fan power control module. Although the primary function of the MSP is to monitor and detect faults or failures in the power converters, thermal breakers, cooling fan units, and fuses, the MSP also provides current limit protection and automatic recovery from low battery.

Main shelf layout and circuit packs

The main shelf of an ESMA module is arranged in a dual-unit configuration allowing the control complex in either unit to control all call processing for the module. This arrangement is different from other XPM-based peripherals, which provide redundant control complexes on alternate physical shelves rather than within a single shelf unit.

In addition to the control complex, each main shelf in an ESMA module contains network interface circuit packs, GR-303 specific signaling packs, service circuits, and the initial portion of the required DS-1 and D-channel handler circuit packs.

Main shelf common circuit packs The following circuit packs are common to all ESMA modules:

- 16 MB Processor (NTAX74AA), which consists of a motherboard and micro controller subsystem daughterboard containing a Motorola 68LC040 microprocessor and 16 MB of dynamic RAM. The LC version of the 68040 CPU contains an integrated Programmable Memory Management Unit (PMMU), which provides logical-to-physical memory mappings. This pack occupies slots 3 and 25 in the ESMA main shelf.
- Signaling Processor (NTMX73BA), which performs low-level PCM signaling tasks, including maintenance bytes, ABCD signaling bits, GR-303 facility data link bits, and system clock synchronization, controlled by the NTMX73BA circuit pack. The NTMX73BA uses Motorola 68360 microprocessor technology, with 1 MB of dynamic RAM. This pack occupies slots 11 and 17 of the main shelf.
- Channel Supervision Messaging (CSM) and Messaging (NTMX76BA/CA), which is responsible for signaling and control of messaging between the ESMA and the core of the DMS-10 system. The NTMX76BA/CA performs CSM for call processing and diagnostics between peripherals, DS-30A protocol, ROM and RAM tone generation, and DMSX messaging, The NTMX76BA/CA occupies slots 8 and 20 of the main shelf.
- Enhanced Matrix (NTMX75BA), which provides a non-blocking, single-stage time switch function to map P-side channels to C-side channels for all ports on the main and extension shelves. The time switch has been designed to support *n* x 64 kbps switching and 28 Virtual Tributary (VT) 1.5 links for future SONET applications. The NTMX75BA occupies slots 10 and 18 of the main shelf.
- Enhanced ISDN Signaling Pre-processor (NTBX01BA), converts GR-303 messages used on the TMC and EOC to the proprietary DMSX protocols used within the DMS-10 switch. The card also provides a communications channel between the CAP Processor and the D-channel handler cards used for ISDN. The NTBX01BA occupies slots 4 and 24 of the main shelf.

- DS-30A Interface (NT8X18BB), connects the ESMA to the DMS-10 switch using up to 16 DS-30A links, each of which carries 32 PCM channels. These links are supported by two DS-30A interface cards, one in each control complex of the main shelf. The DS-30A Interface cards occupy slots 9 and 19 of the main shelf.

Main shelf application-dependent circuit packs

The following circuit packs are application-dependent and give the ESMA module its identity:

- Universal Tone Receiver (UTR, NT6X92EA), receives and interprets multi-frequency (MF) and dual-tone multi-frequency (DTMF) signals. Up to four NT6X92 packs may be provisioned on the main shelf, in positions 6, 7, 21, and/or 22.
- Custom Local Area Signaling Services (CLASS) Modem Resource (NT6X78AB), supports the CLASS Calling Number Delivery and Calling Name Delivery features. The CMR provides the in-band signaling capabilities necessary to support signaling to CLASS terminals. The NT6X78ABs occupy slots 5 and 23 of the main shelf.
- Enhanced D-channel handler (NTBX02BA), supports ISDN-BRI services for a maximum of 112 BRI lines. The NTBX02BA cards terminate ISDN D-channels appearing in the 4:1 Time Division Multiplexing format defined by GR-303. These cards can occupy slots 14 and/or 16 of the main shelf. A single hot spare is usually provided.
- DS-1 PCM Carrier (NTMX87AA/NTMX81AA), used to accommodate four dual DS-1 interfaces (NTMX81AA) or filler plates (NTMX83AA). This configuration makes DS-1 interfaces four times as dense as other DS-1 circuit packs in a DMS-10 switch. Up to 8 DS-1 interfaces can be provisioned per slot for a maximum of 24 DS-1 interfaces per main shelf. DS-1 interfaces may be provisioned in increments of two. DS-1 PCM Carriers can reside in slots 12, 14, and/or 16 of the main shelf.

Extension shelf layout and circuit packs

The extension shelf works with the main shelf, supplying additional slots for DS-1 interfaces and ISDN capacity. Each half of the extension shelf contains duplicated DS-60 extension cards to provide connectivity to the main shelf, and can be provisioned with up to eight Enhanced D-channel handler packs for additional ISDN capacity and up to three DS-1 PCM Carrier packs or 24 DS-1 Interface packs. (EDCH packs may be provisioned on the extension shelf if all three DS-1s on the main shelf have been provisioned with NTMX81s.)

Extension shelf common circuit packs The following circuit packs are required in all ESMA extension shelves that are to be provisioned with the optional functions described below:

- Extension Shelf Interface (NTMX79AB), transfers signals between the main shelf and the extension shelf to support the DS-1 and EDCH ports. The redundant NTMX79AB packs may be located in slots 2 and 13 of the first extension shelf, and in slots 14 and 25 of the second extension shelf.

Extension shelf application-dependent circuit packs The following extension shelf circuit packs are application-dependent:

- DS-1 PCM Carrier (NTMX87AA/NTMX81AA), which can be provisioned in slots 4, 6, and/or 8 of the first extension shelf, and in slots 19, 21, and/or 23 of the second extension shelf. Up to three DS-1 PCM Carrier packs or 24 DS-1 Interface packs can be supported per extension shelf.
- Enhanced D-channel handler (EDCH, NTBX02BA), which can be provisioned in slots 3, 5, 7, 8, 9, 10, 11, and 12 of the first extension shelf, and in slots 15, 16, 17, 18, 19, 20, 22, and 24 of the second extension shelf. Up to eight EDCH packs can be provisioned per extension shelf.

Integrated Digital Terminal

The Integrated Digital Terminal (IDT) is a logical entity consisting of the switching resources dedicated to a single RDT. The IDT serves as the interface to an RDT. The DS-1 links connecting the RDTs and ESMA (2 messaging and up to 26 voice) are mapped to IDT ports (0 - 27).

Remote Digital Terminal

Remote Digital Terminal (RDT) is a name applied generically to any vendor remote digital terminal equipment that complies with Bellcore GR-303 specifications. The RDT is the access vehicle that connects terminal devices capable of transmitting either voice or data to the DMS-10 switch. The RDT can provide support for up to 2048 subscriber lines from various types of terminal devices. A single RDT may be physically divided into multiple access vehicles as long as it appears logically to the ESMA as a single IDT entity. The ESMA can connect with up to seven RDTs.

SCM-10A Signaling and Communication

The RDTs communicate with the DMS-10 switch over DS-1 links that terminate at the ESMA shelf.

Communication protocols

The ESMA shelf uses the following protocols for communication and subscriber services:

- Q.921 CCITT link access procedure on the D-channel (LAPD)
- Q.931 CCITT Digital Network access

Q.921 The Q.921 LAPD protocol is used to establish data link communications between a service access point identifier (SAPI) and a terminal end point identifier (TEI), in order to transmit information sent from a higher-layer protocol or to receive information for delivery to a higher-layer protocol. The protocol is used for transmitting TMC messages and EOC messages.

Q.931 The Q.931 protocol is used to communicate call setup, call monitoring, and call tear-down information between an ESMA shelf and an RDT. The ESMA shelf must translate the Q.931 generic-based signaling messages sent by the RDT into a DMSX message format that the host can understand. The ESMA shelf must also translate DMSX-format messages from the DMS-10 switch into Q.931 format for delivery to the RDTs.

Signaling and communication types

The following signaling and communication types are used to exchange information between the ESMA shelf and the RDTs:

- DS-1 extended superframe format (ESF) signaling
- GR-303 hybrid signaling
- EOC communication messages
- ISDN Basic Rate Interface (BRI) signaling

These signaling and communication types are described in the following paragraphs.

DS-1 ESF signaling DS-1 ESF signaling is used for information exchange over DS-1 lines between the ESMA shelf and the RDTs. DS-1 links operate at a rate of 1.5444 Mbps, with a sampling frequency of 8000 frames per second. The DS-1 link signaling frame consists of 24 bytes preceded by a framing bit. The bytes fit into time slots or channels. The channels carry either speech information, signaling information, or operations information.

GR-303 hybrid signaling GR-303 hybrid signaling, required for integrated digital loop carrier (IDLC) call processing, uses extracted ABCD bits (or, robbed bit signaling) and TMC signaling.

In ABCD bits signaling, bits are extracted from the least significant bit of each 8-bit channel in the 6th, 12th, 18th, and 24th frames of each superframe. The combination of A, B, C, and D bits can define up to 16 unique codes in each direction, IDT to RDT and RDT to IDT. ABCD bits are used for the exchange of POTS call supervisory information between the IDT and the RDTs, including hook state changes, ringing patterns, loop signaling and supervision, coin call processing information, ANI two-party line testing information (for billing purposes), and DP digit collection information.

TMC signaling is used to set up and take down calls through channel 24 of a DS-1 link, using the Q.931 message protocol. The TMC channel is path-protected. For every IDT-to-RDT connection, there is a dedicated TMC on two links, a primary path and a secondary path. Although both paths must be in service and enabled, only one path is active at a time. Messages contain protocol discriminator, call reference, message type, and information elements.

EOC communication messages EOC is a message-oriented operations channel used to exchange maintenance and testing information between the ESMA shelf and the RDT, in channel 12 of a DS-1 link. The ESMA shelf sends EOC messages to the RDTs to initialize and maintain object-oriented static data at the RDT, to provide line test position (LTP) capabilities to the RDTs, and to permit the RDTs to connect to external test systems. The RDTs use EOC messages to inform the ESMA shelf of its activities through log messages and remote telemetry.

The EOC channel is path-protected. For each RDT, there is a dedicated EOC on two links, a primary path and a secondary path. Although both paths must be in service and enabled, only one path is active at any one time.

ISDN BRI signaling ISDN BRI signaling (2B + D) consists of two 64-kbit B-channels for voice and data and a 16-kbit D-channel for signaling and packet data. Q.931 protocol is used along with the signaling control protocol to transfer call control messages between the terminal and the network.

Subscriber Interfaces Supported for Locally Switched Services

The signaling interfaces supported by the SCM-10A feature include:

- loop start
- ground start
- coin (coin first and dial tone first)
- loop reverse battery
- multiparty
- ISDN BRI (Type B)

The ringing types supported by the SCM-10A feature include:

- single party
- teen
- multiparty fully-selective
- CLASS
- distinctive
- revertive
- immediate

SCM-10A Maintenance

Automated Maintenance

The automated maintenance of the SCM-10A feature system includes:

- autonomous switch activity (SWACT) when a fault is detected in the active unit
- automatic recovery actions when an ESMA shelf loses, then regains, communication with the host
- fault isolation, which determines the smallest replaceable unit to be changed in order to restore normal system status
- generation of logs and alarms upon detection of fault conditions and automated system maintenance actions
- use of scan points and signal distribution points as an interface to remote telemetry systems

P-side DS-1 link maintenance

DS-1 links are connected to the RDTs on the peripheral side (P-side) of the ESMA shelf. The following types of alarms are processed for DS-1 links:

- loss of synchronization (SYNC)
- frame slip (SLP)
- frame lost (FRLM)
- cyclic redundancy check (CRC)
- carrier fail alarm (RALM)
- card removal (PACK)
- alarm indication signal (AIS)

RDT Alarms

The DMS-10 switch monitors reports of alarms from the RDTs. An alarm is sent from the RDT to the DMS-10 switch if the following conditions are met:

- EOC messaging is active between the DMS-10 switch and the RDT.
- The event occurring at the RDT has a corresponding error type.

Alarm information is output in log reports (output messages), in the following format:

ALM*nnn* THE INDICATED RDT ALARM HAS JUST BEEN ASSERTED
3547 PROC_EOC_MSG
class *status* *category* *location* *alarm text*

where:

nnn	is the message number, from 320 through 329
class	is either MIN (minor), MAJ (major), or CAT (catastrophic), for the particular event indicated in the message
status	is either SET (alarm asserted) or CLR (alarm retired)
category	is one of the categories described in Table 2-B, below
location	is the location of the RDT
alarm text	is the alarm text from the RDT received in the EOC message

Table 2-B lists the possible log reports, by category, that can be output to the DMS-10 and shows the kinds of events that generate them. Not all of the categories shown in the table may be supported by all RDTs.

RDT external alarms If the RDT supports the external alarms message class, the "environmental" category alarm can be reported to the DMS-10 switch. When an environmental category alarm occurs at the RDT, EOC messaging between the RDT and the DMS-10 switch is performed and the alarm scan point number is extracted from the EOC message. If the alarm point is not defined in the host switch, a corresponding error message containing the scan point number and alarm text included in the EOC message displays. For example, the following message might be output when alarm point 3 is asserted in a SLC2000 RDT:

**ALM221 MAJ SET RDT1 IDE1 ENV-3 INPUT ACTIVE

If the alarm point is defined, a corresponding error message is displayed in accordance with the scan point number, source mnemonic, and alarm class assigned to the alarm point. For example, the following message might be output when alarm point 3 is asserted in a SLC2000 RDT:

*ALM021 MIN SET RDT1 DOOR

An alarm count is stored for each RDT according to alarm category and level of severity within each category. The alarm counts can be retrieved by using the LIST ACNT command (see the description of Overlay ALO in NTP 297-3601-506, *Maintenance Diagnostic Input Manual*).

Table 2-B:
RDT alarm log reports

Log report category	Triggering event
Transmission (facility)	degraded signal
	framing error
	loss of frame
	loss of pointer
	loss of signal
	alarm indication signal
	equipment failure
Equipment	power problem
	line card problem
	processor problem
	terminal problem
	timing problem
	fuse failure
Environmental	rectifier failure
	battery failure
	cooling fan failure
	enclosure door open

Table 2-B: (Continued)
RDT alarm log reports

Log report category	Triggering event
	storage capacity problem
Software	memory mismatch
	corrupt data
	out of CPU cycles
	software environmental problem
	software download problem
Service	line card problem
	performance monitoring threshold
Threshold alert	other triggered threshold
Indeterminate	cause of problem that occurred cannot be determined

Swact function with ESMA

The ESMA shelf can perform either a cold switch of activity (cold Swact) or a warm switch of activity (warm Swact).

Cold Swact function with ESMA The ESMA shelf can perform a cold switch of activity (Swact). When a Swact is performed, the active unit becomes inactive, the inactive unit becomes active, both units are initialized, and all calls are dropped. Any static data is transferred from the former active unit to the new active unit.

If a Swact occurs when the standby unit is in service but has not achieved “ready state,” or if the inter-module communication (IMC) link is faulty, or if the standby unit is not in normal sync, or if the host has received a message indicating a data table transfer failure, the Swact is cold.

The following events occur during a cold Swact:

1) The standby unit is set to busy.
2) The active unit is set to busy.
3) The previous standby unit is returned to service, making it the new active unit.
4) The previous active unit is returned to service, making it the new standby unit.
5) The new active unit starts call processing.

The duration of the cold Swact process is approximately 2 minutes.

Warm Swact function with ESMA A warm switch of activity (Swact) enables the host to maintain stable calls during a switch of activity from an active unit to the standby unit. For a warm Swact to be performed, both ESMA units must be in-service and the standby unit must be in the “ready state.” The inter-module communication (IMC) link connecting the two controllers must also be ready.

The following events occur during a warm Swact:

1) The active unit sets an activity switch interrupt in the standby unit.
2) The active unit drops activity.
3) The standby unit assumes control and becomes the active unit.
4) Both units report the Swact to the host. The old active unit reports that it has dropped activity and the new active unit reports that is has become active.
5) The new active unit starts call processing.
6) Calls that are in a transient state (such as dialing or ringing) are dropped.

The duration of a warm Swact is approximately 5 seconds.

Pre-Swact query Pre-Swact query is the process to determine that the standby ESMA unit is ready to take control after a Swact. A request is sent by the host to the active unit which, in turn, runs an audit in the standby unit through the IMC link. The pass/fail response determines whether the Swact can continue.

A pre-Swact query is performed for warm Swacts that are initiated manually through the SWCH command in Overlay DED (NTP 297-3601-506, *Maintenance Diagnostic Input Manual*).

Swact back The Swact back causes activity to switch back to the originally-active controller when a switch of activity is unsuccessful. When a Swact begins, the newly-active controller tests for two-way communication with the host. If the communication test fails, control is returned to the originally-active controller.

Path protection switching

The TMC and EOC are dedicated message channels between the IDT and the RDT. For every IDT-RDT connection there is a dedicated TMC channel and an EOC channel on two DS-1 links. One link is designated as the primary path while the other is designated as the secondary path. Although both paths must be in service, only one path is active at a time. The active EOC and TMC paths have default appearances on separate channels of the primary DS-1 (channels 12 and 24, respectively) and on corresponding channels of the secondary DS-1. Path protection switching is the process of switching activity from the channels of the primary DS-1 to the standby channels of the secondary DS-1 when a fault on the primary link is detected.

Initiation of path protection switching is initiated either by operating company personnel or through automatic fault detection. Either end of the path must be capable of detecting a failure and initiating a protection switch. In either case, a path switch may be originated by the ESMA shelf or by the RDT, after a failure is detected. There is no automatic switching back to the original path configuration after the fault causing the protection switch has been corrected. Software buffers store any messages that might arrive during a path protection switch and, thus, the messages can be re-sent after the switching process has finished.

A protection switch takes approximately 10 seconds to complete.

EDCH pack sparing

The Enhanced D-channel Handler (EDCH) pack (NTBX02) supports the ISDN D-channel carrying Q.931 messages for ISDN call processing. Each pack contains 32 LAP-D channels. Channel 0 is reserved for connection to the Enhanced ISDN processor (EISP) pack (NTBX01). Channels 1 through 31 are used either for passing the Q.931 messages to the EISP card for ISDN call processing or for passing the Bd channels from the D-channel through the ESMA matrix to the packet handlers.

In the BRI application, the EDCH pack terminates layer 2 for an ISDN service group (ISG). The ISG is a logical entity which may include ISDN lines from several RDTs. If a fault occurs on the EDCH pack, the ISG being served by the faulty pack can be transferred over to a spare EDCH pack. EDCH sparing takes approximately 2 seconds.

Remote Switching Center (RSC-S)

The RSC-S is a remote switching system comprised of a family of DMS-100 remote peripherals, based on Common Peripheral Module (CPM) architecture. The RSC-S provides a low cost alternative to HSO/SSO configurations and increased DMS-10 line capacity as a result of line concentration and Intraswitching. The primary system components include:

- Remote Cluster Controller 2 (RCC2) shelf, which contains the central processing equipment and circuitry for the RSC-S
- Line Concentrating Modules
- Remote Maintenance Module (RMM) shelf, which is used for maintenance and line diagnostics

These RSC-S components are provisioned in the following two cabinets:

- Cabinetized Remote Switching Center (CRSC), which houses the RCC2, the RMM and an LCM, and provides control for associated LCMs and RMMs as directed by the host, maintenance and service circuits provided by the RMM, and up to 20 DS-1 links which can be used for digital trunks

- Cabinetized Line Concentrating Equipment (CLCE), which houses up to two LCMs, each of which can contain 640 line cards; up to three CLCEs and up to 4480 lines can be supported in a single RSC-S configuration

The RSC-S supports the OPM, OPAC, OPSM, RLCM, RSLM, RSLE, and SCM-10S. This conserves host resources and DS-1 links, expands intraswitching and ESA capabilities, and increases flexibility in network configuration. The additional primary system components that enable the remotes to be configured with the RSC-S include:

- DS-1 links for connection to the RLCM, OPM, RSLM, RSLE, and OPSM

RSC-S configuration

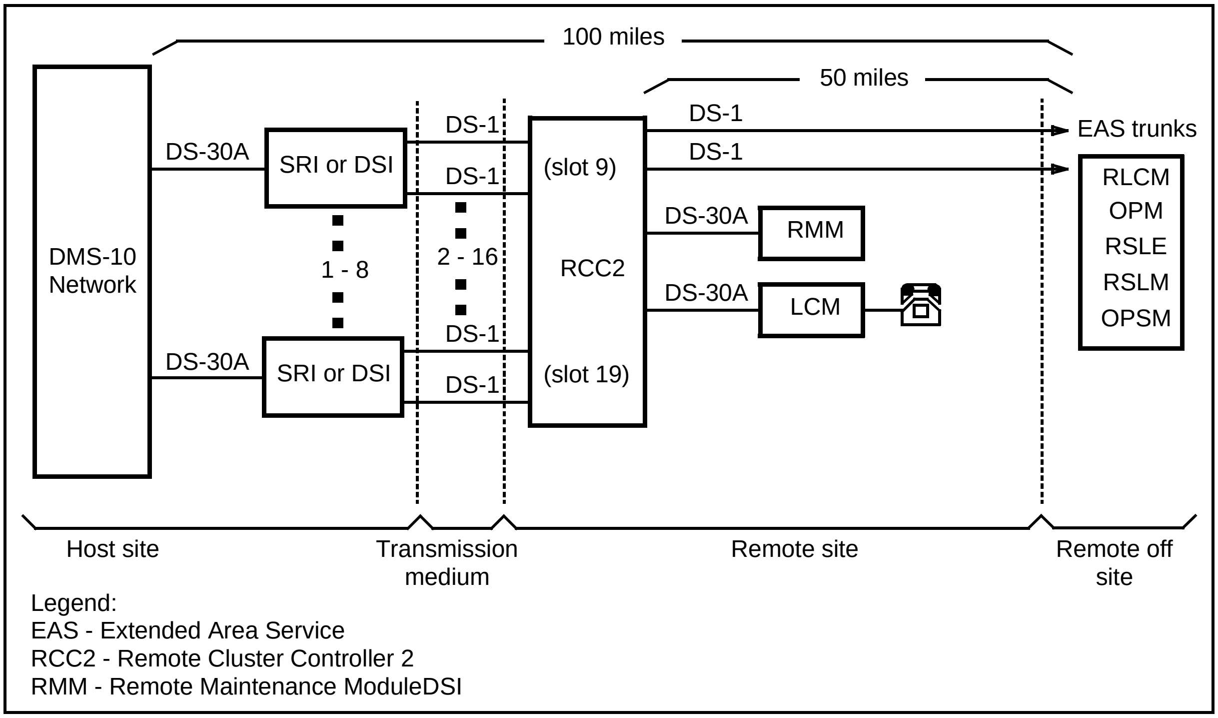
The RSC-S is connected to the host DMS-10 switch by way of a minimum of either 2 Subscriber Remote Interface links supported by NT4T09 Subscriber Remote Interface (SRI) packs or 2 Digital Signal Interface links supported by DSI modules (in SRI mode). Two links are supported by each SRI pack or DSI module; either one link is used for signaling and the other is used as a speech link, or both links are used as speech links. A maximum of 16 links to the RSC-S can be supported with two links used for signaling (one channel is used for signaling in each of these two links). Figure 2-46 shows a sample RSC-S configuration.

RSC-S trunking

P-side links for a device are links that extend to the device's peripheral equipment; C-side links extend to the device's control equipment. RSC-S trunking provides the operating company with the capability to use the P-side of the RCC2 to terminate trunks to and from central offices and to offer Emergency Stand-Alone (ESA) on these trunks. Thus, trunks off of an RSC-S may be intraswitched to RSC-S lines.

The RSC-S connected to a DMS-10 only supports dynamic trunks, or trunks that do not have a permanently allocated C-side channel. To minimize C-side channel usage, a call originating at an RSC-S can be routed (that is, intraswitched) to a trunk hosted on the same RSC-S site, assuming that a trunk with the required direction is defined at that site. Since the DMS-10 switch is unable to distinguish among trunks in the same group at different sites, all members of a trunk group must be located on the same RSC-S.

Figure 2-46: RSC-S configuration



RSC-S remotes

The RSC-S supports the remotes connected to it through P-side DS-1 or DS30-A links. In this configuration, a remote unit can be located up to 100 miles from the host office. This distance limitation is imposed to meet standards for echo performance on 0dB line-to-line calls. The RSC-S and its subtending remote should be located within that distance limit unless host-remote calls are padded with 2dB loss. A remote can be located up to 50 miles from the RSC-S because if an intraswitched call is blocked at a remote LCM, it can be intraswitched at the RSC-S and still be within the 100-mile distance limit.

RSC-S software

The software of an RSC-S connected to a DMS-10 switch consists of DMS-10 CPU software (host software) and the RCC2 software. The basic design of this software enables:

- line messaging and alarms to pass through the RSC-S
- the RSC-S to treat digital trunks in the same way that the Multiplex Loop Interface (MLI) treats Digital Carrier Module (DCM) trunks
- RSC-S resources (Universal Tone Receiver (UTR), CLASS Modem Resource (CMR), tones) to be utilized, thus releasing the host's resources for other use

- digit collection and outpulsing for tones to be handled by the RSC-S
- maintenance to be controlled by the host DMS-10 switch

For a description of ESA and Intraswitching capabilities pertaining to the RSC-S, see NTP 297-3601-105, *Features and Services Description*.

RSC-S maintenance

The host DMS-10 switch is able, through the maintenance subsystem, to load, control, diagnose, and provide status information for the RSC-S. Maintenance activities are initiated by manual commands issued from the host DMS-10 switch, by scheduled processes such as audits, and when unsolicited messages from the RSC-S notify the host switch about faults in the RSC-S that have been detected.

The three primary functions of the maintenance subsystem are fault detection, fault isolation, and fault recovery. The maintenance subsystem tests all components of the RSC-S continuously in order to detect failures in peripherals as early as possible. Faults may be detected by call processing software during normal operation, by hardware, or by periodic audits. Because the RSC-S has duplicated controllers, most internal faults can be isolated so that the functionality of the peripheral is not affected. An activity switchover (Warm Swact/Cold Swact) to an unaffected unit removes most faulty components from operation and is usually the first recovery action performed. (For a complete description of the Swact feature, see NTP 297-3601-105, *Features and Services Description*.) The next action performed is fault localization through the listing of faulty components and the diagnostics that should be run on these components. The diagnostics to be used are fully described in NTP 297-3601-506, *Maintenance Diagnostic Input Manual*.

Test access from the DMS-10 host to the RSC-S

RSC-S LCM lines can be tested from the host DMS-10 switch. For a description of metallic access testing RSC-S LCM lines, introduced in Generic 412.20, see section 7, “Line and trunk test equipment interfaces” in NTP 297-3601-500, *General Maintenance Information*.

RSC-S remotes maintenance

Maintenance of remote controllers is the same as that for remotes connected directly to the host office. Maintenance of DS-1 links that connect remotes to the RSC-S is the same as that for RSC-S trunks. For a description of metallic access testing for remotes connected to the RSC-S, see section 7, “Line and trunk test equipment interfaces” in NTP 297-3601-500, *General Maintenance Information*.

Voice Over Internet Protocol (VoIP)

Session Initiation Protocol -SIP Lines

Packet-Switched Networks

A packet-switched network carries voice and data traffic as a series of discrete messages (“packets”), rather than a continuous time-division-multiplexed bit stream. The following table lists the network elements and their sub-components that make up the DMS-10 packet network product offering and provides a brief description of their function. These symbols are used in Table 2-C: and throughout the remainder of this document.

Table 2-C: The role of each element in the network

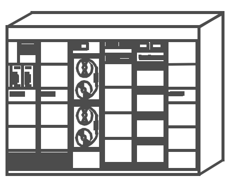
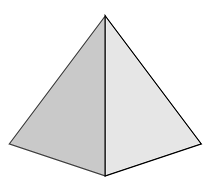
Network element	Sub-componet of element	Description of role
Network Intelligence		
DMS-10 		Provides the intelligence for operations, administration, maintenance, call routing, call control, end-user services, and billing functionality. In a hybrid TDM/packet network configuration, a DMS-10 will support current TDM peripherals as well as IP-based endpoint devices.
	System Processor Pack (NT3T98) **System Processor (NT3T98)**	The DMS-10 System Processor pack (NT3T98) is the central processing unit for both the 500-Series and 600-Series generic releases. The System Processor pack has an ethernet interface which supports 10Base-T 10 Mbps ethernet. The ethernet interface enables the DMS-10 to connect to the IP-based packet network for signaling.
	Communications Server 	The communications server performs all functions related to completing calls. A device driver receives call control messages from IP-based endpoint devices and generate events. These are reported to call processing which uses them to set up calls over the packet network. Call control commands are then sent back to the IP-based endpoint devices by way of the device driver.

Table 2-C: The role of each element in the network

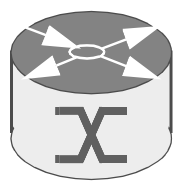
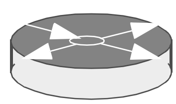
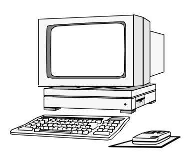
DMS-10 (cont.)	Packet Gateway Interface **Packet Gateway Interface**	To support packet networks a new DMS-10 network component will be introduced - the Packet Gateway Interface (PGI). Designed to route call control and provide voice bearer path interworking between peripherals on the DMS-10's TDM network and IP-based endpoint devices.
DMS-10 Central Office Local Area Network		The DMS-10 Central Office Local Area Network (CO LAN) delivers messages between subcomponents of the DMS-10. The CO LAN consists of the following components:
		Router may be used in a CO LAN to concentrate the number of links from all Packet Gateway Interfaces (PGIs) to the packet network. In addition, security features and services available in the router may be used to protect the DMS-10 data network infrastructure.
		Ethernet switch or hub functions as repeaters in local area network. Operates at layer 2 of the Open System Interconnection (OSI) reference model.
	OAM&P Equipment 	The ethernet interface on the System Processor pack (NT3T98) enables the DMS-10 to provide services and features such as: Operations, Administration, Maintenance, and Provisioning (OAM&P) via a Telnet interface; patch delivery; Integrated Billing Storage and Retrieval (IBSR); and CALEA (Communications Assistance for Law Enforcement Act) Call Data Channel.
	Remote Access Server (RAS) **Remote Access Server**	A Remote Access Server (RAS) provides dial-in access to the DMS-10 CO LAN from a location outside the service provider's network to provide support remotely. A RAS device establishes a remote connection on demand and only as long as necessary.

Table 2-C: The role of each element in the network

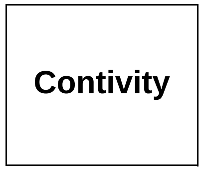
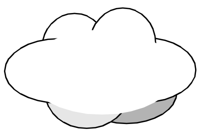
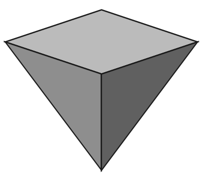
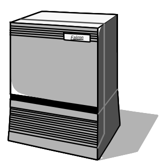
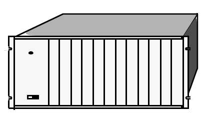
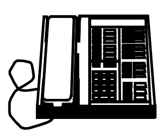
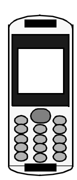
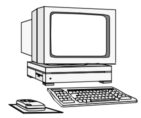
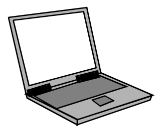
DMS-10 Central Office Local Area Network (cont.)	Contivity 	The Contivity VPN Switch enables secure IP connections from a location outside the service provider's network to provide support remotely. The Contivity Switch provides authentication, authorization, encryption, and routing for connecting to network elements from outside the network.
IP Packet Network		
Subscriber Access WAN 		From this point forth in this document, the term "Subscriber Access WAN" shall refer to the IP-based packet network used to transport the packetized bearer and call control signaling between the DMS-10 communications server and the IP-based endpoint device.
IP-based endpoint device		
SIP user agents 	The User Agent (UA) is the SIP entity that interacts with the user. SIP UAs are implemented on top of many different systems, such as:	
	Gateways and Terminal Adapters  	Gateways provide the connectivity between the packet network and other networks or devices (e.g., subscriber lines, circuit-switched networks, wireless networks, data and video services, etc.). Terminal Adapters or access devices provide the connectivity between the packet network and other devices (e.g., analog phones, faxes, and computers). Devices can vary in size from small integrated access devices to large multi-service access platforms. The devices contain a SIP user agent.
SIP user agents (cont.)	IP Telephones  	Dedicated device resembling traditional telephone. Telephone contains a SIP user agent.

Table 2-C: The role of each element in the network

	Computers   	Computer program contains a SIP user agent.

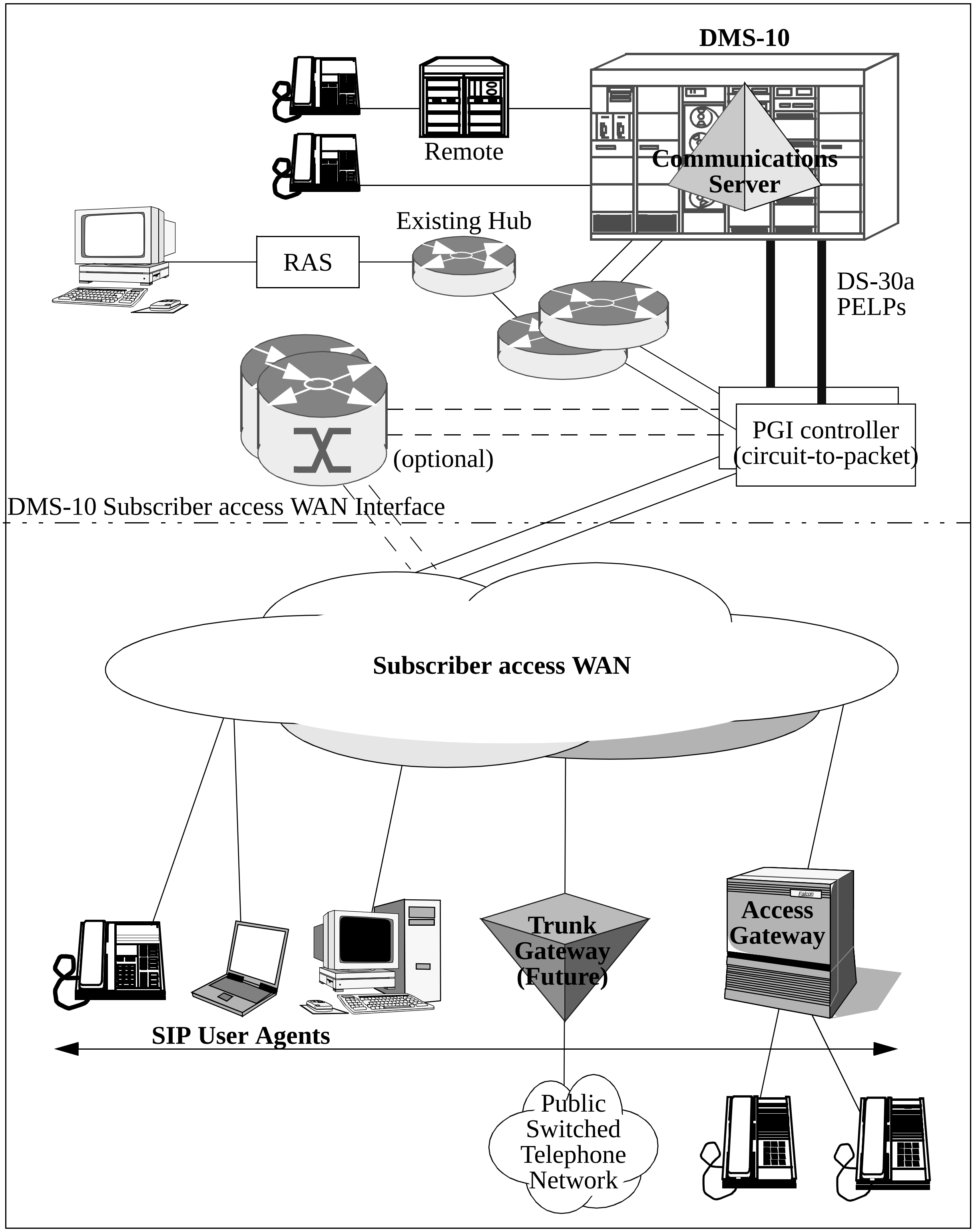
Nortel DMS-10 Packet-Switched Network

From a network perspective, the DMS-10 functions as the communications server and interfaces to a number of network elements to provide voice over an IP-based packet network. Looking at Figure 2-47, the DMS-10 packet-switched network consists of four main areas (See Section 2):

- SIP user agents;
- Subscriber Access WAN;
- DMS-10 Central Office Local Area Network (CO LAN);
- DMS-10 switch.

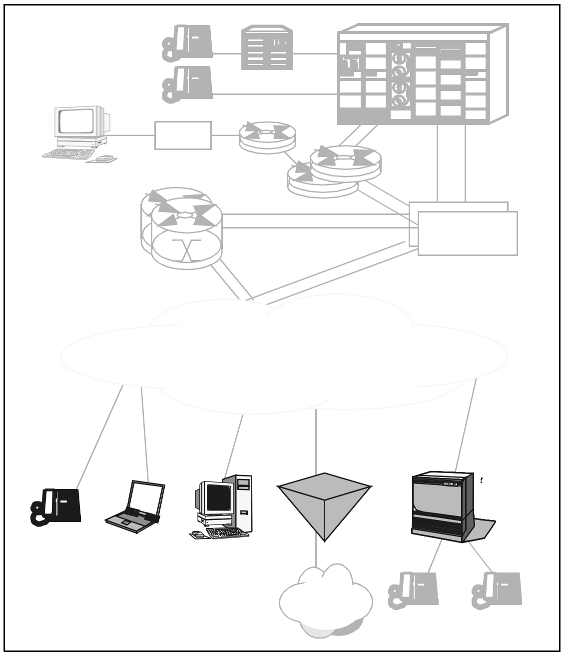
Each of these areas is described in the following sections.

Figure 2-47 Nortel DMS-10 Packet Network



IP-based Endpoint Devices

Figure 2-48 IP-based Endpoint Devices



This section describes the IP-based endpoint devices in the DMS-10 packet network product offering, as emphasized in Figure 2-48. IP-based endpoint devices are external to the DMS-10 system and are described here in general terms.

This document does not assume that the user's service provider is the same as the DMS-10 service provider; for example, an access gateway in an Enterprise Network.

SIP User Agents

Initially, the DMS-10 will support the *Session Initiation Protocol* (SIP) and IP-based endpoint devices that handle the SIP signaling. These devices are known as *SIP user agents.* SIP user agents are positioned at the edge of the packet network and offer a wide range of voice, data, and video services. SIP user agents provide connectivity from the device's user interfaces directly to a common subscriber access WAN.

SIP user agents may provide a single access platform for multiple services. This is accomplished by combining voice, data, and video services into a single device, with a single network interface and single management infrastructure.

The initial DMS-10 packet network product offering will support devices that have SIP user agents. Therefore, the device must support the SIP signaling so that call control messages can be sent between the SIP user agent and a communication server, such as the DMS-10. The SIP user agent will provide an end office appearance for voice and data communications over a subscriber access WAN. The device uses the subscriber access WAN to carry IP packetized voice and data traffic, as well as call control signaling.

SIP user agent line types

The objective is that subscriber line features shall operate in such a way that there is no apparent difference to a subscriber who is moved from a TDM line termination to an IP-based line termination with a SIP user agent. However, the features and services available to SIP user agents will be limited.

SIP user agent resources

SIP devices shall provide appropriate resources commonly used in providing voice services. SIP user agents are responsible for the interface towards the user. For example, the following resources are assumed to be available within an access gateway or telephone device:

- Call progress tones;

  For example, dial tone and special dial tone, ringback, busy, quiet, overflow (reorder), and call waiting tones.
- Dual-Tone Multi-Frequency (DTMF) digit receivers;
- Dial Pulse (DP) digit receivers;
- Custom Local Area Signaling System (CLASS) modem resources;

  Used for Customer Premise Equipment (CPE) with Caller ID displays and message waiting indicators.
- Power ringing - support the existing ringing patterns for North America;
- Echo cancellation.

Network Interface

The SIP user agent device’s physical interface to the subscriber access WAN is beyond the scope of this document.

Session Initiation Protocol (SIP)

The DMS-10 will support the Session Initiation Protocol (SIP). SIP is a new Web signaling protocol currently being defined by the Internet Engineering Task Force (IETF) for controlling multimedia *sessions*. In other words, it provides a way to establish, modify, and terminate real-time, multimedia sessions that integrate voice, data, and video. It is not a protocol used for controlling devices.

The SIP user agent devices must support the protocols listed in Table 2-D: and Table 2-E: between the DMS-10 communications server and the SIP user agent device for bearer path and call control.

Table 2-D: SIP user agent protocol stack

OSI Model Layer		Bearer path	Call Control
Layers 5 through 7:	higher layer protocols or applications	G.711 PCM T.38 Fax relay RTP	SIP
Layer 4:	transport	UDP	UDP
Layer 3:	network	IP	IP
Layer 2:	data link	(Ethernet, ATM, etc.)	
Layer 1:	physical	...	

Table 2-E: SIP user agent protocols

For	Standard	Function
Call control	SIP	Session Initiation Protocol. An Internet standard developed by the Internet Engineering Task Force (IETF). SIP is used between the DMS-10 communications server and SIP user agents to establish, modify, and terminate multimedia sessions.
Bearer path	G.711 PCM	ITU standard for the Pulse Code Modulation (PCM) of voice-frequency signals. G.711 PCM bearer data is carried in Real-time Transfer Protocol (RTP) packets.
	T.38 Fax Relay	ITU recommendation T.38 for Fax over IP, permits the transport of facsimile data in Internet Protocol packets to the PSTN via UDP/IP.
	RTP	Real-time Transfer Protocol is a standard for streaming real-time media over IP in packets. RTP supports transport of real-time data such as voice and video over packet switched networks.

Notes and Limitations

There are several important differences between a SIP line termination and a traditional subscriber line termination.

Service Outages

Subscribers will lose service during commercial power outages when they do not provide backup power, or when there is an outage with their broadband service provider.

Mobility

Provided the user has access to the internet and sufficient bandwidth (e.g., broadband), access can be provided independent of location.

Emergency calls

Because SIP user agents are portable and the exact location of the user is not readily available through SIP, two issues must be addressed:

- When a user temporarily moves location, a call to the emergency services will be connected to the emergency services bureau associated with the user’s provisioned data (i.e., the emergency region assigned to the subscriber’s directory number); this may not be the emergency services bureau closest to the caller’s location.
- Caller identification data sent to the emergency services bureau is determined from the user agent’s provisioned data (i.e., directory number). This information may reflect the user’s permanent location and not the actual location of the caller when they have temporarily moved to another location.

Synchronization

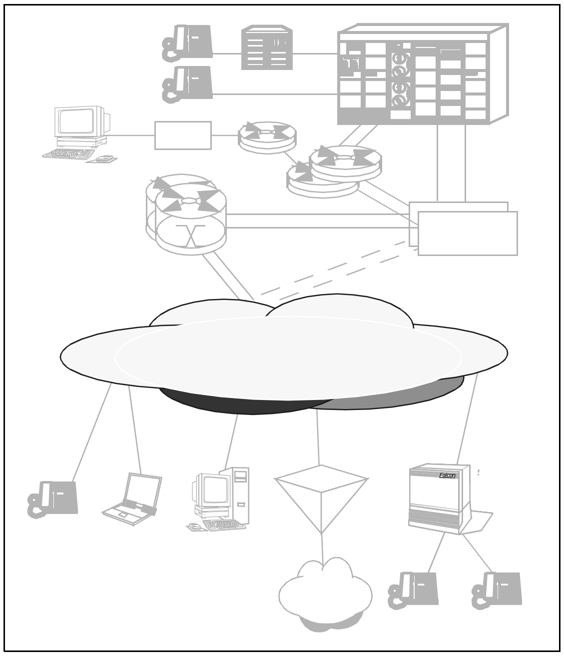
The IP-based endpoint device’s clock must be synchronized to an accurate clock source. The device may use a clock source such as either a Simple Network Time Protocol (SNTP) time server, a Building Integrated Timing Supply (BITS) clock source, a clock signal derived from the interface to the subscriber access WAN, or an accurate internal clock.

SNTP is designed to synchronize the clock of a SNTP client with the clock of a SNTP server. This SNTP server in turn acts as a Network Time Protocol (NTP) client to several highly accurate clock sources. This allows the time of day on every node in the system to maintain a very accurate clock. When supported by an IP-based endpoint device, the address of the SNTP server would be provisioned in the device.

An external BITS clock source may be used, for example, by some high capacity gateways.

Subscriber Access Wide Area Network

Figure 2-49 Subscriber Access WAN



This section describes the Subscriber Access WAN in the DMS-10 packet network product offering, as emphasized in Figure 2-49. The subscriber access WAN is external to the DMS-10 system and is described here in general terms.

This document does not assume that the packet network service provider is the same as the DMS-10 service provider.

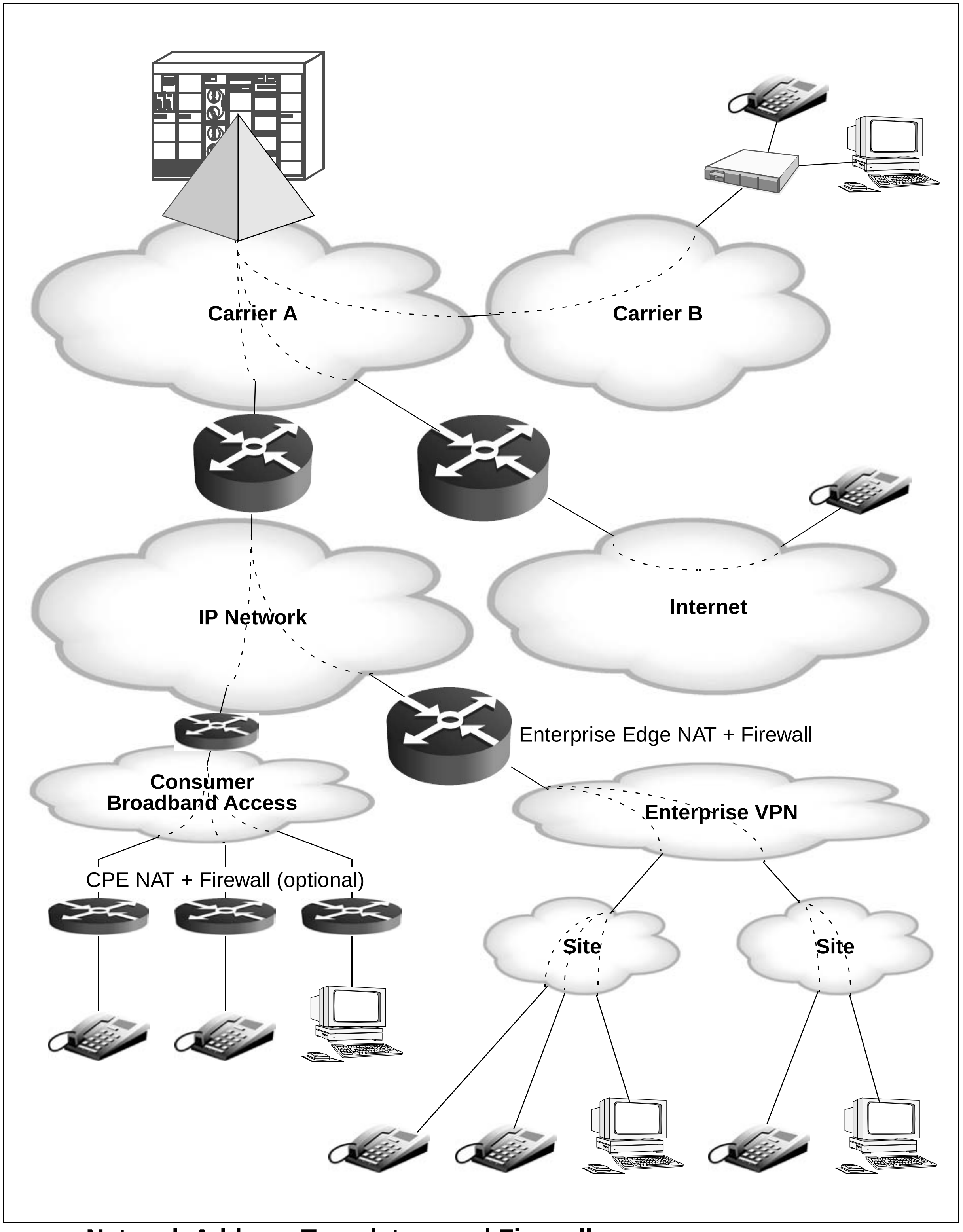
The OAM&P of the Subscriber Access WAN is not a function of the DMS-10. There is no requirement for the DMS-10 to be capable of communicating with the network elements of the Subscriber Access WAN for purposes of administration and provisioning.

Definition of “Subscriber Access WAN”

For the remainder of this document, the phrase “subscriber access WAN” will be used to represent a collection of interconnected packet networks, as shown in Figure 2-50. These packet networks, working together, provide the transmission path for all of the packetized voice, data, and video traffic, as well as call control signaling that is passed between IP-based endpoint devices and the communications server; for example, between SIP user agents and the DMS-10 communications server.

The subscriber access WAN will most likely be spread over a wide geographic area. When the DMS-10 carrier’s packet network is connected to the internet, access can be provided independent of location provided the user has sufficient bandwidth (e.g., broadband) to support voice service.

Figure 2-50 Subscriber Access WAN Overview



Network Address Translators and Firewalls

One technical problem for the SIP implementation on the DMS-10 is that of Network Address Translation (NAT) and firewall traversal.

Network Address Translators (NATs)

A NAT is commonly found in subscriber access paths between remote users and a packet network, such as the Internet. It serves the purpose of translating private IP addresses to public IP addresses and may be implemented in Customer Premise Equipment (CPE) based access devices, Enterprise access devices, or within the Internet “cloud” (see Figure 2-50).

Firewalls

A firewall will generally not allow unauthorized traffic to pass through it in a public-to-private direction; a proxy will receive traffic from one side of the network boundary and re-present it on the other side after ensuring security. Only legitimate transactions can reach critical LAN subnets.

NAT and Firewall traversal

The NAT and firewall functions are often co-resident in the same access device.

The problem is that NAT implementations are not always application transparent and can restrict certain IP-based protocols from traversing the network. SIP is one such protocol. Many NAT devices do not pass SIP traffic and therefore prevent remote SIP user agents from communicating to their host switch or other users from communicating with SIP user agent behind a NAT/firewall.

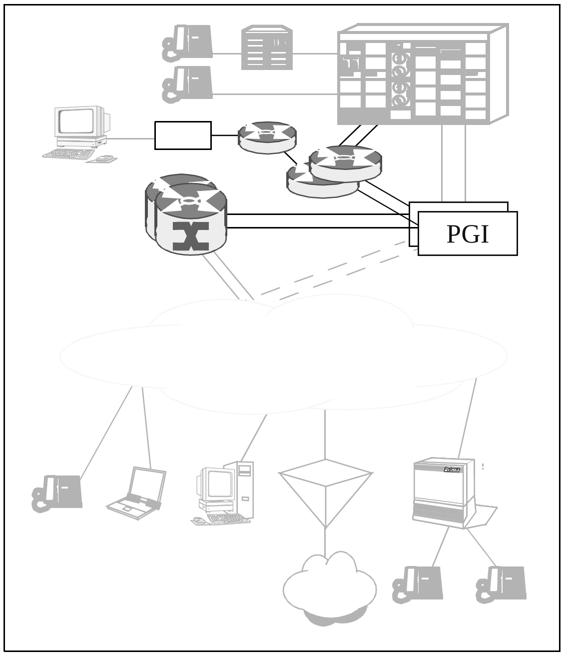
SIP is not meant to bypass firewall security policies. However, SIP should be firewall friendly.

The DMS-10 packet network product offering solves the problem of NAT and firewall traversal by implementing a "RTP Media Portal" design.

> ***Note:*** *Refer to 297-3601-906 NTP for more details.*

MS-10 Central Office Local Area Network

Figure 2-51 DMS-10 Central Office Local Area Network



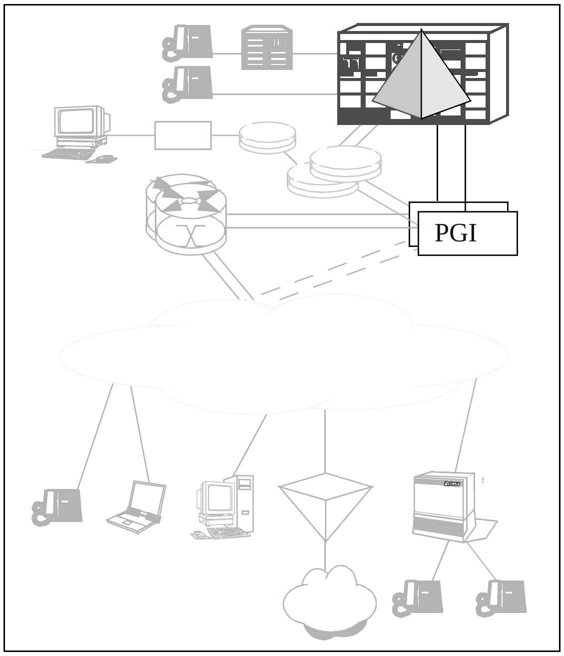
This section describes the data networking equipment and characteristics that comprise the DMS-10 Central Office Local Area Network (CO LAN) in the DMS-10 packet network product offering, as emphasized in Figure 2-51. The main DMS-10 sub-components covered in this section are:

- DMS-10 System Processor
- Existing OAM&P data network
- New Ethernet Switch
- Packet Gateway Interface (PGI)
- Network Connection device (optional)

Note: *Refer to 297-3601-906 NTP for more details.*

DMS-10 System Architecture

Figure 2-52 DMS-10 System Architecture



This section describes the DMS-10 system in the DMS-10 packet network product offering, as emphasized in Figure 2-52. The main DMS-10 sub-components covered in this section are:

- DMS-10 Communications Server
- Packet Gateway Interface (PGI)

The circuit-to-packet network gateway interface product offering will be an evolution of Nortel's ***500-Series*** DMS-10 circuit switches, peripherals, and software. For more information on the base 500 series, refer to Nortel's Technical Publication (NTP) 297-3501-100 *General Description*.

All current DMS-10 TDM peripherals will be supported when soft-switch capability is added to the DMS-10. In a hybrid TDM/packet network configuration, a DMS-10 will support current TDM peripherals as well as IP-based endpoint devices; the initial DMS-10 packet network product offering will support SIP user agent devices. This will allow traffic to operate between current DMS-10 peripherals and new IP-based endpoint devices with full DMS-10 feature transparency.

To support packet networks a new DMS-10 network component will be introduced - the Packet Gateway Interface (PGI). Designed to route call control and set up calls over the packet network, the Packet Gateway Interface will also provide voice bearer path interworking between peripherals on the DMS-10's TDM network and IP-based endpoint devices.

DMS-10 Communications Server

The “communications server” function will be performed by software programs running on the System Processor pack (NT3T98) Central Processing Unit (CPU), as shown in Figure 2-53 on page 116.

The initial DMS-10 packet network product offering will support SIP user agents. The number of features and services that will be available to those SIP user agents will be limited.

Protocol Handler

Parsing of call control messages will be performed by the software functions running on the System Processor pack. Call control messages will flow between the System Processor pack and the IP-based endpoint device. These messages will pass through the Packet Gateway Interface (PGI) and will be transported by the subscriber access WAN network elements.

SIP Servers

SIP servers receive requests in order to service them and send back responses to those requests. The “SIP servers” will be software functions running on the System Processor pack. The SIP server entities, are as follows:

- Proxy servers

  Proxy servers are devices in the signaling path between SIP user agents. They route requests and responses on towards their destination. Proxy servers are similar to a router, but at the SIP level.

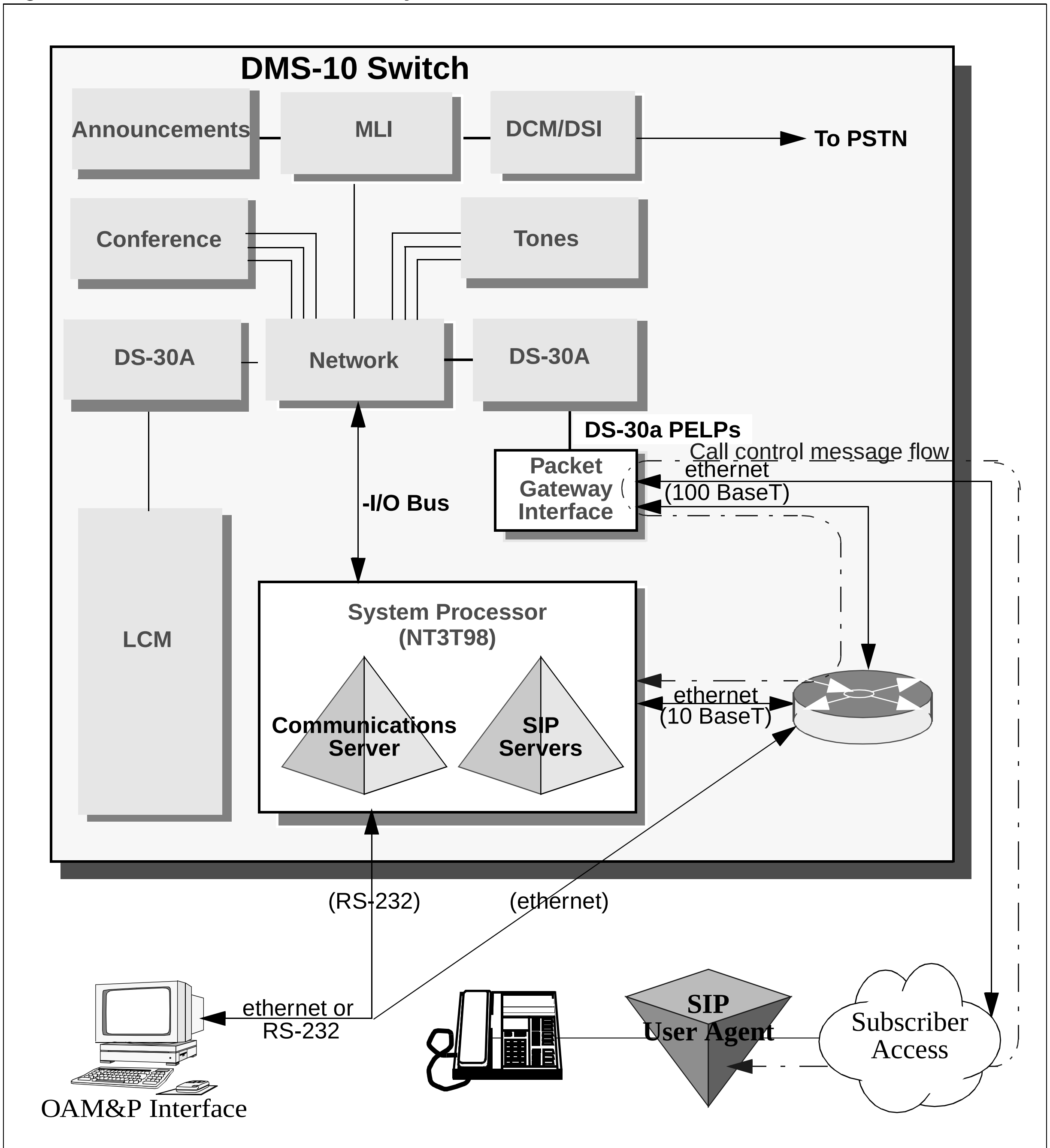
- Registrar

  Accepts user location messages (registrations) and updates a location database.

- Location database

  The location database is not a SIP entity, but is included here because it is an important part of any SIP architecture. The location database stores and returns a possible location for a user.

Figure 2-53 DMS-10 Packet Gateway Interface Architecture



Packet Gateway Interface

To support packet networks, a new DMS-10 network component will be introduced - the Packet Gateway Interface (PGI), as shown in Figure 2-53.

The PGI will route call control messages and set up calls over the packet network and will also provide voice bearer path interworking between peripherals on the DMS-10's TDM network and IP-based endpoint devices.

When a circuit-to-packet bearer path interworking between TDM and IP-based packet networks is required, bearer packets will flow between the IP-based endpoint device and the PGI where the packets are converted to TDM and vice versa.

A PGI has two separate PGI controller packs for reliability, each pack having its own redundant power supply. In the event of a single failure condition, the PGI can continue to operate but at half its normal capacity.

Each PGI will be connected to the DMS-10 network equipment by up to sixteen (16) DS-30A peripheral loops. Each PGI will also have six (6) ethernet ports (10 BaseT/100 BaseT) supporting both internal and external IP network addresses.

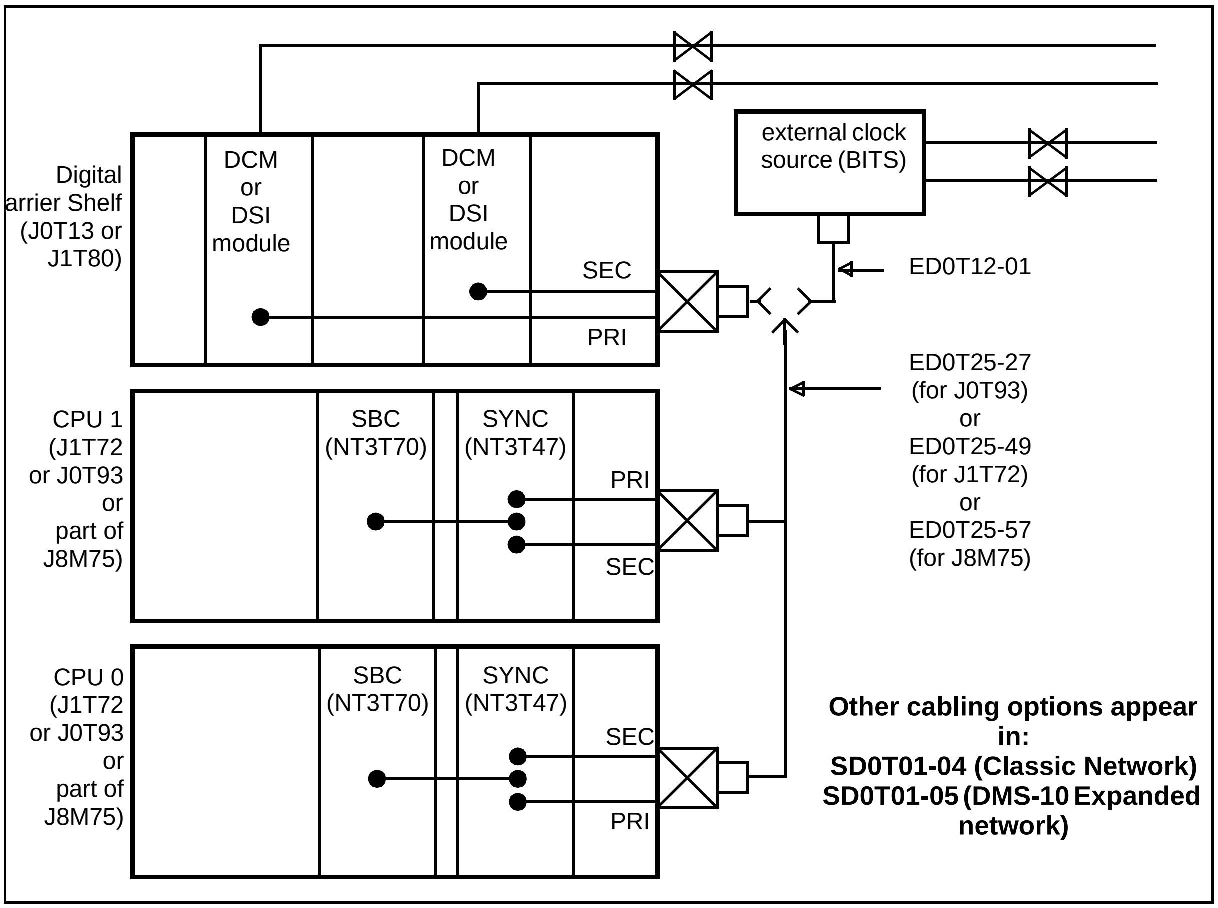
As the packet network expands, additional PGIs may be added to accommodate higher VoIP traffic. The number of PGIs required will be determined by engineering rules; a minimum of one (1) is required.

System clock synchronization

System clock synchronization permits the DMS-10 switch to function in a synchronized digital network. Synchronizing the timing of several digitally interconnected switching centers minimizes the number of frame slips (lost or duplicated information) in digital interconnections.

As Figure 2-54 shows, the hardware required for system clock synchronization includes a Synchronous Clock pack (NT3T47) on each Control shelf and the System Bus Controller pack (NT3T70). The Synchronous Clock pack contains a voltage-controlled crystal oscillator with a nominal frequency of 20.48 MHz. The nominal frequency is adjusted by software to maintain the same frequency relative to an 8 kHz reference clock. The System Bus Controller pack uses the 20.48 MHz clock signal generated by the Synchronous Clock pack to provide the 8 kHz, 5.12 and 4.096 MHz signals required by the system.

Figure 2-54: Clock synchronization equipment



The Synchronous Clock pack derives a clock rate from a *master* clock reference. The clock signals may be obtained either from an external clock reference source or from the DMS-10 switch. External clock reference source signals are obtained either through DS-1 links by way of a Digital Carrier Module (DCM) or by way of a Digital Signal Interface (DSI), or directly from an external clock source (External Synchronous Interface). Figure 2-55 illustrates the DMS-10 system architecture for the synchronous clock feature.

External clock signals from DS-1 links

In this configuration, clock signals are obtained from two DS-1 links, one designated *prime* and the other *alternate*. In the event of failure of the prime clock reference or clock synchronization hardware, the alternate clock reference source can take over. When a clock reference source fails, the Synchronous Clock pack goes into *holdover* mode, in which no frequency changes occur, until the lost clock reference source is restored. When the clock reference is restored, the Synchronous Clock pack goes into a normal operating mode.

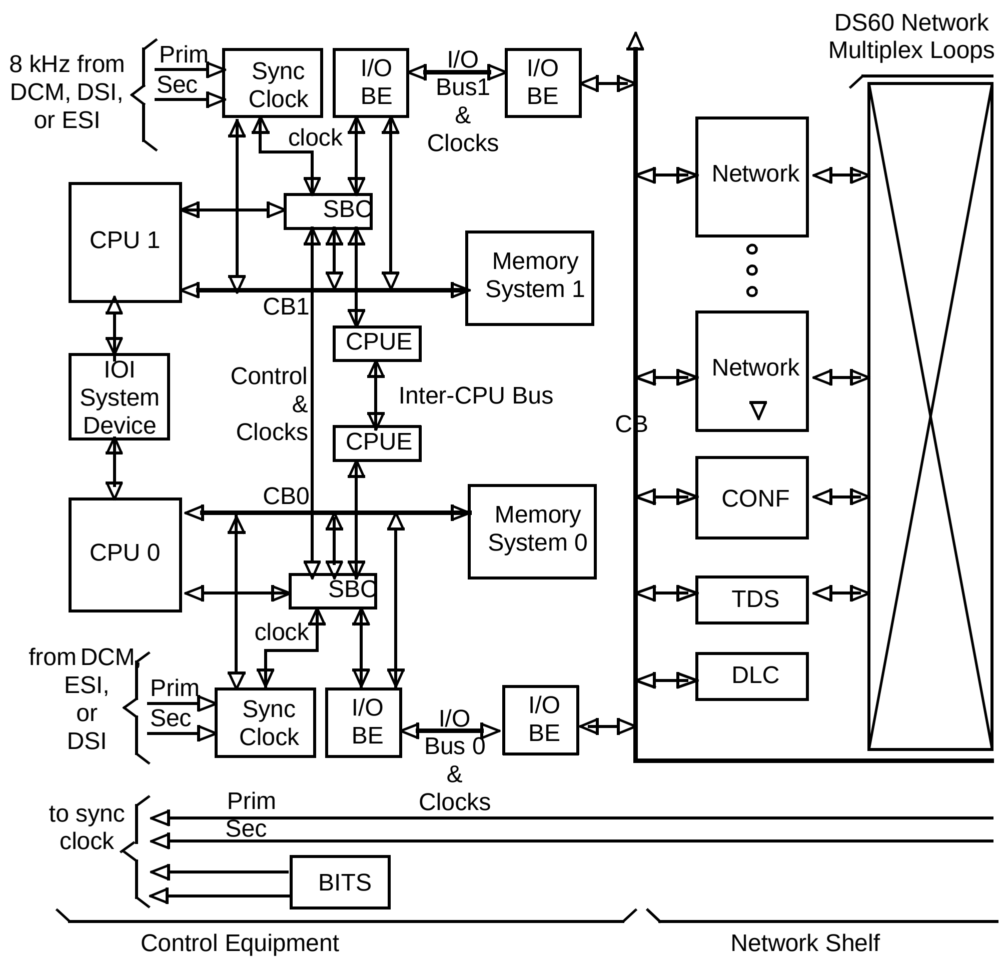
External Synchronous Interface

In this configuration, the Synchronous Clock pack is able to synchronize to 8 kHz clock signals from a Telecom Solutions DCD-400 Building Integrated Timing Supply (BITS) or equivalent unit. This eliminates the need for DCMs that would otherwise be required for connection with the clock synchronization source. For connection to the Synchronous Clock pack, a special adapter cable, which is available from Nortel Networks, must be used. In addition, the Telecom Solutions DCD-400 must be powered from within the DMS-10 isolated ground zone, and must be located within 100 feet of the NT3T47 in the DMS-10 switch.

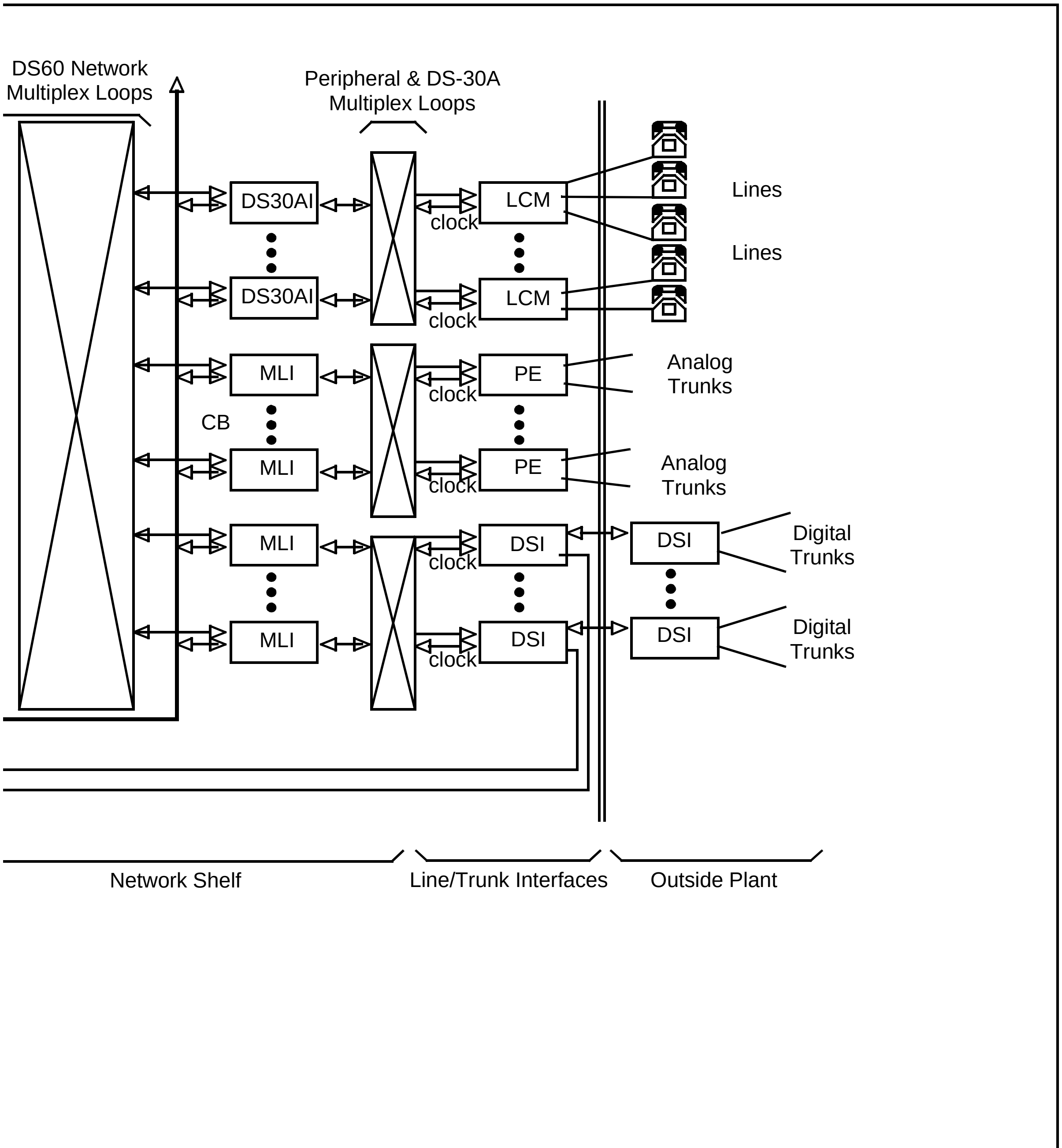
Clock signals from DMS-10 switch

In this configuration, a group of offices are able to synchronize with a DMS-10 master clock reference office which uses a Stratum 3 clock located in the office as the clock source. For a procedure used to set up this capability, see SOP 0141 in NTP 297-3601-311, *Data Modification Manual*.

Figure 2-55: System architecture for synchronous clock



Legend:
BITS - Building Integrated Timing Supply; **CB** - CPU System Bus; **CONF** - Conference Circuit (through the NT4T03); **CPU** - Central Processing Unit; **CPUE** - CPU Extension (CPU Bus Extender pack); **DCM** - Digital Carrier Module; **DS30A**I - Digital Signaling 30A Interface; **ESI** - External Synchronous Interface; **I/O BE** - Input Output Bus Extender; **IOI** - Input/Output Interface; **LCM** - Line Concentrating Module; **MLI** - Multiplex Loop Interface; **PE** - Peripheral Equipment; **SBC** - System Bus Controller; **TDS** -Tone and Digit Sender (NT4T01)


DS60 Network
Multiplex Loops
Peripheral & DS-30A
Multiplex Loops
DS30AI
DS30AI
MLI
MLI
MLI
MLI
CB
LCM
LCM
PE
PE
DSI
DSI
DSI
DSI
clock
clock
clock
clock
clock
clock
Lines
Lines
Analog
Trunks
Analog
Trunks
Digital
Trunks
Digital
Trunks
Network Shelf
Line/Trunk Interfaces
Outside Plant

Clock Sync Enhancement

The Clock Sync Enhancement improves operational and maintenance capabilities of the clock synchronization system. With this enhancement, the operating company personnel are able to:

- override automatic synchronization reference source switching (INH REFS and ALLW REFS commands in overlay CED, *Maintenance Diagnostic Input Manual* [297-3601-506])
- change synchronization reference sources (SWCH REF command in overlay CED, *Maintenance Diagnostic Input Manual* [297-3601-506])
- change phase-locked loop states (CHG SYNC command in overlay CED, *Maintenance Diagnostic Input Manual* [297-3601-506])
- query for the time of the last synchronization reference source changeover (STAT SYNC command in overlay CED, *Maintenance Diagnostic Input Manual* [297-3601-506])
- query for the number of synchronization reference source changeovers occurring during the current day (STAT SYNC command in overlay CED, *Maintenance Diagnostic Input Manual* [297-3601-506])

In addition, phase-locked loop state changes and the causes for the changes are automatically reported by the switch. Operational measurements showing the number and type of span line errors for each DCM or DSI are available on a quarter-hourly, half-hourly, hourly, daily, or weekly basis (see SPAN measurement block [OPM035] in *Operational Measurements* [297-3601-456]).

This enhancement also makes available a new phase-locked loop operational mode, *holdover*. In the *holdover* mode, the active Synchronous Clock pack (NT3T47) has lost connection with its previous synchronization reference source and is using either data acquired during the *normal* mode or internal data to retain its accuracy with respect to the last good frequency from the reference source. The system enters the *holdover* mode either when both reference sources are experiencing problems, when automatic synchronization reference source switching has been inhibited and the primary reference source is experiencing problems, or when a service-affecting hardware fault occurs.

Section 3: System software

Software structure

The DMS-10 software is divided into a system of hierarchical modules, each of which is responsible for a function or a set of functions (see Figure 3-1). In this hierarchy, software at the higher levels builds upon the capability provided by the lower levels.

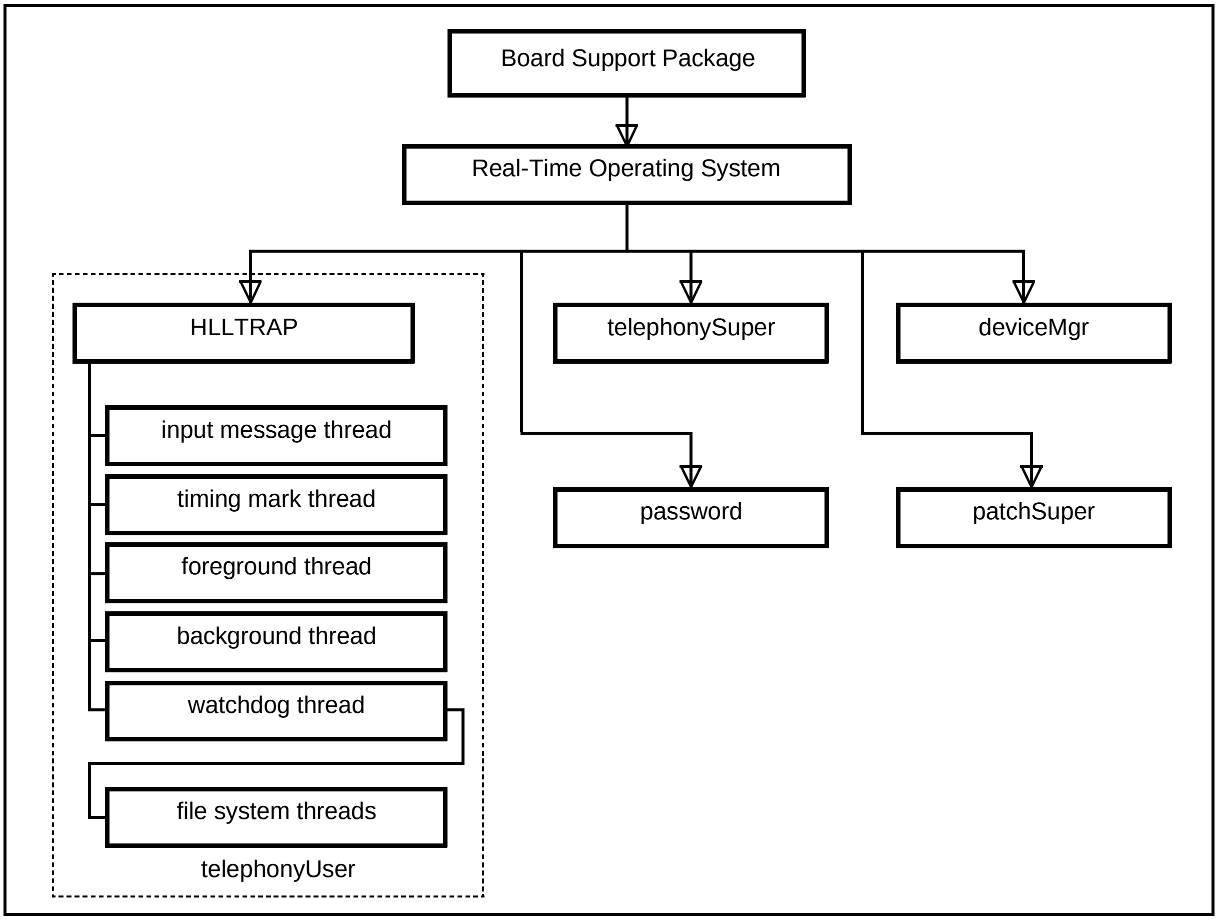
The system software is divided into the following functional units:

- operating system
- file system
- overlay system
- I/O system
- operational measurements
- call processing

Operating system

The real-time operating system (RTOS), which governs the normal operation of the switch, is responsible for loading the DMS-10 software from the file system, after which control is passed to various supervisory and user software applications called “actors.” Each actor contains one or more streams of executable code called “threads.” For example, the “telephonySuper” actor has access to the supervisor memory map, is responsible for performing interrupts in response to events that require immediate attention, for auditing memory, and for loading the “telephonyUser” actor. The telephonyUser actor, in turn, contains executable code for the high-level language trap (HLLTRAP), INITIALIZE, and scheduling procedures, and the administration and maintenance programs, called “Overlays.”

Figure 3-1: System software structure



Operating system directed system restart

There are two separate restart processes used for the System Processor, a low-level process and a high-level process. Restart decisions, including whether to switch CPUs or initiate a system load, are controlled by low-level and high-level telephony software. Examples of hardware-initiated restarts that are not determined by telephony software are:

- 4-second watchdog timeout
- CPU power failure
- changeover button depression detected by the NT3T70

The low-level system restart process ensures functionality for the RTOS and basic hardware. It enables the high-level process to be performed. The low-level process uses the Board Support Package (BSP), which resides in EEPROM firmware, to test and initialize the hardware before loading the RTOS. The BSP tests and configures the devices required to properly load and run the RTOS. If failures are found during testing, recovery firmware re-configures the system in order to minimize system downtime. When faults are detected, the BSP saves debugging information for later analysis. Major BSP functions include:

- bringing the NT3T98 into a known state
- testing hardware functions to ensure a proper operating environment
- handling the boot sequence for reloading the RTOS
- passing control to the RTOS when reloading is not required

A TRAP process residing in the BSP saves register values when multiple low-level faults occur. The TRAP process provides a reference point by retaining a record of register values at the time the faults occurred. The TRAP process does not interact with high-level software during a restart recovery.

High-level system restart uses three procedures that reside in DMS-10 telephony software. Those three procedures are:

- telephony restart
- High-level language trap (HLLTRAP)
- INITIALIZE

All faults detected by telephony software, and determined to be critical enough to cause a restart, begin with the telephony restart process. Telephony restart notifies the RTOS restart manager to restart the RTOS and other essential programs. This process can occur on either the active or inactive CPU. After completing its task, the restart manager transfers control back to the telephony software and the HLLTRAP process. HLLTRAP responsibilities include:

- ensuring that interrupts are turned off for initialization testing
- ensuring that the Field Programmable Gate Array (FPGA) registers are set to a known state
- determining memory quality
- initializing the file system

After completion, HLLTRAP passes control to the INITIALIZE process to complete the restart process. INITIALIZE initializes and tests all I/O bus interfaces and prepares the system for call processing. In instances where the initialization was due to a fault condition, it also has the task of isolating the fault cause. This task consists of checking the TRAP and determining if the cause has been isolated from the system.

There is no cross-mode functionality. This means that if a component on the inactive CPU complex is faulty, the DMS-10 does not try to use other components. During restart, the DMS-10 switch re-initializes to an initial entry point. Access to the permanent storage media for reloading is not required. Protected call store (PCS) and data store (DS) are not deleted during a restart. During high- or low-level recovery, calls in progress remain intact but calls in process are dropped.

A high-level restart cannot be performed unless the system has been previously loaded with both code and office data and is in a known state. It does not affect the processor, therefore no processor tests are performed. Only telephony software can initiate a high-level recovery on the active CPU. If other DMS-10 software processes encounter a fatal error, that software process is terminated. Telephony software initiates a restart on the active CPU based on detection of a critical system fault or if a critical fault occurs in the RTOS kernel. The telephony restart notifies the RTOS restart manager which transfers control to HLLTRAP and then INITIALIZE. A restart on an inactive CPU begins with telephony restart communicating with the inactive CPU's BSP, through the NT3T70. The BSP notifies the RTOS restart manager which, in turn, notifies high-level recovery HLLTRAP and INITIALIZE processes.

A low-level restart on an inactive CPU begins with the BSP on the active CPU detecting a hardware fault and communicating with the inactive CPU's BSP, through the NT3T70. The inactive CPU's BSP notifies the RTOS restart manager which, in turn, notifies high-level recovery HLLTRAP and INITIALIZE processes. Since fault detection occurs at the BSP level, the high-level telephony restart process is not required during recovery,

Telephony User Task scheduling

Time-critical call processing receives the highest priority in task scheduling. Scheduling is controlled by the RTOS through independent threads of execution. Each thread performs a specific task which is processed in a timeslice and is then held until scheduled by the RTOS again. These threads are:

- timing mark thread, which invokes foreground processing to service the timing queues
- input message thread, which processes input messages from the message queues
- foreground thread, which performs timing and resource management functions
- background thread, which performs tasks such as providing time slices for audits, OPMs, maintenance, and user interface

Interrupts

The NT3T98 receives four externally-generated (off board) interrupts, and produces another six interrupts internally (on board). These ten interrupts are combined in the interrupt controller function of the FPGA and sent to the processor as a single interrupt. Tables 3-A and 3-B list all ten interrupts.

Table 3-A: System Processor system Externally Generated Interrupts

Mnemonic	Description
READY	Ready Interrupt (generated from the NT3T50 and NT3T70)
LINT	Line Interrupt (generated from the NT4T16, NT4T01, NT4T04, NT4T05)
IOINT_BP	I/O Backplane Interrupt (generated from the TTY, NT3T90, and Alarms)
IOINT_CAB	I/O Cable Interrupt (generated from the inactive processor TTY)

Table 3-B: System Processor system Internally Generated Interrupts

Mnemonic	Description
MINT	Manual Interrupt (generated from the manual interrupt button)
PINT	Periodic Interrupt (generated from the periodic interrupt timer)
WDINT	Watchdog Interrupt (generated from the watchdog timer)
OSINT	Operating System Interrupt (generated from the operating system timer)
DBINT	Serial Debug Port Interrupt (generated from the UART)
INT_MAC	Ethernet MAC Interrupt (generated from the Ethernet Controller)

When one of the ten interrupts is detected by the Field Programmable Gate Array (FPGA), it generates an external interrupt request to the processor. The Real Time Operating System (RTOS) Interrupt Manager (IM) handling function is activated to handle this interrupt request. The IM saves and restores the user environment when an interrupt occurs. The IM checks the CPU Status Register to determine the cause of the interrupt. Once the interrupt source has been determined, the appropriate interrupt handler is called.

Overlay system

DMS-10 system administration and maintenance programs, called “Overlays,” reside permanently in system memory. Determining which overlays are active is performed by a background task called overlay supervisor. To ensure that operating company personnel have the access to an overlay when it is required, the overlay supervisor maintains a priority based on the user class.

If an overlay is active when a higher priority user requests another overlay, the overlay supervisor automatically aborts the current overlay at the completion of a logical sequence. The overlay supervisor also aborts an overlay if the overlay is not in use for an administered period of time.

Depending on compatibility, multiple administration overlays can run simultaneously from different I/O ports. The compatibility of each overlay request is compared against a list of active overlays. The overlay supervisor assigns a first timeslice to a DMO request that has passed a compatibility check. Maintenance overlays always receive a normal timeslice. Each overlay to receive a timeslice is marked accordingly and the next active, unmarked overlay is selected to receive a timeslice.

Maintenance diagnostics

Maintenance overlays can be executed upon the request of operating company personnel or system software, either automatically on a scheduled basis or manually on detection of a fault condition. When requested by software, maintenance overlays operate in a free-running mode. Otherwise, they operate in an interactive mode with operating company personnel by way of a data terminal.

On detection of a fault, a free-running maintenance overlay automatically attempts to reconfigure the system so that it can continue operation. This reconfiguration is accomplished by sparing the faulty equipment with redundant circuitry. When the overlay is interactively requested, operating company personnel can test and reconfigure the system through direct commands.

For general descriptions of each diagnostic overlay, see the NTP entitled *Maintenance Diagnostic Input Manual* (297-3601-506).

Data modification

Office data are entered into DS by means of data modification order (DMO) overlays. The office data, which are initially defined when an office is installed, includes the following major categories:

- system configuration
- dialing plan
- prefix, address, and screen translators to provide digit translation
- routing data based on completed translations
- trunk interfaces to other offices
- subscriber station options

For an explanation of DMO prompting sequences and for procedures to perform specific DMO tasks, see the NTP entitled *Data Modification Manual* (297-3601-311).

Input/output system

The I/O system software provides the human/machine interface for the system. It handles all requests from the system software for I/O devices.

Requests from the I/O subsystem are executed as background tasks. A centralized I/O program arbitrates among the I/O requests to ensure that the same device is not used simultaneously by several requesting programs. Storage media may be accessed simultaneously by multiple users. The programs enter data in the appropriate I/O buffer in CS. The contents of the buffers are then output to the I/O devices as availability and priority warrant.

Operational measurements

The OPM software monitors system performance and level of service. These programs accumulate data associated with various system functions. There is also an OPM overlay used to set the parameters for the storage and printing of OPM data.

The purpose of the OPM system is to assist switch administration and switch maintenance activities in the following areas:

- day-to-day system performance calculations
- plant maintenance programs (on the basis of OPM data, maintenance tasks can be scheduled during periods of low equipment use)
- traffic studies (for cost separation)
- facilities planning (OPM data can be used to determine the quantity of equipment required to maintain a level of service)
- traffic studies on individual line and trunk circuits

For detailed information on the measurements kept by the OPM system and on the overlay program that controls the system, see the NTP entitled *Operational Measurements* (297-3601-456).

Call processing

The call processing software performs all functions related to completing calls. The separation of the call processing and device driver logic has already been noted. The device drivers collect messages from peripheral devices and generate events. These are reported to call processing, which determines whether any new devices are required. Control commands are then sent back to the peripheral devices by way of the device drivers.

However, the call processing and device driver logic is further subdivided to provide various software sub-modules that correspond to the different states that a peripheral device or a call may assume. The separation of the call processing logic and device driver logic, and the sub-modules contained in each, is illustrated in Figure 3-2.

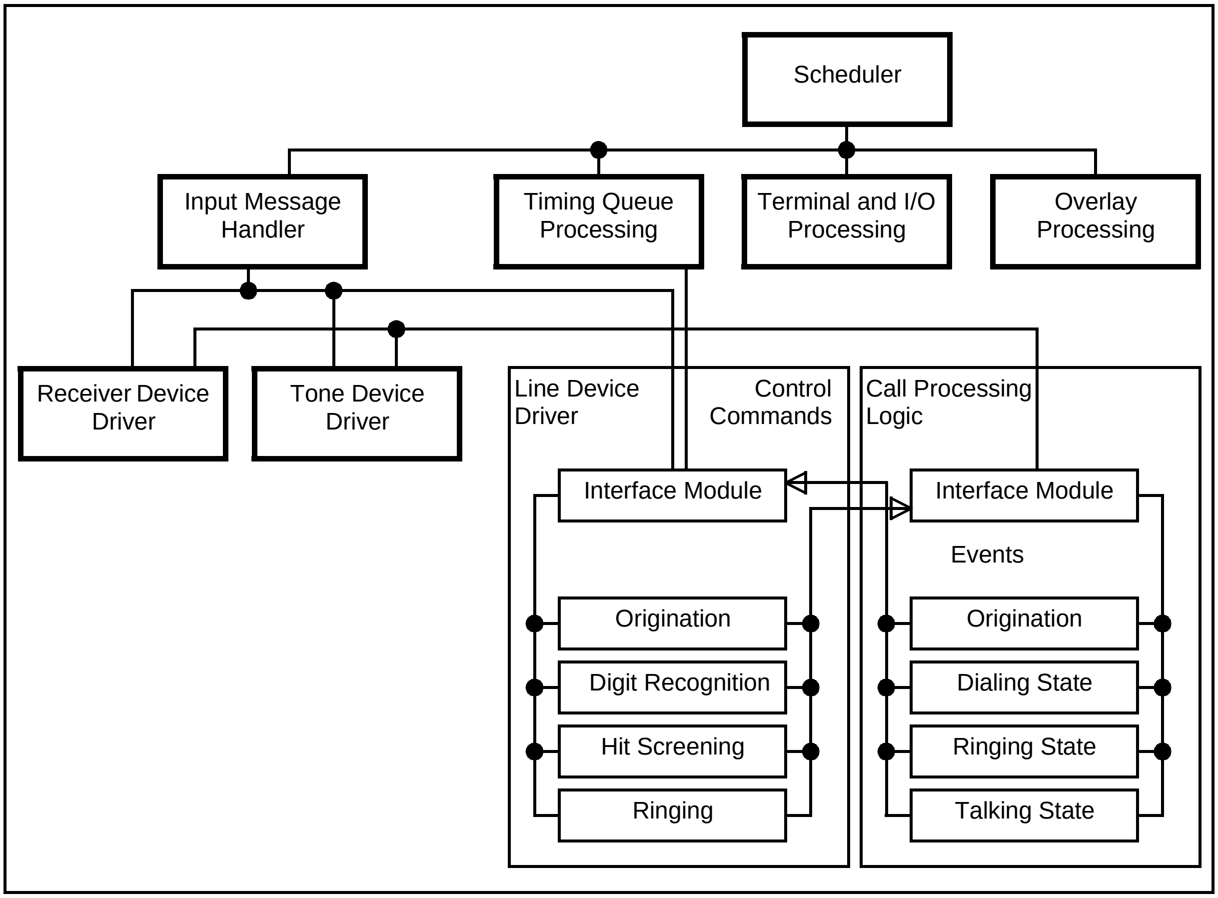
Based upon the events detected, the call processing software selects a course of action, executes the course of action, and waits for another event. Each event is evaluated in the context of the current state of the device that originates the event. For example, an on-hook (loop-open signal) received during dial-pulse dialing has an entirely different meaning than an on-hook received after a call has been connected.

An intraoffice call connection is described below. The description traces the steps followed in processing a dial pulse (DP) call from calling party A to called party B.

Origination

When calling party A lifts the handset, contacts are closed in his/her subscriber loop. This closure is recorded as a change of state on the line card associated with the subscriber's line. The change of state is sensed by the Bus Interface Circuit (BIC) card, which is continuously scanning all the cards in the Line Drawer it serves. The BIC card then generates a message and sends the message through an output buffer to the Line Concentrating Module (LCM) Processor pack on the LCM shelf. The LCM Processor formats the message, and the Digroup Control card then sends the message over a DS-30A multiplexed loop to a DS-30A Interface pack (NT4T04) on a Network shelf or Network Interface pack (NT8T04) on a CNI shelf.

Figure 3-2: Call processing software modularity



The DS-30A pack or Network Interface pack passes the message to the CPU as an interrupt. The CPU firmware interrupt handler reads the message from the interface pack and puts it in the CPU input message buffer. The input message handler then removes the message from the buffer for processing.

The idle/busy map in CS is checked to determine the last known status of the line. Because the last known status was idle, and the present status of the line is off-hook, the message handler recognizes that the off-hook signals an origination, and it marks the line as busy. The handler then consults DS to determine the options assigned to the line. With this information, the handler obtains a line device register and a call register to store transient data during the call. The call processing logic now takes over because it has been informed that the caller has lifted the handset.

On receiving an origination from the subscriber's line, Call Processing logic connects a dial tone from the Tone and Digit Sender (TDS) pack (NT4T01) or from the Global Tone Services pack (NT8T04) through the digital network to the line circuit. The subscriber can now hear a dial tone. The line device register is simultaneously put in a receive-digit state, the LCM is set to the digit recognition state, and the call processing logic waits for dialed digits.

The LCM Processor collects the on-hook/off-hook (make/break) events that constitute the dial pulses for a single digit. The device driver and call processing logic are informed of the dialing information as each digit is completed. On receiving the first digit, call processing logic disconnects the dial tone from the line of calling party A.

Translation and routing

Translation is the process of identifying a destination based upon analysis of dialed digits. The translation programs examine translation data structures specified in office data. As each digit is received and stored in the call register, the translation programs compare it to the data structures until a termination within the office or a route out of the office is recognized.

In this case, the dialed digits are found to correspond to the directory number (DN) for the called party B. The receive-digit function of the device register and the LCM digit recognition are then turned off. If the called line is idle, it is marked busy in the idle/busy map, and its options are checked to ensure that it is allowed to receive the call.

Ringing

Called party B is assigned a line register which is then linked to the call register. Call processing logic puts the line device register in a ringing state. Ringing current is applied to the line for called party B, and audible ringback tone is supplied to calling party A through a command to the TDS or GTS.

When called party B lifts his handset, his/her associated line device register informs the call-processing logic, which then commands the TDS or GTS to remove the audible ringback tone to calling party A. The line device register for Party B is put in a talking state to remove ringing.

Connection

When the call is established, timeslots on the DS-60 loops in the network are reserved for the speech data of the call. Network connection memory maintains a record of the timeslots reserved for every call in progress. The contents of this memory are controlled by the CPU. Speech data between the connected parties are exchanged by means of these timeslots for the duration of the call. The CPU plays no role in the call between call connect and disconnect.

Disconnection

When the LCM detects an on-hook signal from either party A or B, it notifies the call-processing logic by way of the DS-30A Interface pack (NT4T04) or Network Interface pack (NT8T04). The reserved path between A and B through the network is idled, the device register for the released party is idled, and the LCM is put in the off-hook timing state for that line. When the other party releases, call processing is notified as previously described. Both the device and call registers are idled, and the LCM is put in the off-hook timing state for that line. Both parties are marked idle in the idle/busy map. The call is now completely released.

Other call types

Processing of other call types follows the same basic pattern as described for the intraoffice call. Differences exist only in the type of device registers involved and in the possible states which may be recorded by registers. For example, Digitone (push button) reception rather than dial pulse reception may be required, or the call may originate from or terminate to a trunk rather than a line.

Memory configuration

The call processing, I/O, and overlay programs, along with their associated data, determine the memory configuration of the system. There are three basic types of memory: Program Store, Data Store, and Call Store.

Program Store

Program Store (PS) contains all of the machine-executable instructions assembled from the SL-1, C, and C++ source code. The PS resides, according to need, in read-only memory (EEPROM), in random-access memory (DRAM), and in the file system.

Program instructions that must not change and, therefore, must be protected from power failure, reside as non-volatile firmware. This firmware resides on the NT3T98 CPU. This firmware includes the procedures used to load and initialize software from the file system. It also includes TRAP, a program that controls recovery from various system faults.

Call processing programs reside in volatile RAM or DRAM. Memory resides on the NT3T98 CPU. To protect against software failure, a copy of the call-processing software is maintained in the file system and can be reloaded by the procedures contained in firmware.

In the CPU, administrative and maintenance overlays are resident in memory. Resident overlays reduce access time since they do not require loading from an I/O device.

Data Store

Data Store (DS) holds the write-protected office-dependent data, such as trunk and line assignments, or subscriber custom-calling data, such as abbreviated-dialing lists and call-forwarding information. System-related data, such as the data necessary for the translation and routing of calls, also resides in DS.

Call Store

Call Store (CS) holds the non write-protected, transient data associated with calls in progress, including call, device, billing, and maintenance registers that are set up and maintained in DRAM by the call-processing modules.

File system

The 500-Series generic file system is organized into files and directories. Directories are containers for files. The 500-Series file system is accessed from a common point known as the root directory. The root directory is represented by a forward slash “/”. All files and directories are accessible from the root directory.

Files are identified by their location, known as a path. A full path name includes the file's name and, starting from root, the directories that contain the file. For example, the full path name */dms10/projects/data* indicates that a file named “data” is stored in a directory named “projects”. The path name also indicates that the “projects” directory is located in another directory named “dms10". A directory that is stored within another directory is known as a sub-directory. The forward slash at the beginning of the path name indicates that everything is contained in the root directory.

Access permissions

The following three types of access permissions pertain to both files and directories:

- read
- write
- execute

For files, system users with “read” access can view those particular files. Those with “write” access can modify those particular files. “Execute” access only pertains to executable files that contain compiled machine instructions or commands. System users with “execute” access are able to run those particular executable files.

For directories, system users with “read” access can view a directory's contents which could consist of sub-directories and files. Those with “write” access can create new sub-directories and files within the directory. “Execute” access allows a system user the ability to access sub-directories and files within the directory. Although those users have the ability to access files and sub-directories, they still require read access to determine the directory's contents.

A 500-Series file system user that creates a file through an application, or creates a directory, becomes the owner of that file or directory. Generally the owner has the exclusive ability to delete, modify or control access to a file or directory. System users may belong to a group of users. Assigning permissions to a group allows specific users file and directory access by assigning that access to the group rather than each individual user. Granting file access permission to “other” allows all file system users access to a file or directory.

Disk partitioning

The hard disk is divided into four partitions. Each partition provides an isolated area on the disk for a specific function. Disk partitioning isolates static files from dynamic files to reduce the chances of errors caused by file system corruption.

The first partition stores static files that are normally included in the generic release package. Generally, these files are written into the partition once and then marked as read only. The second and third partitions are created when the disk is initialized. Applications are read from and written to these partitions. For this reason, partitions two and three are considered dynamic. The second partition contains permanent files that are updated on a regular, but not constant, basis. Office database dumps, for example, are written to the second partition. The third partition is used for temporary files and for files that are continuously updated. The fourth partition stores system upgrades and boot code.

Software packages

500-Series DMS-10 system upgrades and updates are distributed through software packages. Each package contains individual files packaged (using the UNIX “tar” command) as a single file. A software package may contain a complete generic release or an incremental release. The software package can be delivered to a 500-Series DMS-10 system either electronically through File Transfer Protocol (FTP) or using removable media. A package must be “un-tarred” before it can be installed. After installation, the package must then be activated.

Section 4: DMS-10 cluster configuration

Introduction

The DMS-10 cluster configuration allows a group of DMS-10 switches to be connected via digital and/or analog data links so that most administrative and maintenance tasks for the entire group of switches can be performed at a single, central location. This minimizes operating costs, providing an integrated network of low cost and high reliability.

Cluster overview

The cluster is organized in a radial pattern, with the hub switch designated as the Host Switching Office (HSO) and the offices at the ends of the radiating links designated as Satellite Switching Offices (SSOs). The HSO serves as the centralized maintenance and administrative location for the cluster, while at the same time performing its own Central Office operations.

Both the HSO and its SSOs may have Remote Equipment Modules (REMs), Subscriber Carrier Modules (SCMs), and Remote Line Concentrating Modules (RLCMs) connected to them. Any or all of the switching offices can be connected to other class 5 offices by adding trunks, allowing Extended Area Service connections. The network transmission loss plan does not change because the offices are clustered for maintenance and administration purposes only.

Large Cluster Controller

The Large Cluster Controller (LCC) is a host office that supports a greater cluster line capacity than an HSO, but does not perform telephone switching functions of any kind.

The LCC supports a maximum of 16 SSOs and approximately 55,000 subscriber lines. Although the HSO also supports up to 16 SSOs, its line capacity is limited to approximately 19,000 subscriber lines. All of the cluster-related features that an HSO supports, such as Operations Support Systems (OSS) and Automatic Message Accounting (AMA) billing backup, are supported by the LCC.

Hardware configuration

The LCC is a two-bay configuration (Figure 4-1) that is based on the DMS-10 three-bay configuration; however, the LCC contains no ringing equipment and no network or peripheral equipment, and does not perform call-processing or offer any subscriber services. Its purpose is to control and maintain cluster data processing and data exchange only. To support call processing and subscriber services at an LCC location, the LCC must be collocated with another DMS-10 switch (SSO) or DMS-100 switch.

The LCC contains a standard CE-3 bay (J1T83E-1) with the following provisioning modifications:

- Network packs are not provisioned in the combined CPU/Network shelves (J1T72B/C)
- a new Alarm Module is provisioned that contains no ringing equipment

In addition, the LCC contains a CE-1 bay (J1T30E-2), but it differs from the three-bay CE-1 as follows:

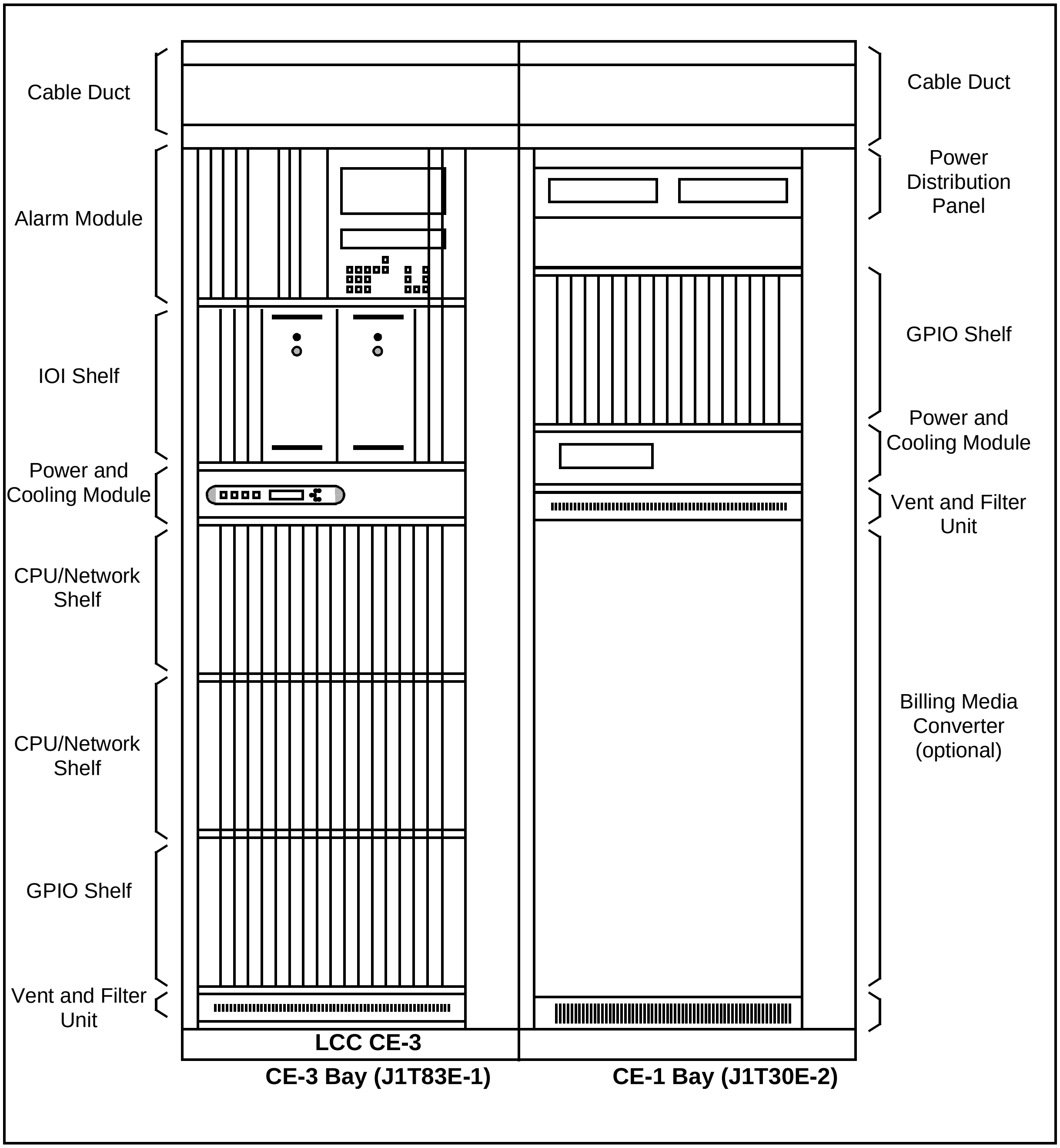
- the Power Distribution Panel (PDP), which is normally in the PE-1 bay, is instead provisionable in the J1T30
- the General-Purpose Input/Output (GPIO) shelf is provisionable on shelf 4
- a Power and Cooling Module (PCM) is provisionable below the GPIO shelf
- a Billing Media Converter (BMC) is provisionable (optionally) in the shelf space below the PCM

For more information about the LCC bays, shelves, and packs, see the NTP entitled *Equipment Identification* (297-3601-150).

Alarm system

The LCC supports the present system of maintaining the cluster by receiving cluster-related alarm printouts at the LCC's maintenance terminals. In addition, the LCC provides visible and audible alarm indicators located on the Alarm and Ringing Module, as well as its own alarm printouts at the maintenance terminals. However, when the monitoring of LCC alarms from a remote location is required (that is, the LCC is located in an unattended office), an automatic-dialing, alarm monitoring system that reports the status of the LCC's active alarms must be purchased by the operating company.

Figure 4-1: Large Cluster Controller bay configuration



Cluster synchronization

The HSO and all SSOs in a cluster have the ability to synchronize their local network clocks to incoming DS-1 (T-1) lines. Therefore, the cluster can be synchronized to an external master clock such as a class 4 switch (clock source to HSO to SSOs). Also, the HSO can provide its own clock to which the SSOs are synchronized.

The offices in a cluster should be synchronized so that link (T-1 span) stability is assured. While an HSO can provide the SSOs with a clock to which they can be synchronized, the LCC can not because it has no network clock. However, a DMS-10 switch collocated with an LCC could provide a master clock source to the SSOs through its DCMs or Digital Signal Interface modules (DSI) (see “Cluster architecture” for a discussion of colocation).

Cluster maintenance

Most maintenance tasks for SSO sites can be performed via the cluster maintenance terminal located at the HSO or LCC; thus, maintenance terminals are optional at SSO sites. On-site maintenance activities can be performed via a portable terminal connected to a port provided with the SSO, if a dedicated terminal is not on-site.

Cluster office memory allocation

The host and satellites in a cluster operate as independent class 5 offices; therefore, the satellites do not rely on the host for any direct call-processing functions. As a result, the major factor that limits total line size for the cluster is the throughput capacity of the data links that join the SSO(s) to the HSO or LCC.

In addition, an SSO's line size, its data link throughput capacity, its amount of traffic, its line-to-trunk ratio, and its resident software influence how memory (that is, Call Store) is to be allocated within that SSO. The combination of these factors in the individual SSOs in turn determines the allocation of memory in their shared HSO or LCC.

Specifically, how blocks of Call Store are allocated in any office is determined by the size of certain registers and message buffers that are defined as part of the Configuration Record. Formulas for accurately calculating the necessary sizes of these buffers in a particular office can be found in the AMA and BUFF prompting sequences of Overlay CNFG in the NTP entitled *Data Modification Manual* (297-3601-311).

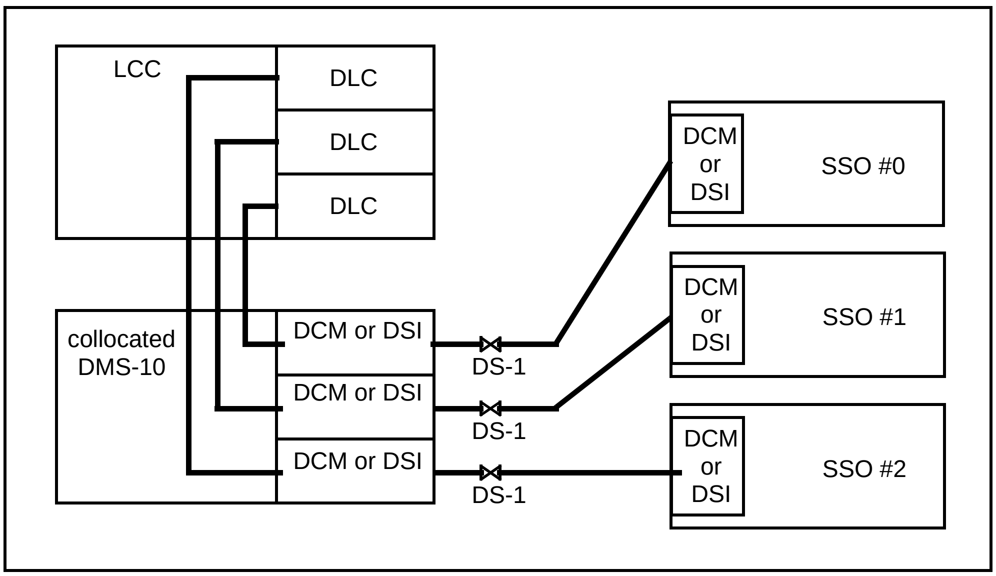
Cluster architecture

The design and architecture of a cluster system is dependent on the various ways that different transmission facilities, different link devices, and the DLC packs in the DMS-10 switch are utilized. However, the variety of designs that are possible in a cluster reduce to two basic plans: (1) a host office with a collocated DMS-10 switch, and (2) a host office with no collocated DMS-10 switch.

Host office with collocated DMS-10 switch

For a block diagram of a cluster with a host office that utilizes a collocated DMS-10 switch for data transmissions, see Figure 4-2. The only host office configuration in which a collocated DMS-10 switch is required is the following: an LCC that uses Digital Carrier Modules (DCMs) or Digital Signal Interface (DSI) modules for host/satellite communications. This does not mean that the colocation of cluster offices using other link devices is not possible. An LCC or HSO can be connected, through a modem or drop-and-insert unit, to a collocated SSO. However, in an HSO, with DCMs or DSIs normally equipped as part of the trunking facilities, no collocated DMS-10 switch is required. For more information about DCMs or DSIs and other cluster-related hardware and devices, see “Data Link Controller” and “Data links” later in this section.

Figure 4-2: Cluster architecture: host office (LCC) with collocated DMS-10 switch



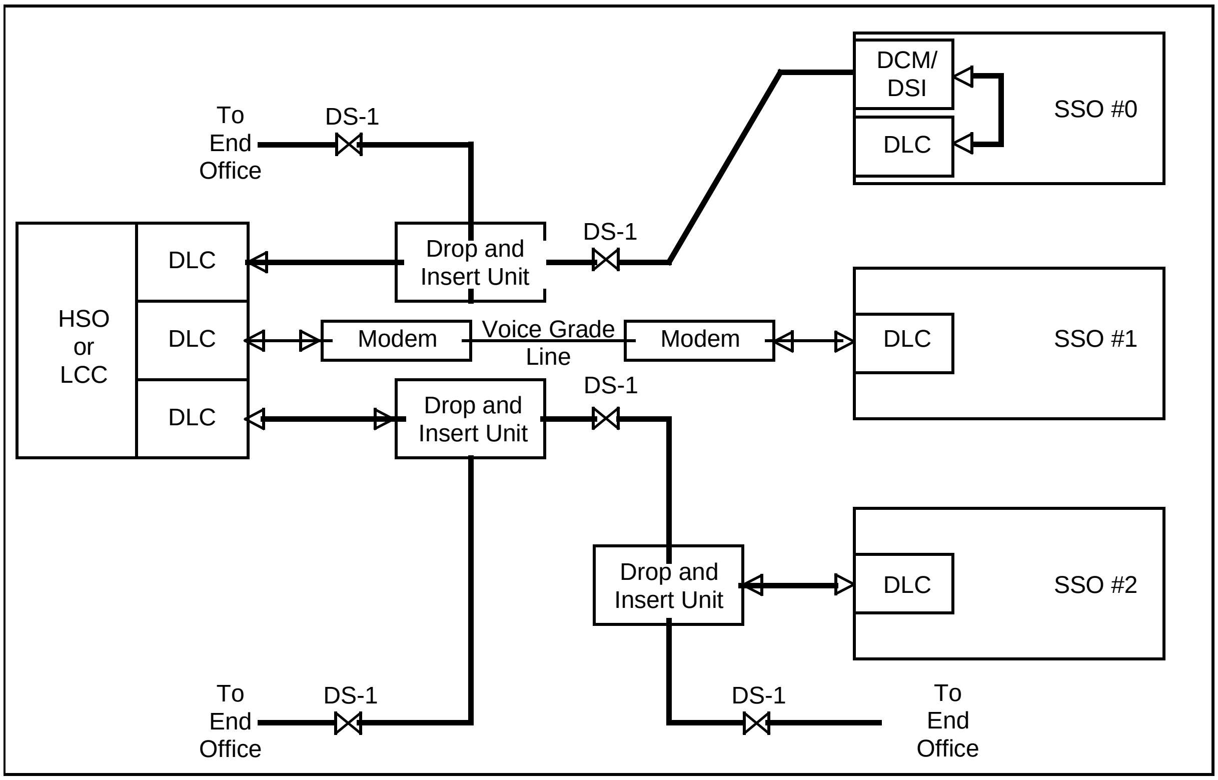
When installed, the collocated DMS-10 switch must be within 50 feet of the LCC. In this arrangement, DS-1 (T-1) spans running from the SSOs can terminate at DCMs or DSIs in the collocated DMS-10 switch.

Although this collocated switch does not have to be a satellite, it must contain the appropriate Digital Carrier shelf and DCM or DSI packs required for message protocol compatibility (see the NTP entitled *Equipment Identification* [297-3601-150] for the required family code versions of this equipment).

Host office without collocated DMS-10 switch

For a block diagram of a cluster with a host office that does not utilize a collocated DMS-10 switch for data transmissions, see Figure 4-3. The two host office configurations in which no collocated DMS-10 switch is required are the following: (1) an HSO that uses its own DCMs or DSIs, or that uses modems, drop-and-insert units, or code detectors for data transmission, and (2) an LCC that uses modems, drop-and-insert units, or code detectors. Figure 4-3 shows this cluster architecture using modems and drop-and-insert units.

Figure 4-3: Cluster architecture: host office (HSO or LCC) without collocated DMS-10 switch



Data Link Controller pack

The DLC pack is the key component of the message transmission system between the HSO or LCC and its SSOs. Each pack contains two ports and provides control of up to two digital or analog data links between the HSO or LCC and each SSO in the cluster. This pack supports Level-2 Link Access Protocol-Balanced (LAPB) protocol, which is compatible with the International Standards Organization (ISO) HDLC protocol, as defined in the CCITT yellow book (Volume VIII).

The DLC pack is located on mated Network shelves of a network module in an HSO and SSO or on the GPIO shelf (CE-3 bay or CE-1 bay) in an LCC (see the NTP entitled *Equipment Identification* [297-3601-150] for details). From this position, it interfaces with one of four device types (discussed later in this section), which in turn are connected to, and drive the cluster data over, outside-plant transmission facilities.

The DLC pack interfaces with the DMS-10 switch (LCC, HSO, or SSO) via the I/O bus, through the Control bus, to the CPU. The CPU is able to retrieve standby outbound messages, disconnect the link, run diagnostics, perform looparound tests, and retrieve statistics from the remote DLC. Each DLC reports diagnostic results, link status information, system errors, and message errors to its CPU.

The primary purpose of the DLC is the overall control of the data link. This control consists of the following functions:

- Maintenance and initialization of the link. This includes establishing the data link, monitoring its integrity, performing maintenance functions, and informing the CPU of any problems.
- Assurance of end-to-end message integrity. This is done by using an HDLC-type protocol over the data link.
- Control of the message protocol over the data link. These functions include formatting the messages, creating message headers and checksums, sequencing the messages, ensuring their integrity, acknowledging received messages, and performing error recovery.
- Parallel-to-serial/serial-to-parallel conversion of messages. Message data are received from the CPU in a format that is 16 bits wide. This format must be converted to a serial bit stream for transmission over the message channel and reconverted to parallel form at the receiving end so that the message can be read by the far-end CPU.

DLC components and internal functions

The DLC pack contains circuitry that, under internal firmware and external software control, performs multiple tasks for cluster operations.

Microprocessor and on-board memory.

The DLC pack includes an Intel 8088-based microprocessor with direct memory access to 64K static random-access memory (RAM). The pack also has two on-board memory areas one of erasable, programmable read-only memory (EPROM) and the second of RAM. A maximum of 32 kbytes of EPROM is accessible only by the microprocessor for DLC initialization, preoperational checkout, and conditioning the data link. The on-board 64 kbytes of RAM, which is accessible by both the microprocessor and the Direct Memory Access controller, provide the necessary buffer space for data to and from both the CPU bus and the data link. All microprocessor bus control and arbitration of RAM memory is performed by the RAM controller and logic gates.

Error handling.

The DLC provides detection of hardware, firmware, and software errors. Hardware error detection between a host DLC and a satellite DLC includes cyclic redundancy check generation whereby the received message is confirmed to be identical to the generated message. Error detection for data transfer between the DMS-10 switch and the DLC requires a software data checksum and various firmware timers and checks.

DLC maintenance messages and diagnostics.

There are two categories of DLC maintenance messages: solicited and unsolicited. Solicited messages are those messages from the DLC in response to a command issued by the DMS-10 switch. The DLC maintenance handler routes solicited messages to the area of high-level code that issued the original request. Unsolicited messages are those messages originating in the DLC firmware. The DLC maintenance handler, based on the message, takes the DLC out of service.

DLC diagnostics are performed in Overlay IOD (see NTP 297-3601-506, *Maintenance Diagnostic Input Manual*). The test procedures invoked by the enable and test commands consist of several functions to validate the integrity of the DLC. A response test is performed on both enabled and disabled DLCs. Exhaustive testing is performed only on disabled DLCs. The test sequence includes an I/O test, a DLC self test, and a loop-around test. The testing sequence performed during the enable command contains the above functions and a verify-link-communication function that establishes integrity with the far-end DLC.

A DLC test function ensures end-to-end link integrity on in-service DLCs. On a periodic basis, software at the HSO or LCC builds a test message and sends it over the link through the high-level I/O system. This message is sent over only idle links. The main function of the test message is to exercise idle links to locate faults (that is, checksum failures, span line problems, etc.). The SSO acknowledges receipt of the test message from the HSO or LCC.

Low-order DLC packs

Low-order DLC packs are numbered from 0 through 7. This numbering scheme applies to both the host office and the satellite office: the number of the DLC pack at the HSO or LCC must be the same as the number of the DLC pack it communicates with at an SSO. These numbers are assigned, and confirmed to be valid, in Overlay CNFG, prompting sequence DLC (see the NTP entitled *Data Modification Manual* [297-3601-311]).

High-order DLC packs

High-order DLC packs are numbered from 8 through 15. The high-order DLCs are mated to the low-order DLCs and, as before, a strict numbering scheme for these packs prevails throughout the entire cluster. These high-order DLCs are required when duplex links are used for data link redundancy between a host and a satellite.

DLC port parameters

DLC packs contain two ports for data communications. Through software DMOs, DLC ports are configured differently for each SSO according to three parameters. These three - port assignment, type, and application - require strict agreement between the host and satellite.

Port assignment.

DLC ports, as well as the DLC packs, are assigned according to a strict map that software logic maintains, and that can not be violated, for any cluster configuration. This scheme is determined on two levels: (1) the numbers of both the low-order DLC pack and its high-order mate in the HSO or LCC must agree with the numbers of the DLC packs they are connected to in each SSO, and (2) the port numbers from host DLC to satellite DLC must be the same (that is, host DLC #3, port 0, must send data to satellite DLC #3, port 0). See Figure 4-4 for the full extension of this plan.

Every satellite is assigned to a particular DLC pack and port (as well as mate DLC pack and port) in the host. In addition, all DLC port 0s in the host send their data to even-numbered SSOs, while all DLC port 1s send their data to odd-numbered SSOs. This is the only host-to-satellite, DLC-to-DLC, and port-to-port configuration that system software will allow.

Port type.

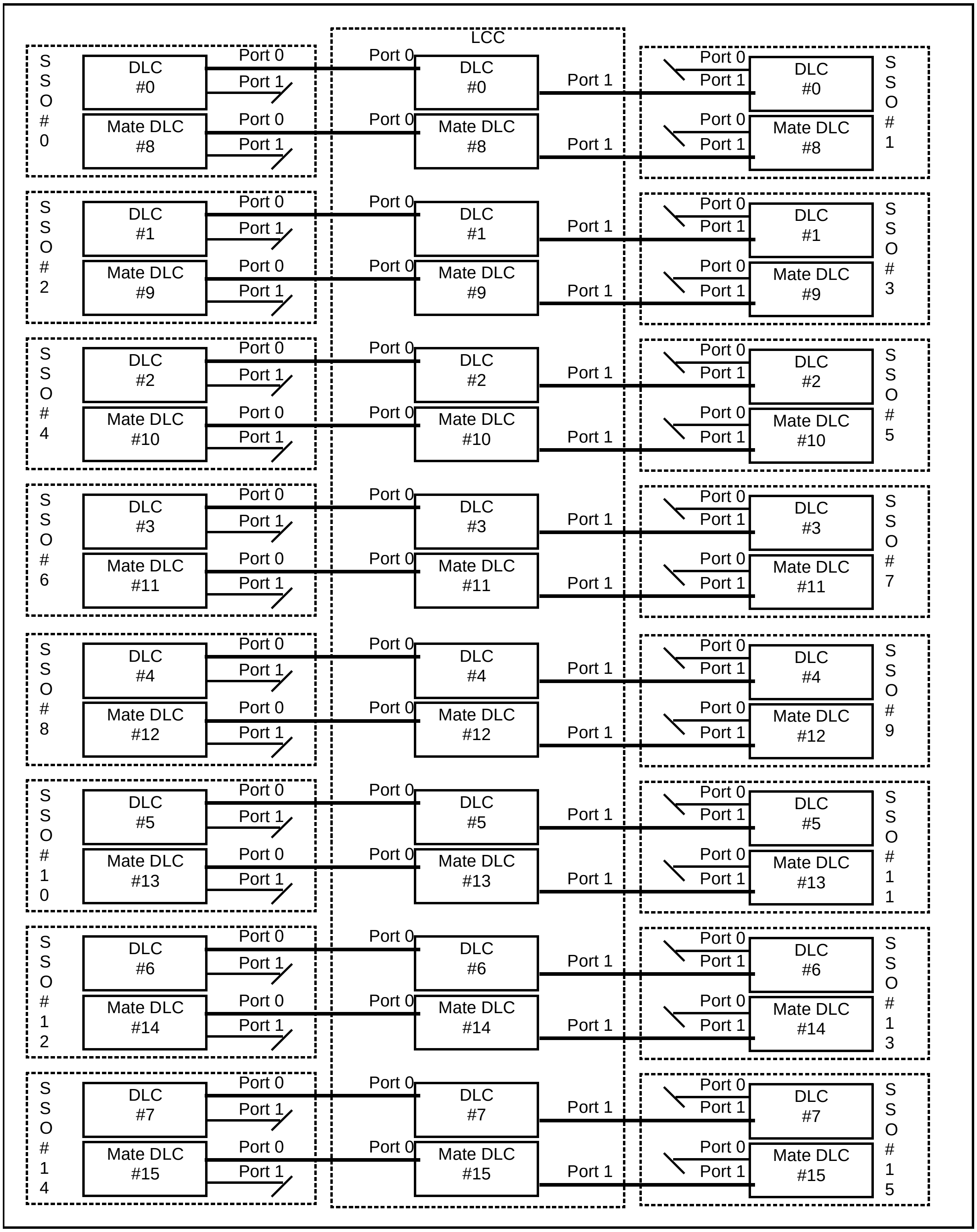
DLC port is determined by the kind of data link that connects the host and satellite offices, and can be one of three types: (1) an unassigned link (UNAS), (2) a simplex link (SIMP), or (3) a duplex link (DUPL). See “Data links” in this section for more information about simplex and duplex links.

A number of dependent port-type configurations exist for a low-order DLC pack and its high-order mate pack. They are the following:

- if the low-order DLC port 0 or 1 = UNAS, then the high-order mate DLC port 0 or 1 = UNAS (or SIMP if the device connected to the port is a code detector in an SSO
- if the low-order DLC port 0 or 1 = SIMP, then the high-order mate DLC port 0 or 1 = UNAS
- if the low-order DLC port 0 or 1 = DUPL, then the high-order mate DLC port 0 or 1 = DUPL only

Generally, the port type of the mate, or high-order, DLC pack is determined by, and must follow, the port type of the low-order DLC pack. To prevent the incorrect assignment of DLC port types, internal software checks are run by the system code when data modifications are performed, and appropriate messages indicating an error in this procedure are printed at the data terminal.

Figure 4-4: Complete port-to-port mapping for a maximum number of SSOs in a cluster



Port application.

A DLC port can be assigned one of four applications in software DMOs, and these are determined by the type of device that interfaces with that port. The devices that are used to transmit the DLC-processed data, and the corresponding DLC port applications (in parentheses) are:

- Digital Carrier Module (DCM)
- modem (MODM)
- Drop-and-Insert unit (DRIN)
- code detector (CODE)

So that the DMS-10 switch can recognize which device is attached to a DLC at a particular site, Overlay CNFG, prompting sequence DLC, is used to establish all of the parameters (port type, port application, etc.) that are necessary to define the function of a DLC port.

Data links

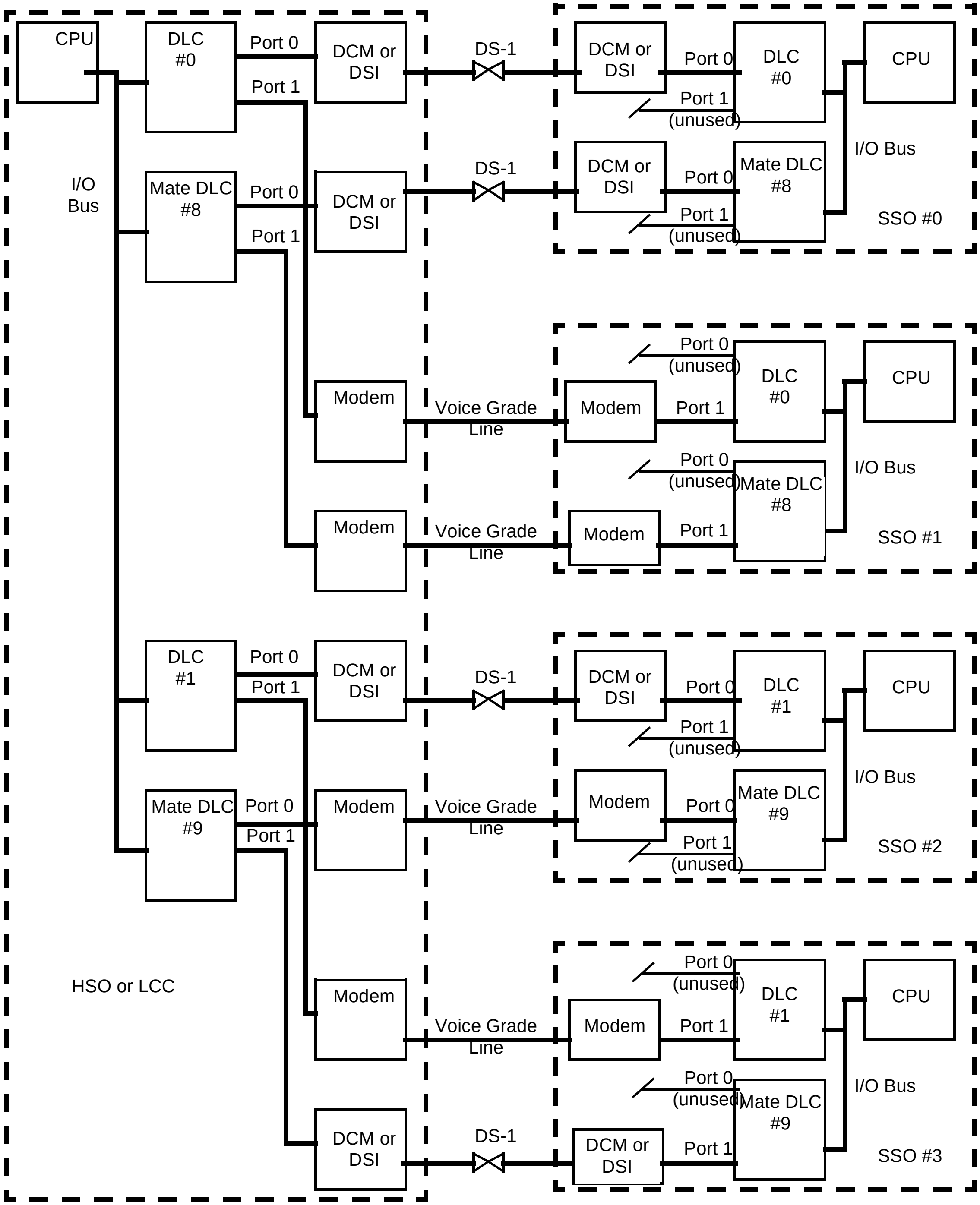
The HSO is connected to each SSO in a cluster by either two active data links (duplex link) or a single data link (simplex link). Both simplex and duplex links provide a data path for the following operations:

- transfer of alarm, maintenance, and other messages from SSOs to the HSO or LCC
- transfer of alarms from one SSO to another SSO via the HSO or LCC
- centralized maintenance terminal access from the HSO or LCC to any SSO
- centralized administration terminal access from the HSO or LCC to any SSO
- central collection of billing information for the entire cluster at the HSO or LCC

These data links transfer information between the HSO or LCC and the SSOs in either a digital or an analog form, depending on the device that actually drives this data across transmission lines. The devices that send analog data are connected directly to voice-grade transmission facilities, while the devices that send digital data require DS-1 (T-1) span lines (see Figure 4-5).

Each of these devices is connected to a Data Link Controller (DLC) pack, which is the key hardware component of the cluster configuration. The DLC pack serves as the interface between the DMS-10 CPU (LCC, HSO, and SSO) and these various link devices. Three of these devices (modem, DCM, and DSI), and the transmission facilities they are connected to, can be seen in Figure 4-3, which diagrams the hardware interfacing at the host and satellite offices as well as a simple cluster configuration with mixed analog and digital transmission lines.

Figure 4-5: Simple DMS-10 cluster configuration with mixed analog and digital links



Note: An SSO DLC is always assigned a number identical to the number of the HSO or LCC DLC to which it is connected. Corresponding DCMs or modems are connected to identical port numbers.

Link devices and applications

The following types of devices can be used to communicate directly between the HSO or LCC and any SSO. These devices, the kind of data they send, and their valid baud rates, are listed in Table 4-A.

Table 4-A:
Link devices and data transmission rates

Device	Type of Data	Valid Baud Rates
Digital Carrier Module	Digital	56K
Digital Signal Interface	Digital	56K, 64K
Modem	Analog	1200, 2400, 4800, 9600
Code Detector	Analog	1200, 2400, 4800, 9600
Drop and Insert Unit	Analog or Digital	1200, 2400, 4800, 9600, 56K

Digital Carrier Module

The Digital Carrier Module (DCM) is a digital trunk module manufactured by Nortel, and is an integral part of DMS-10 equipment. However, the DCM is configurable only in an HSO or SSO, and not in the LCC.

If the cluster is controlled by an LCC, and DCMs are required for digital data transmission, then a DMS-10 switch that contains DCMs must be collocated with the LCC, thereby providing the DLC packs in the LCC with access to the digital channels of the DCMs. A DCM control signal is supplied by the DLC pack, which allows the DLC to use one of the DCM's 24 speech channels for cluster data communications.

All DCMs that are used for cluster data link applications are housed in a modified Digital Carrier shelf (J0T13A-1, L3 through L6). The DCM is connected to a DLC pack with a DCM/DLC cable assembly, which terminates in one of two ports on a single DLC pack. When dual (duplex) data links are required, a second, mate DLC must be configured for connection to a mate DCM (see “Simplex data links” and “Duplex data links” below). A DLC pack cannot be connected to a DCM Carrier Interface pack (NT2T32) provisioned either in position 8 or 18 on the J0T13A-1 shelf.

Digital Signal Interface

The Digital Signal Interface (DSI) module replaces the DCM and the Subscriber Remote Interface (SRI). The DSI module comprises a Span Interface Controller (NT4T24) and a DS-1 Interface pack (NT6X50) and is housed on a Digital Carrier Interface (DCI) shelf. For additional information about the DSI module, see Section 2 of this NTP and also NTP 297-3601-150, *Equipment Identification*.

Modem

An analog data link is interfaced to each SSO, HSO, or LCC by a modem and an analog cable assembly. The cable assembly terminates in one port on each of two DLC packs. The DLC pack can support modems supplied by different vendors;

however, whatever modem is used must conform to DMS-10 specifications. The modem standards that are currently compatible with the DLC pack are as follows: 201C, which operates at 2400 baud; 208A, which operates at 4800 baud; and 209, which operates at 9600 baud.

In addition, the modems should be configured with the following features:

- four-wire analog interface
- synchronous clocks
- clocks supplied by the modem (internal timing)
- constant carrier
- isolated signal and frame grounds
- automatic equalization in the receiver
- anti-stream control not used
- new synchronization feature turned off
- continuous request to send

Any additional features that are supplied with a particular modem should be set so that they do not conflict with the requirement stated above.

The transmitter and receiver levels are determined by the equipment to which the modem terminates. This equipment is not controlled or specified in any way by Nortel. Therefore, the operating company alone must determine, on a per-site basis, the proper settings for these modem levels.

Code detector

The code detector is a device that interfaces with a digital alarm scanner (DAS) located at a satellite office. The code detector monitors the telemetry between the DAS and the switching control center (SCC) that is collecting office data, while maintaining the proper functioning of the DAS in the DMS-10 switch. The code detector can turn the DAS on or off and will disable it when the DAS malfunctions. This prevents the DAS from causing multiple Initializations or SYSLOADs of the switch in response to system and/or cluster alarms.

Drop-and-insert unit

The drop-and-insert unit is a device that interfaces to a DS-1 (T-1) span line. It inserts and extracts an individual DS-0 channel and uses that channel for data transmission.

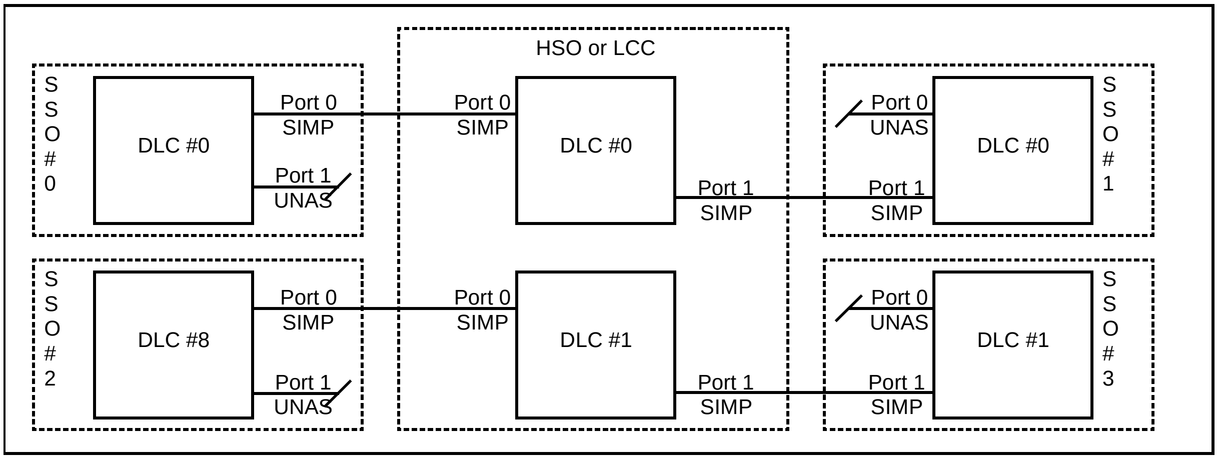
Simplex data links

Simplex data links offer the operating company the ability to configure a DMS-10 cluster with a maximum number of SSOs (16) and a minimum amount of hardware (that is, DLC packs and T-1 spans). When a simplex link connects a host and satellite, only one DLC pack is required in the satellite office and one in the host office.

However, using a simplex link between an HSO or LCC and an SSO abolishes link redundancy (see Figure 4-6).

The simplex link provides only one path for data transmission. If a simplex link fails, there is no alternate path for the data to travel between the HSO or LCC and the SSO. For this reason, a catastrophic alarm is raised when a simplex link fails. Without the redundancy that duplex links provide, the risk of losing cluster data communications is greater.

Figure 4-6: Host/satellite simplex data link configuration and port application

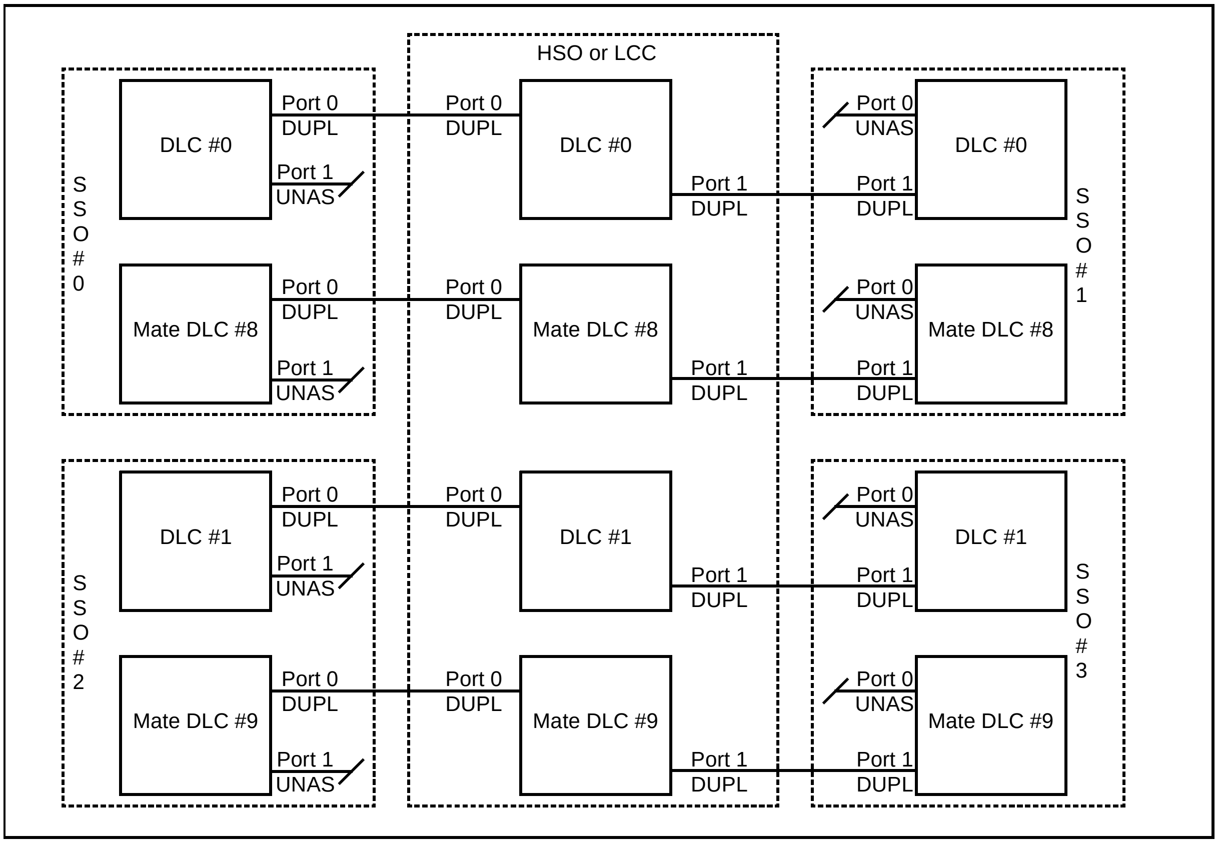


Duplex data links

Duplex data links provide a fully redundant data path between the host and satellite. When cluster data is sent in either direction, it is broken into discrete message packets, which are alternated between the two links according to a set protocol. Therefore, both links of a duplex link are functioning when data transfer is occurring. Should one of the two links fail, then the other link can assume full responsibility for the transfer of cluster data. At this time, a major alarm is raised. If the second link is taken out of service, then a catastrophic alarm is raised.

When duplex links are used between the host office (HSO or LCC) and a satellite office, additional hardware is required. Two DLC packs (one low-order pack and one mate, high-order pack) are required in the SSO, as well as two in the HSO or LCC. However, because there are two ports in every DLC pack, with port 0 (in the host DLC) assigned to one satellite and port 1 assigned to another satellite, only two DLCs are required in the host to provide duplex links to two different satellites (see Figure 4-7). In this way, the maximum number of SSOs (16) can be served by duplex links in the cluster when an LCC is configured as the host office.

Figure 4-7: Host/satellite duplex data link configuration and port application



Daisy chaining

The drop-and-insert unit provides a means of “daisy chaining” SSOs, whereby data links are configured in a linear path along one T-1 span from SSO to SSO and back to the HSO or LCC. However, this type of cluster configuration is not recommended with simplex data links. The greater amount of equipment required when daisy chaining a cluster (for example, multiple drop-and-insert units, cross-connects, etc.) would significantly decrease link reliability. The failure of an individual section of the linear path would result in the loss of data communications throughout the entire cluster. Therefore, only the normal radial pattern of host and satellite offices should be considered if simplex links are used.

Cluster communications

Communications in the cluster follow specific protocols that are established and carried out by DMS-10 software through the operations of the DLC pack. These communications take the form of discrete and structured messages that are passed between the host office and each satellite office.

Message transfer

Various types of message transfer occur within the cluster, but all messages are transferred in a similar manner. Messages are removed from existing DMS-10 queues and are turned over to the DLC pack. The DLC then adds the appropriate header and trailer information, as defined by the HDLC protocol, and transmits the message (including the header/trailer), across the digital or analog line. The far-end DLC then validates the message and passes it to the far-end CPU for processing.

A typical message transfer from an SSO to an HSO or LCC proceeds as follows. The CPU at the SSO creates the message of 16-bit words. The CPU passes the message to the DLC by writing it in the transmit buffer. Direct memory access (DMA) is used to pass the message to the HDLC chip, which formats it and creates a checksum according to the message protocol. The message is then transmitted over the data link.

After receipt of the message by the DLC at the HSO or LCC, an acknowledgement is returned to the DLC at the SSO. The message is then erased from the transmit buffer of the DLC at the SSO. If the message is lost or garbled, retransmission is requested for that message and all messages following it.

CPU interface

To ensure high message throughput with minimum CPU overhead, the DLC interfaces with the CPU bus through the I/O bus. Messages are passed to the CPU in a 16-bit wide parallel format. One or more receive and transmit buffers are provided to minimize interactions between the CPU and DLC. These are used to pass messages between the CPU and the data link.

An interrupt line is associated with the CPU interface. When the DLC wishes to communicate with the CPU, an interrupt is raised. This reduces CPU overhead by eliminating the need for the CPU to scan all DLCs continuously. Upon receiving the interrupt, the CPU will read the message from the DLC to determine the action to be taken.

Flow control

The transfer of data from the various SSOs to the HSO or LCC is regulated by *flow control*. Flow control is the protocol for system software that governs the unpredictable number and variety of messages sent from satellite to host. As cluster size increases, especially with the introduction of LCC, so do the complexities of cluster data flow. To ensure the functionality of cluster communications and message processing and the compatibility of cluster generics, every office in a cluster must contain flow control.

Specifically, flow control offers the host office the capability to determine the kind of message it will receive and process from its satellites and the amount of information contained in those messages. Software in the HSO or LCC calculates the threshold level for a specific application, or message type, it can receive and process, and then broadcasts that threshold level to all of the SSOs. The SSOs send data to the established threshold and stop, awaiting the restart message from the HSO or LCC. In this way, large buffering pools and elaborate queuing of cluster data, which would consume system memory in each office, are not needed.

Host message classes

Operational measurements and other data may be collected by support agencies outside of the central office. With the advent of the cluster concept, these messages are automatically sent (via the DLC pack) from the SSO through the HSO or LCC to a common data collection agency, such as an SCCS or EADAS office (see the discussion about these cluster data collection centers later in this section). However, an SSO that already sends a particular class of messages to its own collection agency can designate (through DMOs) that the same message class not be sent through the HSO or LCC to the cluster's collection agency, thereby preventing needless duplication of information. For more information on assigning host message classes, see Overlay CNFG, prompting sequence HMCL, in the NTP entitled *Data Modification Manual* (297-3601-311).

SCCS interface

A DMS-10 cluster can be linked to a *Switching Control Center System* (SCCS), which allows the status and performance of each DMS-10 switch in the cluster to be monitored and controlled from a remote switching control center (SCC). Data reflecting the performance of each switch are passed from the host office (HSO or LCC) to the SCC.

SCCS configuration

The SCC is equipped with a maintenance terminal that can address any of the switches in the cluster in order to perform maintenance and trouble-shooting procedures. This terminal provides the same message and monitoring functions as a maintenance terminal located at any SSO in the cluster. Messages input at any local maintenance terminal in the cluster, and the host/satellite responses to them, are also transmitted to the remote maintenance terminal at the SCC. Similarly, all messages input at the SCC, and the host/satellite responses to them, are echoed at all of the local maintenance terminals in the cluster.

Each SSO in the cluster is connected to the SCCS via the HSO or LCC. This centralized architecture reduces the quantity of outside-plant facilities that would be required to link each of the DMS-10 switch in the cluster individually to the SCC.

All of the types of data links (duplex and simplex) and link devices (DCMs, modems, drop-and-insert units, code detectors) that are available for data transmission within the cluster can be used to relay SCCS telemetry.

Analog links

In a cluster configured with analog data links, telemetry information collected by the digital alarm scanner (DAS) at the SSO is routed through a 1200-baud RS-232C modem (Bell 202T data set) and over a dedicated voice-grade line (Bell Standard 3002) to the SCC. For a block diagram of the analog interface between a DMS-10 cluster and an SCCS, see Figure 4-8 (the numbers in parentheses in the next paragraph refer to numbering in the diagram).

In a cluster configured with analog links, the SCCS maintenance terminal access from a host office to a satellite office utilizes one of the two redundant analog links between the host and the satellite. Data destined for the SCCS maintenance terminal (MTTY) are routed from the DLC pack at the SSO (1), through a modem (2), to a Data Mounting Unit (DMU) (3), a two-input, four-wire analog multiplexer. When this connection is made, the DMU switches to the backup input. The DMU, in turn, is connected to a single 1200-baud, dedicated four-wire modem link (4), which is connected to a Serial Data Interface (SDI) pack in the SSO (5).

One of the two four-wire inputs of the DMU is dedicated; the other is for dial-up backup of the primary input. If the primary input fails, the SCC dials up the DMU in order to make a two-wire connection; the DMU then calls the SCC to establish a four-wire connection.

Digital links

In a cluster configured with digital data links, telemetry data collected by the DAS at the SSO are routed to one channel of a DCM or DSI, which transmits the data via a DS-1 span to a DCM or DSI at the host office. Here, telemetry data are pulled from the bit stream and are routed to a 1200-baud RS-232C modem (Bell 202T data set) and over a dedicated voice-grade line (Bell Standard 3002) to the SCC. When DSIs are used, conversion from RS-232 to RS-449 is required since the DSI uses RS-449 ports for data transmission. For a block diagram of the digital interface between a DMS-10 cluster and an SCCS, see Figure 4-9 (the numbers in parentheses in the next paragraph refer to numbering in the diagram).

In a cluster configured with digital links, the SCCS maintenance terminal access from the HSO or LCC to an SSO utilizes one of the two redundant DS-1 (T-1) digital data links between the host and each satellite. Data destined for the SCCS maintenance terminal (MTTY) are routed from the DLC pack at the SSO (1), through a modem (2), to a DMU (3), a two-input, four-wire analog multiplexer. One of the two four-wire inputs is dedicated; the other is for dial-up backup of the primary input. The DMU, in turn, is connected to a single 1200-baud, dedicated four-wire modem link (4), which is connected to an SDI pack in the DMS-10 SSO (5).

If the primary input of the DMO fails, the SCC dials up the DMU to make a two-wire connection; the DMU then calls the SCC to establish a four-wire connection. When this connection is made, the DMU switches to the backup input.

SCCS telemetry

SCCS telemetry data are passed between the HSO or LCC and the SCC via separate 1200-baud modems (Bell 202T data set) with RS-232C inputs that transmit data over voice-grade lines (Bell Standard 3002) for each DMS-10 switch in the cluster (up to 16 links total). For a block diagram of this telemetry data link, see either Figure 4-8 or Figure 4-9.

SCCS maintenance terminal interface

Maintenance terminal data for all switches in the cluster are passed between the HSO or LCC and the SCC across a 1200-, 2400-, or 4800-baud, dedicated four-wire link to a DMU located at the HSO or LCC. The DMU, in turn, is connected by a dedicated four-wire link to a modem, which is connected to an SDI pack in the DMS-10 HSO or LCC. For a block diagram of this interface, see either Figure 4-8 or Figure 4-9.

EADAS interface

A DMS-10 cluster can be linked to an Engineering and Administration Data Acquisition System (EADAS), an Operations Support System (OSS) that gathers and stores traffic- and performance-measurement data from the DMS-10 switches in the cluster. These data are collected and printed at intervals of either 30 or 60 minutes (selectable via data modification) and 24 hours.

In order to reduce outside plant requirements, the entire cluster is linked to the EADAS center via a single voice-grade link between the EADAS center and the HSO or LCC. Thus, each SSO in the cluster must first transmit its EADAS measurement data to the HSO or LCC via the cluster's standard analog or digital data links (see “Host message classes” above for exceptions). For a block diagram of the interface between a cluster and an EADAS center, see Figure 4-10.

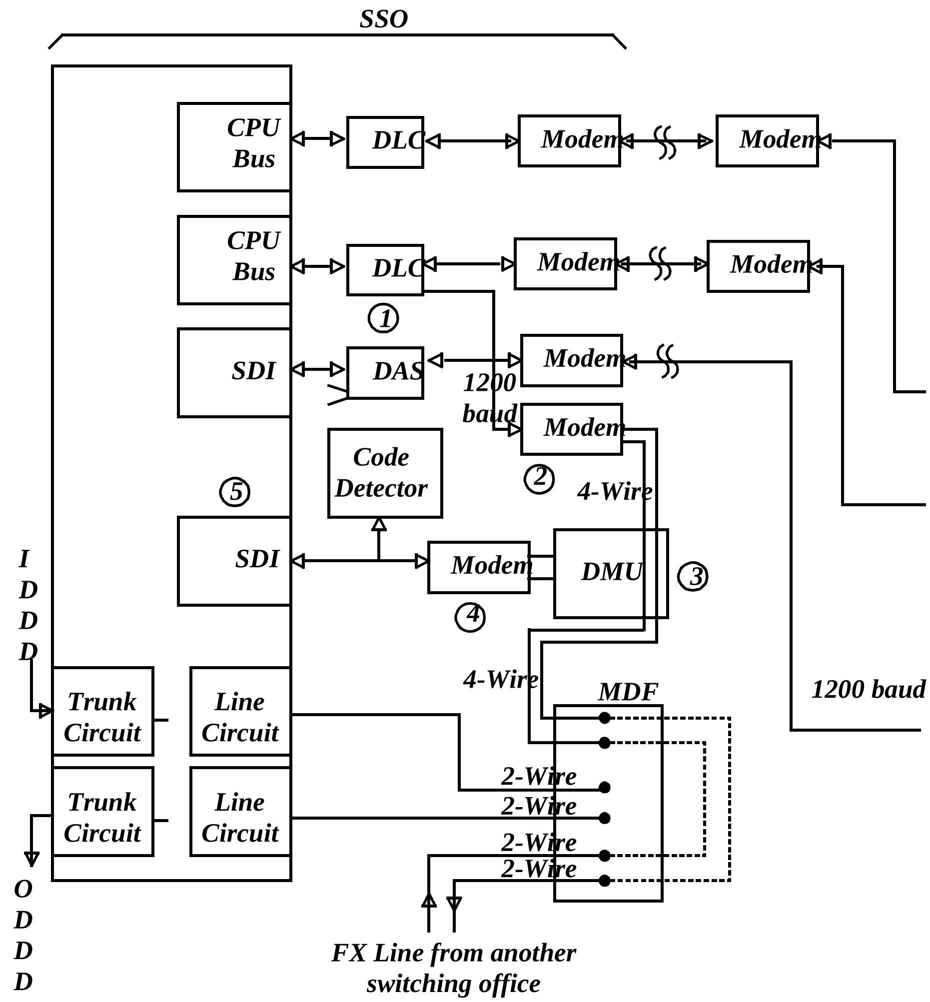
The HSO or LCC relays the data from each SSO successively over the link to the EADAS. Because EADAS software is not able to interpret messages arriving at a single port from more than one source, the EADAS center must be equipped with one front-end processor (FEP) for each cluster it serves. The FEP is a demultiplexer with one physical input (from the HSO or LCC) and 17 physical outputs (EADAS ports), one for the HSO or LCC and one each for up to 16 SSOs.

Data are transferred from the HSO or LCC to the FEP in ASCII format. Each data transmission from one of the switches in the cluster consists of contiguous data lines, with the first line containing the standard EADAS “MSG A” line and the last line terminating with the characters “End.” Each data line is preceded by a control character that identifies the originating office in order to route the message to the appropriate output port of the FEP. For additional details on EADAS and EADAS messages, see the NTP entitled *Operational Measurements* (297-3601-456).

In the HSO or LCC, the EADAS report is generated immediately following the interval (either 30 or 60 minutes) during which the data were accumulated.

When the host office report is complete, the host allows each satellite to send its EADAS data across the data link. By sending a “start” command message to an SSO and waiting for a “done” response when the SSO has completed data transmission, the HSO or LCC permits only one SSO to transmit its data at a time. Upon receipt of the “done” message from the active SSO, the HSO or LCC sends a “start” message to the next SSO. This process is repeated until all DMS-10 switches in the cluster have relayed their data to the EADAS.

Figure 4-8: Analog link interface between DMS-10 cluster and Switching Control Center System



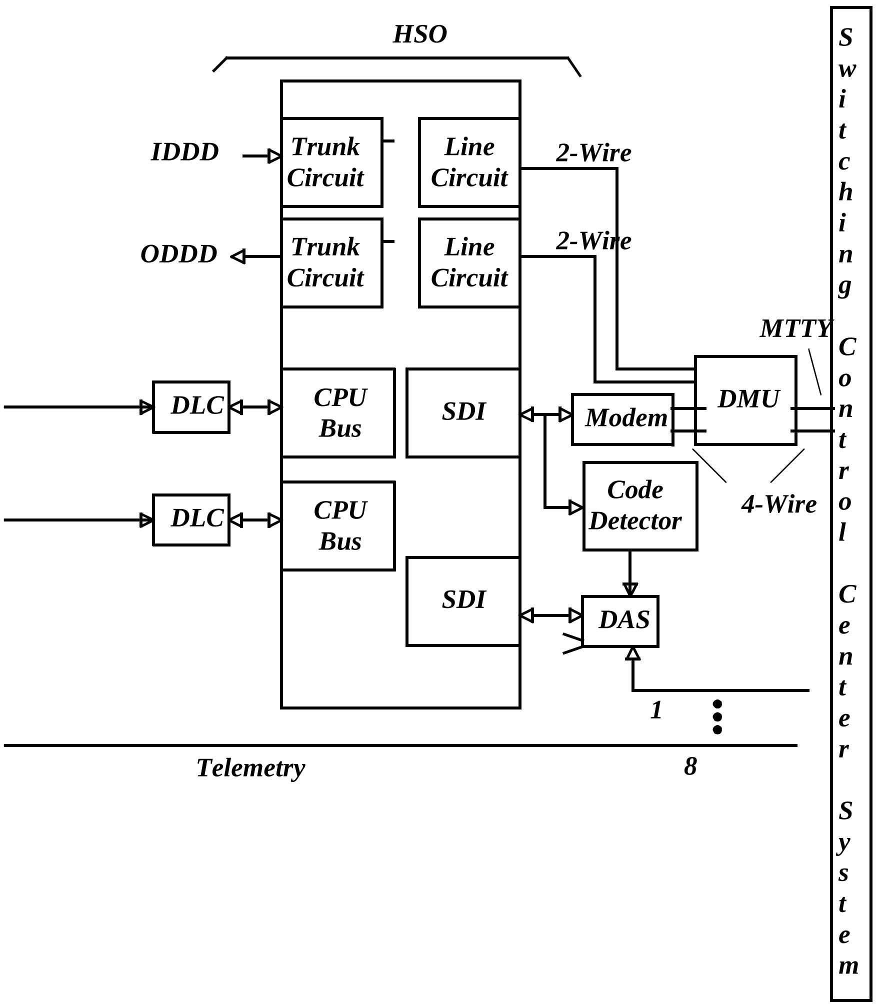
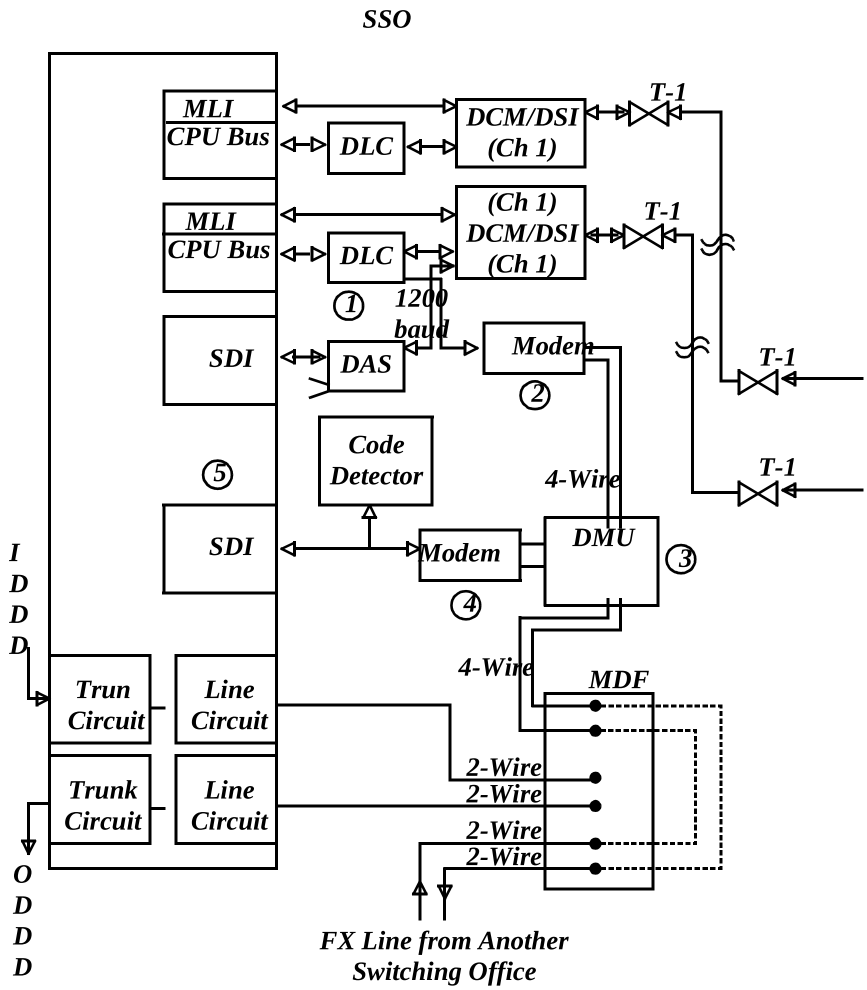

HSO
IDDD
ODDD
Trunk Circuit
Trunk Circuit
Line Circuit
Line Circuit
2-Wire
2-Wire
DLC
DLC
CPU Bus
CPU Bus
SDI
SDI
Modem
DMU
MTTY
4-Wire
Code Detector
DAS
1
8
Telemetry
Switching Control Center System

Figure 4-9: Digital link interface between DMS-10 cluster and Switching Control Center System



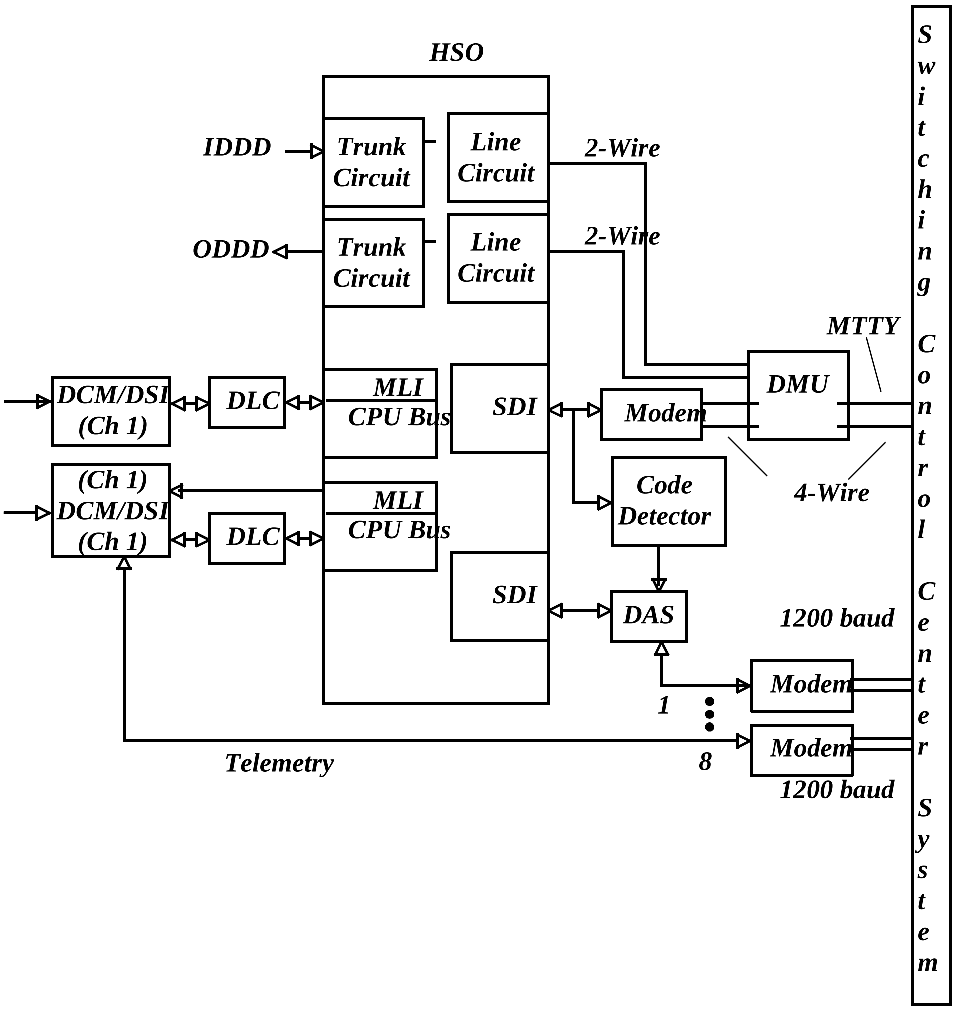
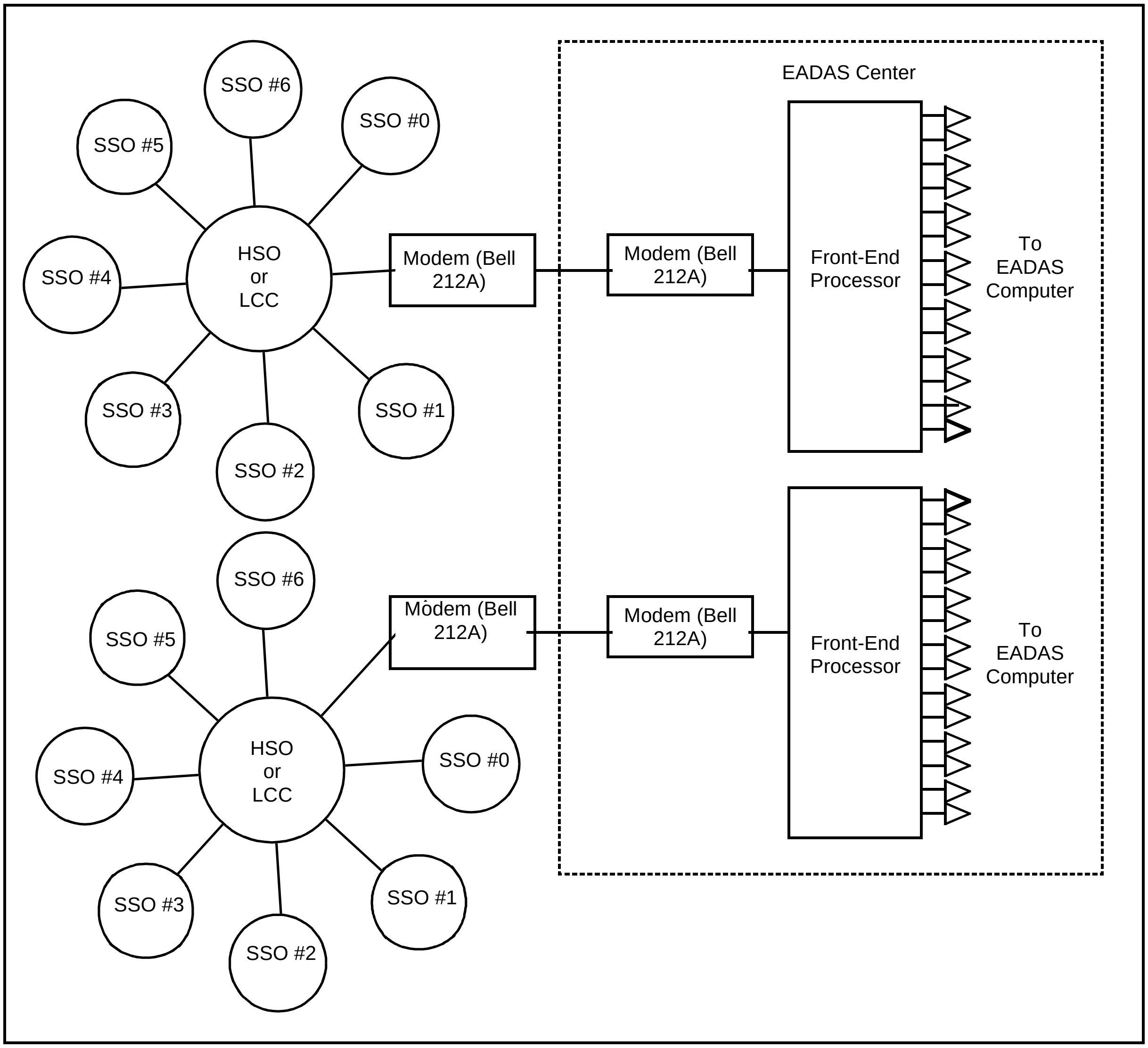

HSO
IDDD
ODDD
Trunk Circuit
Trunk Circuit
Line Circuit
Line Circuit
2-Wire
2-Wire
MTTY
DCM/DSI (Ch 1)
(Ch 1) DCM/DSI (Ch 1)
DLC
DLC
MLI
CPU Bus
MLI
CPU Bus
SDI
SDI
Modem
DMU
Code Detector
4-Wire
DAS
1200 baud
Modem
Modem
1
8
Telemetry
1200 baud
Switching Control Center System

Figure 4-10: Cluster interface with EADAS

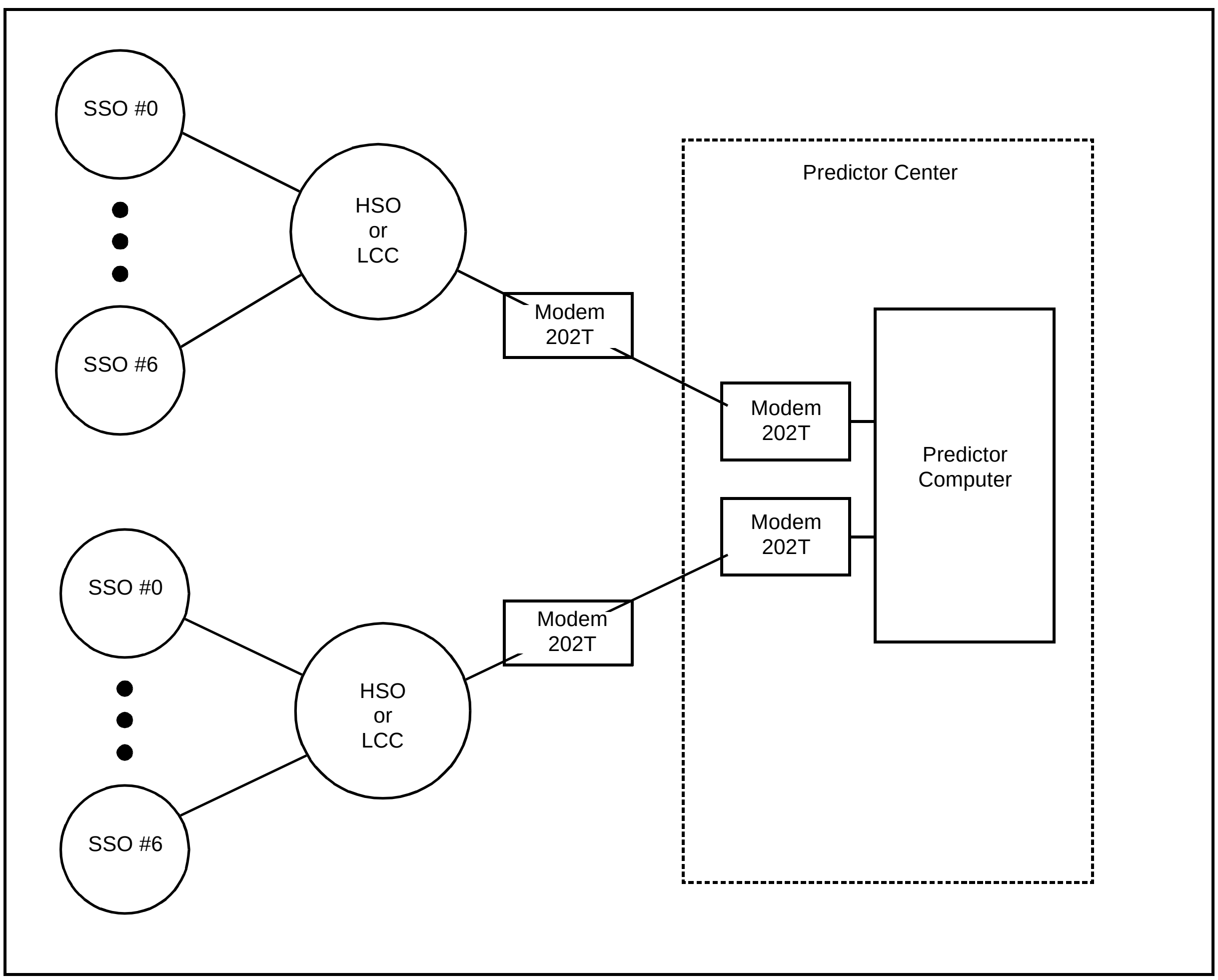


LIT predictor interface

The predictor interface is used with the Line Insulation Test (LIT) feature in cluster applications. In this arrangement, each SSO outputs LIT data to the HSO or LCC (see “Host message classes” above for exceptions) using the DLC data link, and the data are transmitted to the predictor center in succession over a single TTY channel provided at the HSO or LCC. For a block diagram of the interface between the cluster and a LIT predictor, see Figure 4-11.

LIT output emulates LORDEL output using ASCII-encoded characters that are transferred to the predictor center using a single TTY I/O port. The Predictor is viewed by the host office as a TTY connected to the system via an SDI pack, and it is declared in the system using Overlay CNFG. For additional information on the hardware and software requirements for predictor, refer to the NTPs entitled *Equipment Identification* (297-3601-150) and *Data Modification Manual* (297-3601-311), respectively.

Figure 4-11: Cluster interface with LIT predictor



In a cluster configuration with LIT, the HSO or LCC should have only one dedicated output class and one dialup LIT output class for backup. The SSO should have one dialup as backup.

LIT data are output to predictor in a first-in/first-out (FIFO) mode. Because each office's test cycle time is different (declared in Overlay CNFG), a start/stop handshake method is employed to transmit output from an SSO to the HSO or LCC when the SSO is ready. The host starts outputting the LIT data from one satellite to the predictor, and stops when the transmission is complete; the host then moves on to the next office. This approach keeps separate LIT outputs from interleaving.

Section 5: Common Channel Signaling No. 7

Definition

Common Channel Signaling No. 7 (CCS7) is a telecommunications system for routing data and voice signals through separate networks. By separating data and voice networks, features which require extensive office to office and office to database data transfer can be provided without impacting voice network traffic.

Dialed digits can be converted into standard digital signaling data which are sent through the signaling network to determine the optimum voice network routing for the associated voice signal. Established protocols define signaling message structures and error-checking formats. Signaling data may still be transmitted through the voice network, but as more CCS7 features are developed and more offices in the network adopt CCS7 processing, reliance on the voice network to transmit signaling data will diminish.

Voice network

The voice network in a CCS7 system follows the same routing as the pre-CCS7 network. As was the case in the pre-CCS7 network, voice data travels from office to office, over trunks and lines. The only difference in the pre-CCS7 network and the CCS7 voice network is the CCS7 voice network does not carry signaling information.

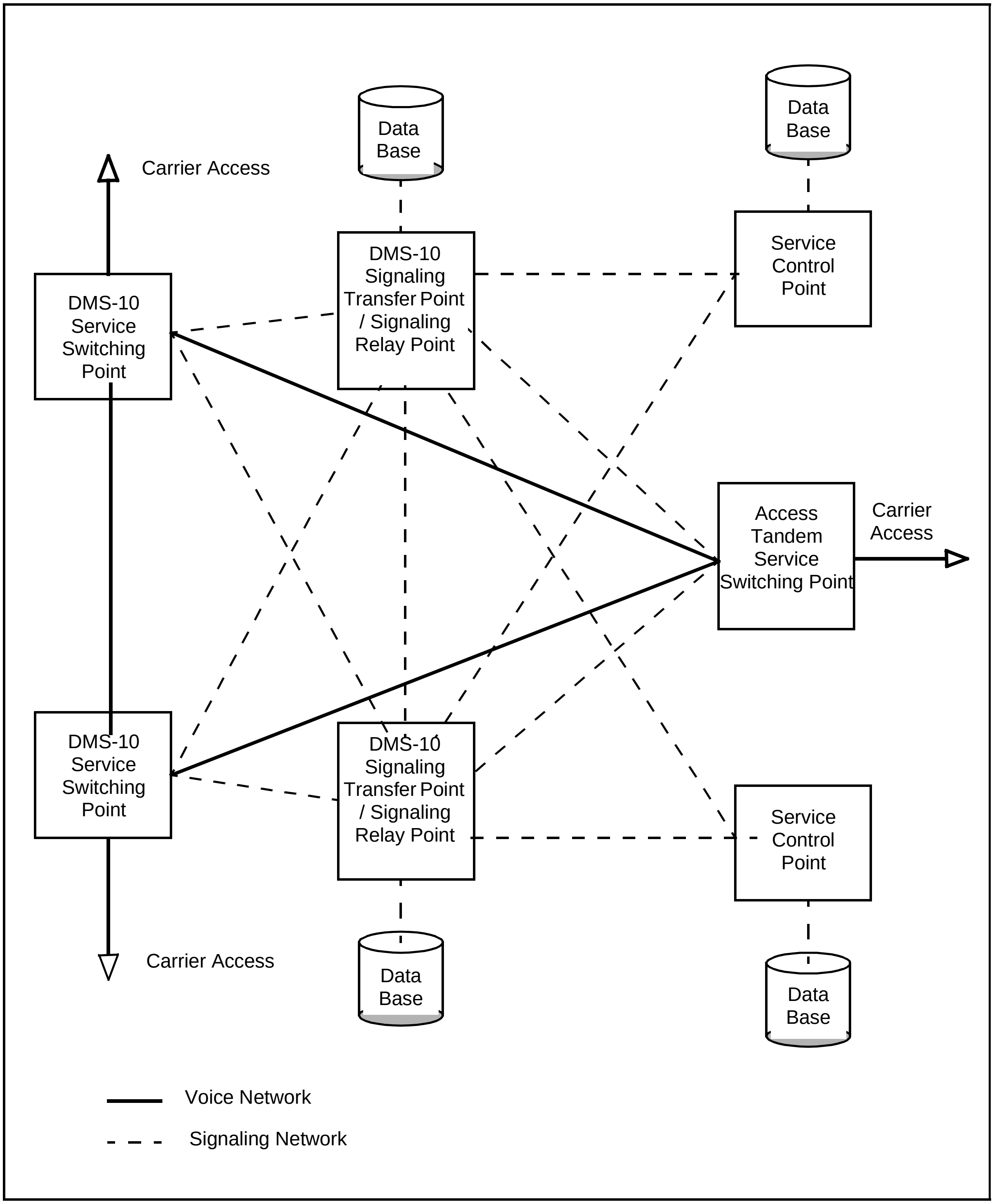
Signaling network components

The signaling network in a CCS7 system is completely independent of the voice network. The signaling network components generate, transfer and receive signaling information on a dedicated set of data links. Figure 5-1 shows a typical CCS7 configuration.

Service Switching Point

Service Switching Points (SSPs) are end offices and access tandems that are sources or destinations of CCS7 signaling messages. End office SSPs provide subscriber access for CCS7 features. SSPs typically route voice as well as signaling data. The DMS-10 switch can be provisioned to function as an SSP.

Figure 5-1: DMS-10 switch in a CCS7 network



Service Control Point

Service Control Points (SCPs) are interfaces to databases that contain customer profiles and routing information. SSPs send signaling queries to SCPs which access the databases and send the information back to the SSP to specify routes or conditions of feature execution. SCPs only interface with the CCS7 signaling network. Figure 5-1 shows the SCP in a typical CCS7 configuration.

SCPs are typically allocated in redundant pairs in the network. Each SCP is accessible through signaling links from any point in the network. This redundancy allows full access to network databases during a single SCP failure.

Signaling Relay Point

A *signaling relay point* (SRP) serves as an interface between an SSP sub-network and signaling transfer points (STP). The SRP performs sub-network message routing and controls CCS7 signaling information transfer between the sub-network and the STPs. The primary purpose of the SRP is to provide smaller telcos with a cost-effective means of interfacing with the CCS7 network by reducing facilities and equipment requirements and by allowing the use of less expensive low-speed links for the transfer of CCS7 signaling information. Figure 5-1 shows the SRP in a typical CCS7 configuration.

Signaling Transfer Point

Signaling Transfer Points (STPs) are data switches that route signaling information. STPs interpret CCS7 application addresses to route signaling messages to and from SSPs and SCPs. Figure 5-1 shows the STP in a typical CCS7 configuration.

STPs are typically allocated in redundant pairs in the network. Each STP is indirectly or directly accessible through signaling links from any point in the network. This redundancy provides signaling traffic load sharing capabilities during normal conditions and complete STP information signaling during single STP failure.

DMS-10 STP

The DMS-10 STP comprises a DMS-10 SRP and either a mated pair of Innovative Systems, LLC CNAM-DB units or a J8T76A-1 DMS-10/AP (DMS-10 Application Peripheral) unit. The DMS-10 STP can be deployed as an independent element within the CCS7 network to provide connectivity for multiple signaling points, as a natural extension of the DMS-10 cluster configuration to serve nodes in a DMS-10 subnetwork, or as an addition to a fully-provisioned DMS-10 switch to extend CCS7 signaling further into the public network. The presence of the DMS-10 STP in the local network serves to decrease the number of external network database queries required for CCS7 call processing.

For complete information about the CNAM-DB or J8T76A-1 systems, refer to the supporting documentation supplied by the manufacturer, Innovative Systems, LLC. For a brief description of the J8T76A-1 system, see Section 6, “Miscellaneous Equipment,” of NTP 297-3601-150, *Equipment Identification*.

DMS-10 STP Gateway Screening

DMS-10 STP Gateway Screening is a filtering process used to control access in a CCS7 network. Each CCS7 message carries with it an array of routing data including destination and originating point codes (DPCs and OPCs), and information identifying the service the message is being used to access. Gateway screening permits the network provider to datafill tables that screen this routing data. By setting up combinations of screening criteria, the network provider can specify exactly what services can be accessed by any user of its network. Traffic originating from unauthorized sources or attempting to use unleased services is blocked from network access.

MTP Screening. In CCS7 protocol, levels 1, 2, and 3 constitute the Message Transfer Part (MTP). The MTP, which is described under the "CCS7 Protocol" heading in this section, provides the basic mechanism needed to deliver signaling messages between the nodes of the CCS7 network. Each node in a CCS7 network is assigned an individual point code that uniquely identifies it. MTP screening uses these codes and other MTP information to determine which signaling points in other networks can have access to a given network and to what points in that network a particular message can be delivered. MTP information related to message priority and message type can also be used to screen messages and to specify which messages are to be discarded to help avoid or correct network congestion.

Gateway screening generally proceeds in the following manner:

1) An incoming message is first processed through a series of tables defined by the network provider that contain the combination of allowed MTP values for the link set that is bringing the message into the STP.
2) System software then decides whether the message is intended for a service local to the STP and further screening or for direct routing to another network node.
3) System software examines messages intended for local services to determine which STP service needs to be accessed.
4) Messages that successfully complete the screening are then routed through the STP to their proper destinations, or to the CPU for local termination. Messages requiring global title translation (GTT) are processed in the LDBS, CNAM-DB, or DMS-10/AP system before being routed to their proper destination.

The following screening criteria are used for gateway screening:

- *allowed OPC*, to determine from which networks, cluster of nodes, or individual nodes CCS7 messages can be received
- *blocked OPC*, to determine from which points in a network messages cannot be received

- *allowed SIO* (service information octet), to screen message priority codes and message type for messages initially destined for a local service in the DMS-10 STP itself, allowing the network provider to control network congestion and to specify which CCS7 facilities can send testing and maintenance messages into its network
- *allowed DPC*, to determine which networks, cluster of nodes or individual nodes can be accessed
- *blocked DPC*, to determine which networks, cluster of nodes or individual modes cannot be accessed
- *affected destination field for signaling network management messages*, to restrict access to information on the status of particular CCS7 nodes in a provider's network.

The screening criteria in the form of screening steps, or “rules”, are datafilled into tables accessed through data modification overlay operation. Messages are successively routed through one or more of the screening tables as determined by the network provider. The screening at each table results either in failure, in which case the message has been blocked and should be discarded, in completion of all necessary screening, at which point the message can be routed through the STP to its network destination, or in transfer to the next screening table specified.

CCS7 protocol

As defined in the CCITT (International Telegraph and Telephone Consultative Committee) CCS7 protocol, CCS7 operations are divided into two parts, the Message Transfer Part and the User Part.

Message Transfer Part

The Message Transfer Part (MTP) of CCS7 manages signaling message routing. It is subdivided into three levels whose functions are provided by LAN Application Controller packs (NT4T20) downloaded with level specific software.

Level 1 - signaling data link.

Level 1 is the bidirectional transmission path for signaling. It is composed of digital transmission channels for carrying CCS7 signaling information.

Level 2 - signaling link.

Level 2 controls transmissions over an individual signaling data link. Signaling links receive signal units from higher levels and specify the conditions of signal transmission over the associated signaling data link.

Level 3 - signaling network.

This level is responsible for the management of the CCS7 network. Level 3 sequences and routes signaling messages to and from signaling links. The signaling network receives signaling messages from the User Part (level 4), converts these messages into signal units, and passes them to the appropriate signaling link for transmission over the signaling data link.

The collection of the DMS-10 resident signaling links that directly terminate to a single CCS7 node (SSP, STP, or SCP) are referred to as a *link set*. Signaling traffic from the DMS-10 switch to a single node is evenly distributed among the links in that link set. In the event of link failure, traffic is re-distributed among the functioning links and an alarm is raised.

User Part

The entire User Part (UP) of CCS7 is referred to as Level 4 in the CCS7 protocol. The “User” in the term “User Part” refers to any applications, such as E800 and Custom Local Area Signaling Services (CLASS), that use the CCS7 network, and any subsystems, such as Signaling Connection Control Part (SCCP), Integrated Services Digital Network User Part (ISUP), and Transaction Capability Application Part (TCAP) that support applications on the CCS7 network.

TCAP and SCCP

TCAP controls non-circuit related information transfer between nodes on the CCS7 signaling network. In the case of E800, TCAP supervises message transactions with Service Control Points. The SCCP provides information transfer functions between applications and the MTP. The SCCP transfers E800 TCAP signaling messages to the signaling network without setting up a signaling connection.

TCAP is also required for the following Customer Local Area Signaling Services (CLASS) features: Screening List Editing (SLE) services, Automatic Call Back (ACB), Automatic Recall (AR), Calling Name Delivery (CNAM), Calling Name Delivery Blocking (CNAB), Calling Identity Delivery and Suppression (CIDS), and Anonymous Call Rejection (ACR). The SLE services use special lists of DNs created by the subscriber. Validation of the DNs entered in these lists is accomplished through TCAP query and response messages transferred between the SLE customer's office and the offices containing the DNs. Starting in Generic 504.10 and later generics, validation of DNs for the SLE lists may be performed by using the Dialable Number Screening Translator; thus removing the need for TCAP to enable subscribers to add numbers to their SLE lists. The operation of the ACB and AR features relies on TCAP queries and responses for the transfer of data pertaining to the destination DN between offices. The CNAM, CNAB, CIDS, and ACR features use TCAP to access a central data base that contains names associated with DNs and control information that specifies whether the names can be displayed. The TCAP queries and responses are transferred to the signaling network by the SCCP. Starting with 504.10 generic, TCAP is used to query the name and the privacy status stored in the central data base for the calling party of a call to a station with the TELE (Telemarker Call Screening) option. The privacy status is used to screen unwanted calls.

The Advanced Intelligent Network (AIN) feature also uses TCAP. AIN features enhance switch call processing logic capabilities to recognize calls that require additional processing and to query an application Service Control Point (SCP). Service logic programs at the SCP determine how AIN calls should proceed for further call processing. TCAP queries and responses provide information exchange between offices equipped with AIN features and the SCP.

ISUP

ISUP enables signaling for call setup to be handled on signaling links separate from network paths used for voice traffic. This increases network efficiency by reducing post-dial delay and network utilization during call setup. ISUP is required for inter-office application of the CLASS features, Calling Number Delivery (CND), Automatic Recall (AR), Automatic Call Back (ACB), and Screening List Editing services (SLE), and for the Local Number Portability (LNP) feature.

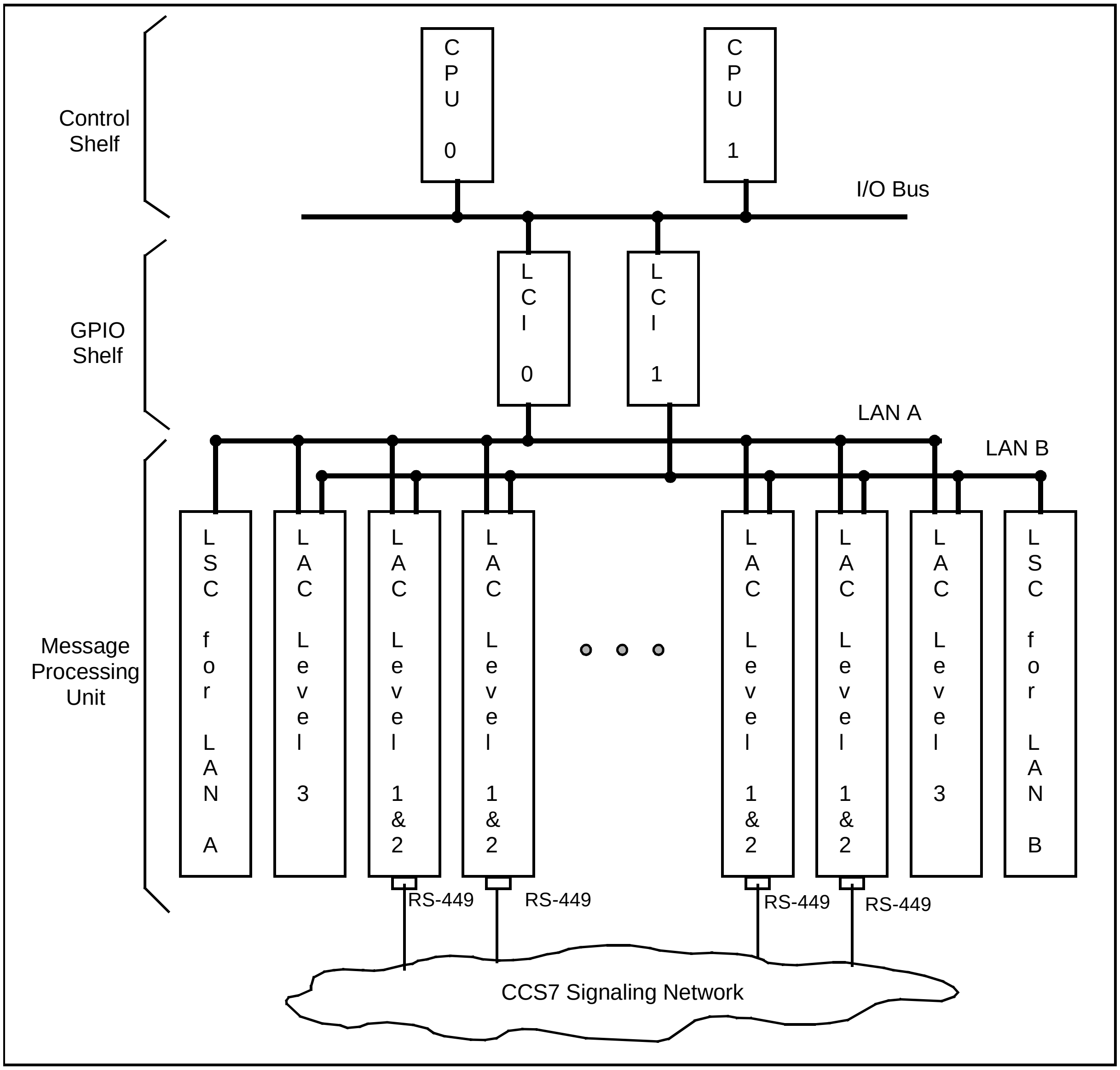
Message Processing Unit

The Message Processing Unit (MPU) is the DMS-10 switch's hardware and downloaded software that provides CCS7 signaling functions, including message processing control and maintenance. MPU hardware consists of a Messaging shelf (J1T65A-1), two Power Converter packs, two Local Area Networks (LANs), LAN Application Controller (LAC) packs (NT4T20), two LAN Shelf Controller (LSC) packs (NT4T18). Two LAN/CPU Interface (LCI) packs (NT4T16) on a GPIO or Network shelf are required to allow communication between the two I/O Buses and the two LANs. Figure 5-2 illustrates DMS-10 CCS7 architecture. For information about the MPU hardware, see NTP 297-3601-150, *Equipment Identification*.

Local Area Network

Two Local Area Networks (LAN A and LAN B) provide communication between the MPU components and the LCIs. Only one LAN is active at a time, while the other is in standby mode. If a fault is detected in the active LAN, the standby LAN becomes active and an alarm is raised. Both LANs interface all LAC packs on the Messaging shelf.

Figure 5-2: DMS-10 CCS7 architecture



Section 6: Integrated Services Digital Network

Introduction

Integrated Services Digital Network (ISDN) is a technology that extends the digital network to the customers' premises and allows end-to-end digital connectivity to support a wide variety of services. ISDN simultaneously transmits voice and (or) data over standard twisted-pair wire normally used to support either voice or data only.

ISDN uses the ISUP Signaling System 7 (SS7) signaling network to set-up, maintain, and tear down inter-office calls, and to enable the user-to-user signaling necessary to implement sophisticated voice and digital data services.

Key Components of ISDN

The key components of ISDN are the ISDN node, which comprises the exchange termination (ET) and the packet handler (PH), and customer premises equipment.

ISDN node

An ISDN node consists of two components, the exchange termination, and the packet handler (PH). The exchange termination terminates all lines and trunks and provides a gateway to the circuit-switched (voice and data) and SS7 networks. The DMS-10 switch is the exchange termination. As the exchange termination, a DMS-10 switch supports ISDN and non-ISDN lines and trunks. The packet handler provides a gateway to the Public Packet-Switched Network (PPSN) and routes data packets between subscriber terminals and the PPSN. All data packets are passed to the PPSN through a common packet handler access point interface (PHI).

The path between the DMS-10 exchange termination and an external packet handler is maintained over semipermanent Bb and Bd links on a DS-1 facility. The Bb links for B-channel packet data, and Bd links for D-channel packet data are provisioned in the DMS-10 switch during service datafill.

Customer premises equipment

Customer premises equipment (CPE) includes ISDN network termination one (NT1), ISDN telephones and terminals, terminal adapters, ISDN interface cards, ISDN local area network products and any other equipment that a subscriber uses in an ISDN environment.

OSI reference model

An open systems interconnections (OSI) model, developed by the *Committe Consultatif International Telegraphe et Telephone* (International Telegraph and Telephone Consultative Committee (CCITT)) and the International Standards Organization (ISO), standardizes ISDN service protocol structure into seven layers. The first three OSI model layers, which govern the connection and information transmission between terminals on an ISDN line and the packet- and circuit-switched networks, are described below.

Layer 1 - physical layer

Layer 1 provides the physical characteristics between the ISDN interface and the network. These include the physical wire connections, transmission of electrical signals between endpoints, and link activation and deactivation. To minimize signal attenuation and maximize loop distances, Layer 1 uses 2B1Q (2 binary, 1 quaternary) line coding technique.

Layer 2 - data link layer

Layer 2 provides the logical links between the CPE and the exchange termination. The data link layer transmits and delivers error-free information over a physical medium. Recommendations Q.920 and Q.921 specify ISDN Data Link protocols. Layer 2 Delta channel (D-channel) signaling uses Link Access Protocol for the D-channel (LAPD) message format protocol. LAPD is a bit-oriented protocol used for exchanging information in frames. LAPD transports call-control signaling (Q.931 messages) and also X.25 data. These two packet types are distinguished from each other through a field in the Layer 2 address called the Service Access Point Identifier (SAPI). Q.931 messages travel between a subscriber's ISDN terminal and the DMS-10 switch, while X.25 messages travel between a subscriber's data terminal and a packet handler.

Layer 3 - network layer

Layer 3 provides the messaging format that enables the connection between two communicating application entities. It provides routing, switching, and relaying functions used to establish, maintain, and clear circuit- and packet-switched call connections. This layer is also responsible for terminal initialization procedures and assigning service attributes to terminals. The two major Layer 3 protocols defined by the SAPI are Q.931 call control and X.25 packet. Q.931 messages contain call control information and also information elements such as the calling party and bearer channel. Each call is identified with a call reference value that is unique to the interface. X.25 packets are sent and received to and from the packet handler.

ISDN switching technologies

ISDN supports circuit- and packet-switching technologies. Circuit-switching carries voice information (VI) and circuit mode data (CMD) over Bearer channels (B-channels) which are dedicated only for the call duration. Delta channel (D-channel) packet-switching is a method of data transmission that routes data in stored packets, using addressing, through virtual network circuits. D-channel packet-switching is provided through semipermanent, (also called nailed-up), channels through the DMS-10 network to an external packet handler. Packet handlers may be located at the DMS-10 site or at a remote location.

Layer 2 establishment

When an ISDN terminal is powered up, it automatically establishes a logical link between itself and the network by sending a notification message over the D-channel. The link remains established until the device is powered down.

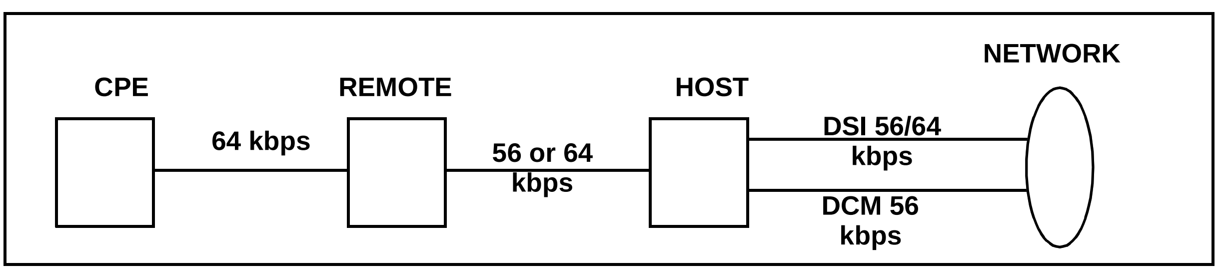
Bearer Capability transmission

Each B-channel is a 64 kbps bidirectional channel. ISDN supports circuit mode voice and data calls over B-Channels. ISDN calls have the capability of providing speech, 3.1 kHz audio, 56 kbps CMD, or 64 kbps CMD. When applied to a call, these characteristics are referred to as the call's bearer capability.

The DMS-10 switch supports both 56 kbps and 64 kbps CMD bearer capability for ISDN. CMD rate, determined through ISDN line administration, allows CMD calls to terminate on data terminals with a comparable bearer capability. Even though a line is provisioned for 64 kbps CMD, the CPE may receive data at a rate less than 64 kbps due to slower equipment across the network.

Bearer capability transmission rates can vary between a host and a remote subscriber, between two remotes, and between two inter-exchange carriers. DMS-10 call screening is designed to allow calls to complete at the greatest available bandwidth. Figure 6-1 shows the transmission rates for various DMS-10 equipment in an ISDN configuration.

Figure 6-1: DMS-10 ISDN data transmission rates



ISDN User Interfaces

There are two ISDN network-to-user interfaces:

- Basic Rate Interface (BRI) - which provides access to a variety of computers, data terminals, and telephone sets over the two-wire facilities which exist in most residential and business telephone environments
- Primary Rate Interface (PRI) - which enables a variety of equipment, including PBXs, computers, LANs and WANs, intelligent peripherals, and video-conference units, to be connected to ISDN over digital trunks

ISDN reference points

ISDN reference points used both by BRI and PRI are described below. The reference points are illustrated in Figure 6-2.

U-loop - BRI

A U-loop is the wiring between a DMS-10 ISDN line card and the CPE. A simple U-loop is a two-wire interface which provides a point-to-point physical connection over a digital subscriber line (DSL). Each U-loop provides the same two B-channels and one D-channel as the S/T interface (described below), but supports only one physical termination. Normally a U-loop terminates to an NT1 (described below), however it can terminate directly to a terminal if the terminal contains NT1 functionality. U-loops may extend up to approximately 18,000 feet in length and require specific restrictions regarding wire gauge and configuration.

U-loop - PRI

The U-loop for PRI uses the North American standard T-1 facility. The physical medium is two twisted pairs of wire. The U-loop requires a normal T-1 carrier plus clear channel capability and extended superframe format.

Network Termination one (NT1)

The NT1 is the interface between the U-loop and the S/T bus to which the subscriber's equipment is connected. The functions of the NT1 include line maintenance, performance monitoring, timing, and multiplexing.

Network Termination two (NT2)

The NT2 provides “higher-layer” functionality, such as a PBX, key system, LAN, or cluster controller.

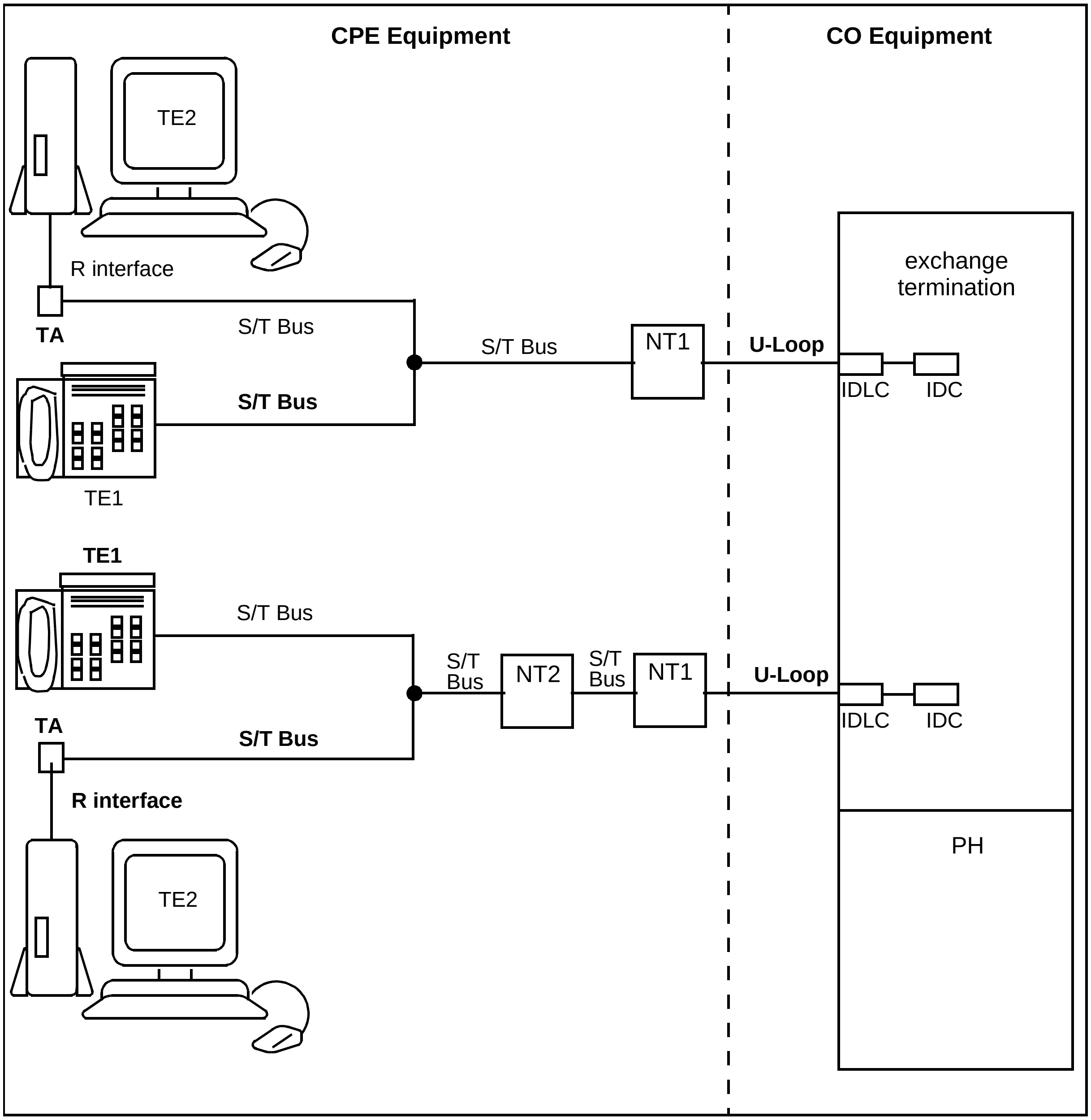
Terminal

A terminal, in an ISDN BRI environment, refers to ISDN compatible CPE, including telephones and data terminals. Terminal adapters are required for non-ISDN devices.

Terminal adapter (TA)

Terminal adapters are devices used to convert ISDN loop signals to a format used by an analog telephone, computer, or another non-ISDN intelligent device. Up to eight ISDN TAs can be connected to the loop, but they must all share the loop facilities.

Figure 6-2: DMS-10 ISDN configuration



S/T Interface

The S/T Interface, also known as the S/T bus or passive bus, is a four-wire interface that supports multiple physical connections. The name *S/T* is the CCITT term for *S* and *T* reference points. Point *T* refers to the terminal connection to the NT1. Point *S*, in non-BRI applications using a PBX, refers to the connection between a PBX and a terminal. Each S/T interface provides two B-channels and one D-channel. All terminals connected to the S/T bus share the two B-channels and the D-channel.

R interface

An R interface, in an ISDN environment, refers to the connection between a non-ISDN device and an ISDN TA. R interface examples include RS-232 and RJ-11 connections.

Basic Rate Interface

ISDN Basic Rate Interface (BRI) provides access to a variety of computers, data terminals, and telephone sets over the two-wire facilities which exist in most residential and business telephone environments.

ISDN BRI telephone lines transmit information on three separate digital channels. Two of the channels, B-channels, support voice calls or data transmissions at a rate of up to 64 kbps. The third channel, the D-channel, supports low-speed packet data, Q.932 maintenance, and Q.931 call control for ISDN calls. BRI is sometimes referred to as 2B + D, in reference to the BRI three channel architecture.

ISDN provides multiple, simultaneous phone calls. For example, a single subscriber can hold a voice call to one location using one B-channel, a circuit-switched data call to a different location on the second B-channel, and still a third data call to another location using a packet-switched device on the D-channel. Up to eight packet devices can share a single 16 kbps D-channel using a D-channel multiplexing algorithm. B-channel call control signaling receives a higher priority, while D-channel packet data receives a lower priority.

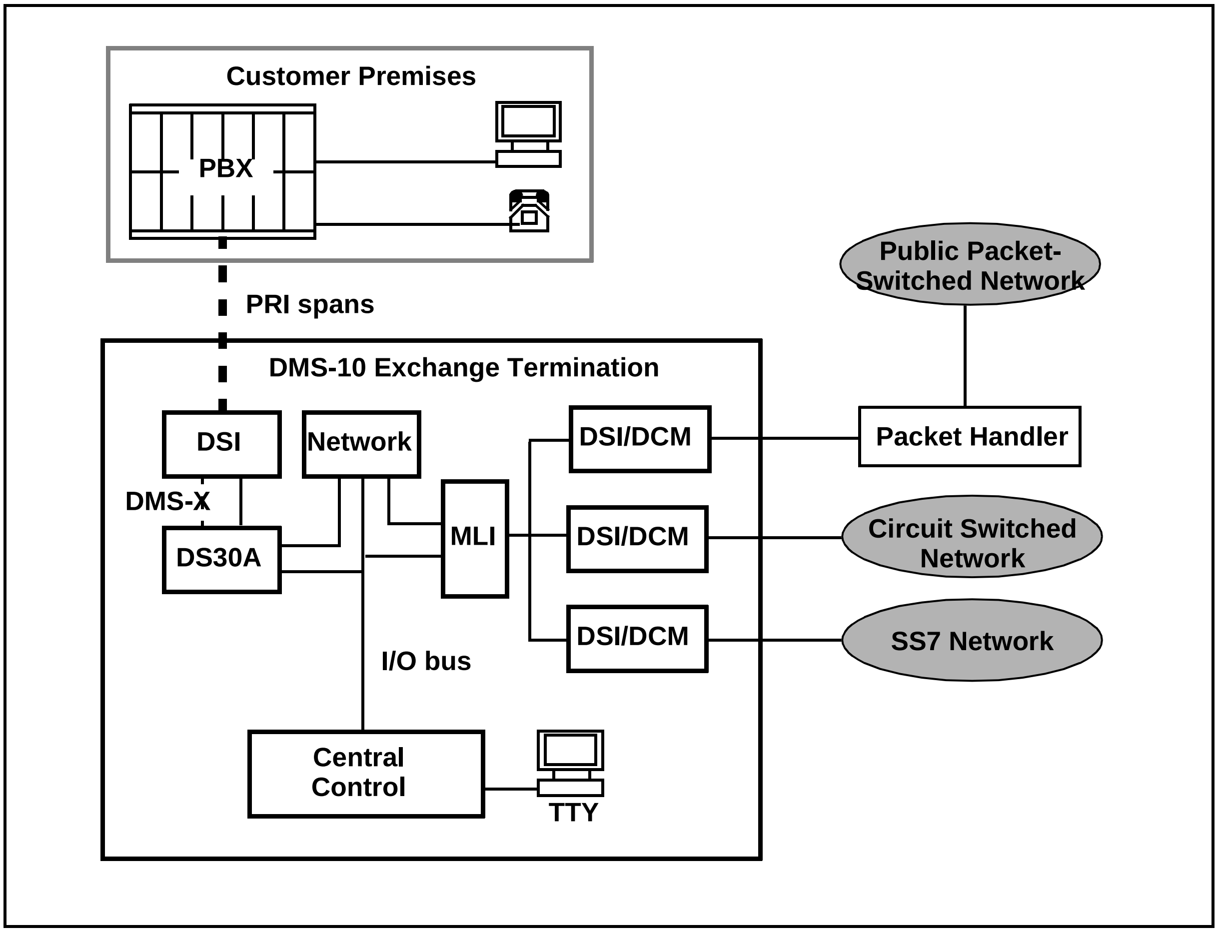
An ISDN BRI line supports up to eight terminal devices. Each terminal can use both B-channels, the D-channel, or a combination of all BRI channels. If more than two terminals are configured as B-channel terminals which may receive calls for a common DN, then B-channel terminal contention exists. A BRI line supports two B-channels, therefore a maximum of two terminals can simultaneously use both channels. The remaining terminals must compete for B-channel service access. Likewise, a configuration with at least two or more D-channel packet data terminals works in a D-channel terminal contention mode. The active D-channel terminals take turns sending packets over the D-channel using a contention protocol.

Voice and data terminals can share directory numbers (DNs) across the two call types. This capability allows an integrated terminal (one that supports more than one call type) to share one DN for both voice and data call types. An integrated terminal can simultaneously access both B-channels which can boost the terminal rate to 128 kbps for high speed data applications.

Primary Rate Interface

ISDN Primary Rate Interface (PRI) enables a variety of equipment, including PBXs, computers, LANs and WANS, intelligent peripherals, and video-conference units, to be connected to the ISDN over digital trunks. Figure 6-3 shows a sample ISDN PRI configuration.

Figure 6-3: DMS-10 ISDN PRI configuration



In North America, most ISDN user-to-network PRI interfaces are configured to provide twenty-three 64 kbps B-channels and one 64 kbps D-channel. This configuration is referred to as 23B + D. PRI uses the DS-1 standard twenty-four full duplex channels to carry ISDN signals between the ISDN exchange termination and Class II equipment such as Nortel's Meridian 1 systems. This is equivalent in bandwidth to the North American standard T-1 carrier, which has a 1.536 Mbps information payload and 8 kbps overhead (framing bits) that make up the full T-1 carrier speed of 1.544 Mbps.

PRI is supported in a DMS-10 Stand-alone switch and in a DMS-10 three-bay configuration when a Digital Carrier Interface (DCI) shelf is provisioned. PRI is not supported in DMS-10 Large Cluster Controller (LCC) configurations, or any remote equipment modules connected to the DMS-10 switch.

PRI is implemented in the DMS-10 switch through PRI application software downloaded in the Digital Signal Interface (DSI) hardware. The AD version of the Span Interface Card (NT4T24) and the AB version of the Dual DS-1 Interface card (NT6X50) are required in the DSI. The PRI application software has an integral D-Channel Handler which encapsulates Q.931 signaling message inside DMS-X signaling information and routes the messages to the central control. The DS-30A Interface pack (NT4T04AM), or the Network Interface pack (NT8T04), provides the interface between the DMS-10 network equipment and DSI hardware.

DSI trunks, using B8ZS (bipolar and 8-bit zero substitution) coding scheme for zero code suppression, are used to achieve clear 64 kbps transmission rates for packet-mode data or circuit-switched voice/data. A DSI is used to provide 56 kbps data transmission rates for packet mode data or circuit-switched voice/data.

The DMS-10 ISDN PRI system operates as a DMS-10 exchange termination and external packet handler system. Only the Nortel DPN-100 Packet Handler is supported and, thus, a single DPN-100 Packet Handler is shared among several DMS-10 exchange terminations. The DPN-100 Packet Handler may be co-located with a DMS-10 exchange termination or may be located at a remote site serving more than one DMS-10 exchange termination.

The DMS-10 exchange termination and the DPN-100 Packet Handler are interconnected by DS-1 digital transmission links. These digital paths enable packet-mode data terminals to gain access to the DPN-100 Packet Handler network through semipermanent (nailed-up) connections at the DMS-10 switch. As packet-mode data service is assigned to the end user's data terminal equipment, a semipermanent connection must be established between a channel to the customer premises equipment and a channel to the DPN-100 Packet Handler.

DSI architecture in the PRI configuration

The DSI architecture in the PRI configuration comprises the following components:

- PRI spans
- Dual DS-1 Interface Controller (NT6X50)
- Signaling Interface Controller (NT4T24)
- DS-30A loops to the network interface pack

The PRI spans terminate on the NT6X50 pack. The NT6X50 pack maps the 48 channels from the PRI spans (24 channels per 2 spans) onto a DS-60 link. The DS-60 link carries the channels to the NT4T24 pack. The NT4T24 pack terminates the two D-channels (one from each PRI span) and their Q.921 signaling. The DS-30A loops carry the 46 B-channels and one DMS-X channel to the NT4T04 or NT8T04 pack. The DS-30A pack, or Network Interface pack, passes the DMS-X messaging to the CPU and switches the 46 B-channels to the Network.

All B-channels are nailed-up from the PRI spans to the DS-30A pack or to the NT8T04 pck. The D-channels messages (along with DSI maintenance messages) are concentrated on the DMS-X channel of the primary DS-30A loop.

PRI spans These spans provide the DMS-10 switch with an NI-2 PRI. For facility associated signaling, each PRI contains:

- 23 B-channels
- a 24th channel (D-channel) that carries span control and B-channel call control messages
- framing bits, in extended superframe format, divided into three separate channels:
  - 2-kbps channel for framing
  - 2-kbps channel for CRC-6 (six-byte Cyclic Redundancy Check code) for each extended super frame
  - 4-kbps channel (Embedded Operations Channel (EOC)) for diagnostic control and transmission of performance statistics. Only the Remote Alarm Indication (RAI) signal is recognized by the DMS-10 switch.

NT6X50 DS-1 Interface card The NT6X50 card terminates the physical (Layer 1) PRI spans. The pack provides basic loop surveillance and data synchronization, and maps the PRI channels onto the DS-60 link to be passed to the NT4T24 pack. The NT6X50 pack provides:

- 2 PRI span terminations
- DS-60 link interface
- DS-1 loopback to the line
- payload loopback to the host

DS-60 link The DS-60 link is integrated into the DCI shelf backplane and connects 64 bi-directional 64-kbps channels between the NT6X50 and the NT4T24.

NT4T24 Signaling Interface Controller (SIC) The NT4T24 card provides the D-channel handler for the PRI spans and maintenance control, and maps the 46 B-channels onto the DS-30A loops. The NT4T24 provides:

- DS-60 interface
- 2 Q.921 (Layer 2) terminations for PRI D-channels
- interface for 2 DS-30A loops
- DMS-X signaling channel on the DS-30A Interface
- payload loopback to the host
- channel loopback to the host

DS-30A loop Each DS-30A loop provides 32 bi-directional 64-kbps channels between the NT4T24 pack and the NT4T04 pack or the NT8T04 pack. The primary DS-30A loop carries DMS-X signaling for the DSI.

Network equipment in the PRI configuration

For ISDN PRI, the DS-30A Interface card (NT4T04) provides the interface between the DSI module and the DMS-10 CPU and network. The NT4T04 switches DS-30A loop channels into the DMS-10 network and terminates DMS-X signaling, passing messages on to the DMS-10 CPU through the I/O bus interface. The NT4T04, or NT8T04, provides:

- DS-30A loop terminations
- DMS-X signaling termination
- switching for DS-30A channels into the DMS-10 network
- I/O bus interface to the DMS-10 CPU

Message flow for PRI call types

The message paths taken by the basic ISDN PRI call types include:

- D-channel call control
- B-channel circuit-switched voice/data
- B-channel packet data

The channel types and the types of data they carry include:

- B-channels - 64-kbps clear-channel timeslot used for circuit-switched voice or data
- D-channel - 64-kbps signaling channel on the PRI span used for Q.931 call control signaling

- DMS-X - signaling channel between the DS-30A Interface and peripheral equipment, used by the DMS-10 CPU to communicate with the PRI application software on the DSI hardware
- Bb channel - 64-kbps/56-kbps channel used to transport X.25 packet data between the DPN-100 Packet Handler and CPE data terminal equipment that uses the B-channel of the PRI span. Bb-channels are provisioned and nailed up according to subscriber request, and each Bb channel is dedicated to the subscriber. There can be more than one Bb-channel per PRI span.

Loops and their channels The use of the channels in the loops connecting the PRI configuration hardware components is described in the following paragraphs.

The PRI span from the CPE contains twenty-four 64-kbps channels and 8 kbps for framing bits, giving a total data rate of 1.544 Mbps (the rate used by the North American T-1 carrier). One channel is used for the D-channel and the remaining 23 channels may be used for B-channels.

The DS-30A loop to the DSI is comprised of thirty-two 64-kbps channels, giving a data rate of 2.56 Mbps. The first channel on the primary loop is allocated as a DMS-X communications channel. Twenty-three channels carry the B-channels. The remaining channels are unused.

The MLI loop to the DSI (for 64 kbps) or DCM (for 56 kbps) is comprised of 32 channels. Twenty-four of the channels are mapped to the 24 channels on the DS-1 signal. The remaining channels can be semipermanent (nailed-up) connections or are unused.

The DS-60 loop is used between the NT6X50 pack and the NT4T24 pack and is comprised of sixty-four 64-kbps channels. Forty-eight channels from the two PRI spans are mapped to 48 channels on the DS-60 loop; the remaining channels are unused.

D-channel call control PRI application software on the DSI module handles the Layer 2 processing for call control messages by terminating the LAPD link from the CPE and the DMS-X link from the DS-30A. Each Layer 3 Q.931 message handled by the DSI is passed transparently between the CPE and the DMS-10 CPU by conversion between LAPD and DMS-X signaling.

In addition to protocol conversion, the DSI multiplexes and demultiplexes call control messages between up to 2 D-channels and 1 DMS-X channel. Because all messaging takes place on the primary DS-30A loop, loss of this loop takes the DSI hardware and associated PRI spans out of service.

The DS-30A terminates the DMS-X channel from the DSI and converts between DMS-X signaling and I/O bus signaling to transfer Q.931 messages between the CPU and the CPE.

B-channel voice/data circuits The path for B-channel voice/data circuits is switched to the circuit-switched network. Once the circuit has been established by call control signaling, no processing is required within the DMS-10 switch until the call is cleared. The DMS-10 switch provides a Layer 1 circuit for passing bits between the terminal and the network.

B-channel packet data The path for B-channel packet connections are nailed-up to the DPN-100 Packet Handler. After the circuit has been established, no processing is required within the DMS-10 system. The DMS-10 switch provides a Layer 1 circuit used for passing bits between the terminal and the network.

Customer premises equipment supported by PRI

Customer premises equipment must comply with the guidelines in Bellcore document, *ISDN Primary Rate Interface Generic Guidelines for Customer Premises Equipment*, SR-NWT-002343. The DMS-10 switch supports the following CPE:

- Class II equipment (intermediate equipment serving as an interface between the central office and the terminal equipment, such as a PBX)
- equipment compatible with the network-provided ISDN PRI offering for NI-2

DMS-10 PRI supplementary services

The DMS-10 NI-2 PRI provides the following services:

- access to selected PRI services on a per-call basis, including Direct Outward Dial (DOD), Automatically Identified Outward Dial (AIOD), Direct Inward Dial (DID), Multiple Inter-exchange Carriers (IEC), Foreign Exchange (FX) facilities, tie trunks, OUTWATS, and INWATS
- calling number identification services, including delivery of network-provided calling number, privacy of calling number, and calling party number screening
- calling name delivery

ISDN call processing

Circuit-switched calls

The circuit-switched network interface carries ISDN voice and circuit mode data into the network over DS-1 signals. Digital Signal Interface (DSI) clear-channel capability supports ISDN applications that require 64 kbps circuits and 64 kbps unrestricted digital information.

After a Layer 2-Link is established, the network and the device use Q.931 circuit-switching protocol to establish a Layer 3-Network end-to-end connection. The network then periodically sends a SAPI 63 audit message to verify that the device is still active. The DMS-10 switch identifies the TEI and SAPI 0 and checks the device's service data. A Service Access Point Identifier (SAPI) indicates whether the call is circuit-switched or low-speed data packet-switched. SAPI 0 indicates a circuit-switched call, and SAPI 16 indicates a packet-switched call.

An ISDN call origination occurs when a SETUP message is received from the calling ISDN equipment and passes validation. The equipment accesses the D-channel and transmits a call request (SETUP) message to the DMS-10 switch. The network then establishes a B-channel call path at SETUP.

The DMS-10 network locates the destination device and looks up the destination device's service data if the called address terminates to a line in the office. The DMS-10 sends either a ring message to a non-ISDN called party, a SETUP message to an ISDN called party, an IAM message on an ISUP trunk, or a seizure on a non-ISDN trunk. The calling party receives an alerting ringback tone and an ALERT message. Each B-channel connection is released when either party goes on-hook.

End-to-end subscriber signaling

D-channel signaling provides the mechanism by which information can be passed between calling and called ISDN users. This information can be any or all of the following Q.931 message information elements (IEs):

- calling party number, if subscribed to by the called party, provides a calling number to the called party before answer, unless prohibited by the calling user.
- calling party subaddress provides up to 20 octets by the calling party to the called party before answer, unless prohibited by the calling party.
- called party subaddress provides up to 20 octets by the called party to the calling party before answer.
- low-layer compatibility information identifies the information transfer rate of the calling party's equipment to allow the called party to determine whether to respond to the call.

- high-layer compatibility information identifies the information transfer type of the calling party (telephony, fax) to allow the called party to determine whether to respond to the call.
- user-to-user signaling (UUS) permits either party to transmit up to 128 octets of information in conjunction with call control messages.

  Note: *UUS is not supported by ISDN PRI.*

Each IE is accepted by the DMS-10 from the calling party and passed to the terminating ISDN line or trunk if the calling party has the corresponding subscription indicators. Calling party subaddress is delivered to the called interface along with the calling party number if the called party subscribes to Calling Number Delivery (CND).

UUS is accepted from the calling ISDN equipment in the initial SETUP message when the User-to-user signaling transfer (UUT) parameter is assigned to the calling BRI DNCT. The UUS is delivered to the called BRI equipment in the outgoing SETUP (or if the called equipment is an ISUP trunk, the IAM message. If the UUS cannot be delivered to the called equipment because either it cannot fit into the outgoing SETUP message, or if the called equipment is non-ISDN or PRI, then the call treatment depends on DUUS subscription by the calling DNCT. If DUUS is subscribed, then the call is dropped, and if not, the call termination completes without delivering UUS, and the calling equipment is notified that the UUS was dropped in a STATus message containing cause #43.

Once UUS has been delivered to the called equipment in the outgoing SETUP or IAM, it may also be accepted from that equipment in either a call reject message or the answer message. Once the call is established, UUS may be accepted from the equipment which initiates call clearing, in the initial clearing message.

Feature activation (ISDN BRI only)

In addition to call control, D-channel signaling also manages feature activation, for ISDN BRI. In this context, feature activation refers to both dial access codes and feature activators. When an activation occurs during a B-channel call, the activation is termed as “call associated” and feature activation begins with a SETUP message and a specified call reference value. When an activation occurs outside of a B-channel call context, the activation is termed as “non-call associated”. In this case, the feature activation begins with an INFO message and a “null” call reference value.

Tones and announcements

Network provided tones (NPT) and announcements are divided into two general categories or classes, Category (or Class) 1 and 2. Category 1 includes dial, reorder, and busy tones, as well as non-intercept announcements. Category 2 includes audible ringing tone and intercept announcements.

A DNCT subscription parameter allows Category 1 tone and announcement provisioning to ISDN BRI subscribers on a DNCT basis. This is known as inband or network provided tones and announcement subscription. ISDN users that subscribe to NPT receive Category 1 or 2 inband tones and announcements on all speech and 3.1 kHz audio calls having an allocated B-channel. Tones and announcements in Category 2 are always provided over an allocated B-channel, regardless of the subscription to this parameter.

ISDN Call Routing

After translations, any call that does not terminate on a line within the switch eventually terminates on a bearer route (BRTE). The BRTE examines the call's bearer capability (BC) and directs the call to the appropriate route specified by the BC.

For calls that do not terminate to a line in the DMS-10 switch, translation ends at a ROUT leaf or at a BRTE leaf. Trunk groups associated with a route defined through the BRTE are examined for BC sufficiency. Based on this examination, translation ends either at a route of known sufficient capability or at a route indicating an insufficient capability condition. A default route option in the BRTE prompting sequence provides a routing alternative that does not consider bearer capability for non-ISDN calls. If not routed to a default route, non-ISDN calls are routed to a 3.1 kHz audio route. 64 kbps trunks used for two-way end-to-end 64 kbps clear channel connections are transferred on common channel signaling facilities and require SS7 signaling capability with DSI trunks configured at a 64K baud rate.

Upgrade routing The ability to select a secondary ISDN call route when the intended route is not available is known as *upgrade* routing. Upgrade routing restricts ISDN calls to reach a route that supports a higher capability level. Thus, upgrade routing ensures that an ISDN call reaches a trunk group that adequately supports the call's BC. Although alternate routes can be specified for all routes, upgrade routes can be specified only for BRTE routes. Alternate routing for BRTE routes occurs only after upgrade routing has terminated on a specific route. The highest BC level, a 64 kbps call, cannot go to an upgrade route and always requires an alternate route when the intended route is not available. If an upgrade route is not assigned, ISDN calls use traditional alternate routes.

Packet switched calls

The DMS-10 supports D-channel and B-channel packet calls. Both types are routed over DS-1 facilities dedicated for packet traffic using semipermanent (nailed-up) DS-0 channels known as Bd- and Bb-channels.

A T-1 span is the physical interface to a packet handler. For D-channel packet handling, a single Bd-channel carries statistically multiplexed X.25 packets from multiple BRI D-channels. The multiplexing occurs at Layer 2. A Bd-channel can handle up to 64 virtual circuits which are identified at Layer 2.

Layer 2 Frame Switching (FS) is a modified LAPD protocol with an expanded address field that allows multiple BRI loops to use a single Bd-channel. In addition to the SAPI and TEI already present in the original LAPD packet, a new field is added to provide unique terminal identification within a Bd-channel. The Layer 3 packet handler interface consists of the X.25 Packet Layer Protocol and is passed between ISDN BRI terminals and the packet handler through a semipermanent connection in the DMS-10. For each ISDN drawer, the IDC receives D-channel X.25 packets from all assigned line cards (up to 28) and multiplexes those packets onto a single Bd-channel. A 64 kbps (with DSI) or a 56 kbps (with DCM) Bd-channel is allocated whenever an ISDN drawer is provisioned for packet switching.

B-channels also transmit X.25 packets using Bb-channels, which are semipermanent circuits, between the CPE and the packet handler, that carry packet data. Subscribers who choose to use B-channel packet switching cannot use that B-channel for circuit mode data or voice information transmission. An ISDN line drawer can support multiple Bb-channels.

ISDN Administration and Maintenance

The following paragraphs describe ISDN administration and maintenance requirements.

ISDN BRI subscriber administration

The North American ISDN User's Forum (NIUF) developed a set of ISDN templates designed to simplify subscriber ISDN orders and operating company ISDN administration. NIUF templates exist for individual ISDN administration views, or for capability packages that combine all ISDN administration views into single configurations. DMS-10 uses the NIUF capability packages as *metatemplates*.

DMS-10 adheres to the following ISDN views, as recommended in Bellcore Technical References (TR), that comprise the structure of an ISDN BRI subscriber line:

- Office Equipment (OE)
- Operating Equipment Directory Number (OEDN)
- Directory Number Call Type (DNCT)
- Terminal Service Profile (TSP)
- Terminal Service Profile Directory Number/Call Type (TSPD)
- Terminal Configuration (TCGN)

Each view contains administrative parameters specific to that level. OE represents the characteristics for an entire set of a subscriber's ISDN CPE. OEDN is the directory number(s) assigned to that equipment. DNCT represents the DN call type features. TSP represents profiles for each individual ISDN terminal. TSPD associates a DN to a terminal. TCGN represents a terminal layout including the feature indicators and activators on a terminal. When not using metatemplates, multiple ISDN views must be created individually for each ISDN BRI subscriber line. Administrators have the option to create ISDN subscriber profiles with, or without, ISDN templates.

Subscribers familiar with the NIUF capability packages can order them directly from the operating company. For example, if a subscriber orders capability package C, after establishing the subscriber's ISDN line, an operating company administrator need only access one overlay to establish all the necessary ISDN views for that subscriber. In this example, the administrator selects metatemplate *C* through ISDN(TMPL). After entering information specific to that subscriber, such as the SPID and DN, the metatemplate automatically configures all required ISDN views through a single prompting sequence.

Templates and metatemplates can be either NIUF-based and identified by letters, or operating company-based and identified by numbers. The operating company also has the option to save an NIUF-based template or metatemplate in a DMS-10 custom format (now identified by a number). Once saved in a custom format, a template or metatemplate can be modified to match ISDN options specific to the operating company.

The Overlay ISDN section in NTP 297-3601-311, entitled *Data Modification Order Manual*, contains a detailed description of each ISDN view and how it pertains to DMS-10 ISDN BRI administration.

ISDN BRI terminal initialization

The ISDN Drawer Controller (IDC) encapsulates a Q.931 message into a DMS-X message format and sends this information to the exchange termination central processing unit through the DMS-10 network. The address field contains a terminal endpoint identifier (TEI). The TEI provides a unique identification for each terminal, or device, on an ISDN loop. TEI numbers 0 through 63 are static (STEI), and numbers 64 through 126 are dynamic (DTEI). TEI 127 is a broadcast indicator used by the network for periodic audits and for call termination. For a DTEI, during Layer 2 terminal initialization, the DMS-10 receives an identity request before randomly assigning a TEI to the terminal. An STEI is stored in the terminal and programmed into the DMS-10 through Overlay ISDN, prompting sequence OE, and the same TEI is always used for that terminal at Layer 2 initialization.

A fully-initializing terminal (FIT) uses a Service Profile ID (SPID) programmed into the terminal which is validated and accepted by the DMS-10 during the Layer 3 initialization process. A non-initializing terminal (NIT) using a DTEI is not individually identified and instead uses a default terminal service profile (DTSP) determined through Overlay ISDN, prompting sequence OE, at Layer 3 initialization.

A FIT is uniquely identified at the exchange termination by its assigned SPID, while a NIT shares the attributes defined for the DTSP.

A SPID is used to distinguish up to eight FITs on a single line. The operating company must provide every ISDN subscriber with a unique SPID for each terminal used by that subscriber. The SPID is a combination of two separate fields, a Terminal Service Profile ID (TSPID) and a Terminal Identifier (TID). The TSPID is a set of digits defined by the operating company through Overlay ISDN, prompting sequence TSP. The TID is a two-character identification code created by the subscriber. Also through prompting sequence TSP, an additional user identifier (USID) is assigned to each terminal on an ISDN line. When power is applied to a subscriber FIT, and layer 2 is established, the FIT transmits the SPID to the DMS-10. A FIT must transmit a SPID to the DMS-10 if Layer 3 initialization is to occur. After successful TSPID validation, the DMS-10 validates the TID portion of the transmission. The TID is stored in a TEI associated table and sent back to the terminal, with the USID, in a Q.931 INFO message after successful Layer 3 initialization.

Auto SPID The Auto SPID feature enables the SPID to be generated automatically by the DMS-10 switch, thus relieving the operating company from having to enter the SPID information manually. The feature eliminates problems caused by incorrect SPID information being entered or by SPID information not being entered at all.

The FIT initiates the Auto SPID selection process by sending an initialization request containing a Universal SPID to the switch. The switch then determines which service profiles are associated with the FIT's interface and sends the corresponding SPID(s) to the FIT. Thus, only when a FIT receives multiple valid SPIDs (when the interface supports multiple terminals) is intervention by operating company personnel necessary, to select the correct SPID. The FIT stores the SPID in non-volatile memory and uses it to request initializations and to request parameter downloading.

The Auto SPID feature complies with requirements outlined in Bellcore document GR-2941-CORE.

ISDN BRI Maintenance

ISDN maintenance uses self-diagnostic capabilities built into the IDC, the NTBX27 ISDN line card, and the NT1 (located at the customer premises). Digital subscriber line (DSL) maintenance supports Performance Monitoring (PM) and maintenance testing . Performance monitoring shows the presence (or absence) of faults in a DSL, and maintenance testing isolates those faults. Additional ISDN maintenance testing is available through existing DMS-10 testing equipment including the Bit Error Rate Tester (IBERT) and the Peripheral Maintenance System (PMS).

It is recommended that ISDN service providers obtain additional test equipment for switch maintenance and CPE installation. Many portable ISDN test sets provide features for verifying voice, data, and packet (B and D channel) customer service, U loop and S/T bus interface testing, and analysis of ISDN Layers 1, 2, and 3.

Performance Monitoring

PM detects the presence, or absence, of DSL faults. Separate monitoring is performed at each OSI layer. All stored PM data may be retrieved through Overlay CKT. PM alert threshold levels are configured through Overlay CNFG, prompting sequence ISDN.

Layer 1 (physical layer) PM, administered by the NTBX27 line card, assesses basic line monitoring (BLM) of the physical layer transmission, between the NT1 and the line card. Along with the NT1 self-test capability, Layer 1 PM is used to determine if ISDN line problems originate in the network or from subscriber equipment. A cyclic redundancy check (CRC) detects block bit errors, a far end block error (FEBE) bit supports customer premise transmission performance network monitoring, and an embedded operations channel (EOC) provides a message-oriented channel between the DMS-10 switch and the NT1.

Layer 2 (data link layer) PM, administered by the IDC, assesses data link monitoring between the line termination and subscriber terminal equipment (TE). Transmission quality is based on Layer 2 frame errors and the number of re-transmitted frames. Counts are recorded for service disruptions and a high protocol abnormality rate. Service disruptions are caused by excessive frame transmission errors and frame protocol abnormalities. A high protocol abnormality register counts D-channel protocol abnormalities between the IDC and the Bd channel.

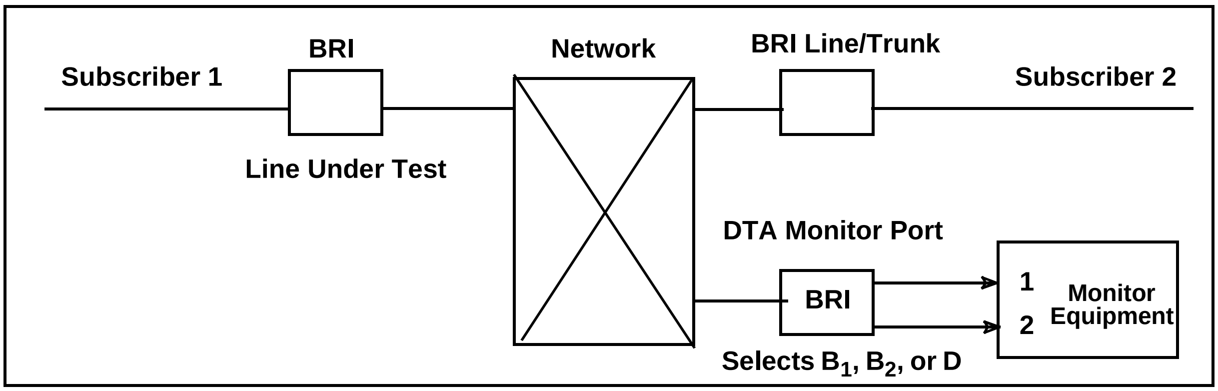
Layer 3 (network layer) PM, administered by DMS-10 software, records counts for non-call associated service disruptions. Layer 3 counts are recorded on a line basis. Counter resets, however, are done on a line basis; every hour, or at each ISDN line card Return To Service. If counter threshold limits are exceeded, a message is generated and the line is taken out of service for an amount of time defined in Overlay CNFG, prompting sequence MTCE, prompt OVRT. Service disruptions are recorded for all Q.931 signaling conditions that cause D-channel Layer 3 protocol abnormalities.

Maintenance testing

Digital testing is composed of a group of tests that include loopback, current-hour performance monitoring and current-hour thresholding. The loopback test measures bit error rates on the B_1 or B_2 channels for a selected ISDN line card. The current-hour test verifies the line card's ability to detect and count block errors, errored seconds, and severely errored seconds. The current-hour test is performed in both directions, between the line card and the NT1. Current-hour thresholding tests the line card's ability to generate threshold-crossing alerts. Digital testing threshold values are administered through prompting sequence CNFG(ISDN).

Digital test access (DTA) permits monitoring a B- or D-channel with a protocol analyzer or an external monitor. This test requires two ISDN line cards. One card serves as a DTA monitor port for test equipment, the other card contains the channel actually being monitored for the line under test (LUT). On the DTA port, channel B_1 monitors the LUT *receive* and channel B_2 monitors the LUT *transmit*. When monitoring the D-channel, the first two bits in the datastream contain the receive or transmit data. Figure 6-4 shows the basic DTA configuration as a block diagram.

Figure 6-4: Digital Test Access

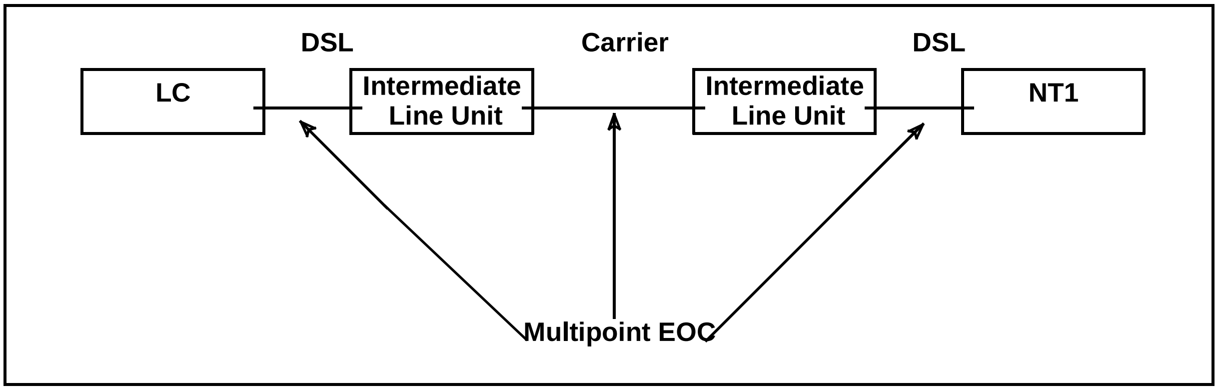


The DTA monitor port is usually assigned to the first line in the first available host ISDN line drawer. For convenience, this line is wired to one of the available test jacks on the CE-03 bay JOT98 Power Cooling Module. It is also possible to select any other ISDN line for temporary or permanent monitoring capability. Only one DTA connection can exist in an ISDN drawer at a time. DTA connections to different ISDN drawers can be established simultaneously. Any ISDN line, in any ISDN drawer, can be monitored from a selected DTA monitor port. Remote ISDN lines can be monitored from a host DTA port. DTA setup and monitoring is controlled through Overlay Trunk and Loop Test (TLT).

ISDN Multipoint EOC

Intermediate line units are used to extend an existing U-loop range beyond 18,000 feet from the DMS-10 host. Up to six intermediate line units can be configured per U-loop. As shown in Figure 6-5, the Multipoint Embedded Operations Channel (MP-EOC) is used for communication between intermediate line units on the U-loop. The ISDN Multipoint EOC feature enhances Layer 1 performance monitoring and maintenance capabilities for IDC ISDN NTBX27 lines by enabling the DMS-10 switch to communicate with and test the intermediate line units through an expanded MP-EOC command/response message set.

Figure 6-5: ISDN Multipoint EOC



The following MP-EOC performance monitoring (PM) information is collected for each intermediate line unit:

- block errors - the number of blocks (superframes) in which a CRC violation occurred
- errored seconds - the occurrence of one or more block errors in a single direction of transmission during a one-second interval
- severely-errored seconds - the occurrence of three or more block errors in a single direction of transmission during a one-second interval

The following counts and history data are maintained in each intermediate line unit:

- current hour (block errors, errored seconds, severely-errored seconds)
- current day (errored seconds, severely-errored seconds)
- previous hour (block errors, errored seconds, severely-errored seconds)
- previous day (errored seconds, severely-errored seconds)
- hourly history, for the seven most-recent hours (errored seconds)

Thresholds for these error types are established for each intermediate line unit and are used to determine whether the ISDN line is operating within prescribed tolerances. When a threshold is exceeded, MP-EOC PM causes the IDC to send a message describing the condition to the DMS-10 switch.

In addition to providing the DMS-10 switch the ability to test and monitor intermediate units, MP-EOC PM also provides the DMS-10 switch the capability to query the status of the intermediate line units to determine current and history counts for the unit's error registers, to determine the unit's threshold values, and to determine whether alarm mode (that is, the ability of the unit to report a threshold violation) is enabled for the unit. Specifically,

- The BERT T command in Overlay TLT (see the *Maintenance Diagnostic Input Manual*, 297-3601-506) can be used to verify the quality of the link between the line card and each of intermediate line units on an ISDN line.
- The STAT LPK command in Overlay PED (see the *Maintenance Diagnostic Input Manual*, 297-3601-506) can be used to display the status of the intermediate line units.
- The TEST LPK command in Overlay PED (see the *Maintenance Diagnostic Input Manual*, 297-3601-506) allows fault isolation on a multipoint ISDN line.
- The QUE PM and ZERO PM commands in Overlay CKT (see the *Maintenance Diagnostic Input Manual*, 297-3601-506) allow Layer 1 performance monitoring on intermediate line units.
- Overlay CPK (LPK) (see the *Data Modification Manual*, 297-3601-311) allows query for the number of intermediate line units on an ISDN line.

DMS-10 PRI administration

Office administration

New translations and routing information must be configured for PRI only if ISDN BRI has not already been configured in the office. Other administrative capabilities that must be configured for PRI include operational measurements and billing. In support of system configuration, default timer values and counts must be set.

Digital Signal Interface (DSI) Module administration

When a DSI module is configured for PRI application, the DMS-10 software ensures that the number of PRI facilities assigned does not exceed the maximum number of PRI facilities allowed. The maximum number of PRI facilities allowed is administered on a per-DMS-10 office basis and is purchased from Nortel as part of the PRI feature.

DMS-10 software ensures that PRI facility data is assigned only on a DSI module set up for PRI application. In addition, the software ensures that the correct peripheral software is downloaded to the Span Interface Controller (NT4T24) card.

Customer profile administration

Data defining a customer's interface (PRI Class II equipment interface) is defined using DMS-10 administrative overlays that define the following elements:

- number of B-channels that can be offered to the customers' premises
- bearer capabilities supported
- up to two calling party default DNs (one per call type)
- screening numbers for the customers' interfaces against which incoming calls are screened
- class of service

- Simulated Facilities Groups (SFG) used by the customers' interfaces
- SFG characteristics including SFG identifier, SFG group size, bearer capabilities supported, billing numbers to be used

Packet handler interface administration

The connection between the DMS-10 and the DPN-100 Packet Handler uses existing digital trunk interfaces (DSI/DCM). Only semipermanent (nailed-up) B-channel packet-mode data is supported.

The DPN-100 Packet Handler interface engineering rules define the way in which the DS-1 link between the DMS-10 switch and the DPN-100 Packet Handler is provisioned. The channels on the DMS-10 switch are statically assigned in two stages:

1) channel allocation configured on the PRI must be coordinated/matched with the channel allocation on the customer's side of the PRI
2) channel allocation configured on the DMS-10 side of the interface must then be coordinated/matched with the channel allocation on the DPN-100 Packet Handler side of the interface

DMS-10 PRI maintenance

Critical capabilities added to the normal DMS-10 OAM&P to support PRI access include:

- Layer 1 (physical layer) surveillance
- Layer 2 (data link layer) transmission performance monitoring
- Layer 2 service disruption monitoring
- Layer 2 high abnormality rate monitoring
- Layer 2 surveillance
- Layer 3 (network layer) service disruption monitoring
- Layer 3 high abnormality rate monitoring
- Layer 3 surveillance

The maintenance subsystem tests the ISDN PRI continuously in order to detect failures as early as possible. DMS-10 NI-2 PRI does not support communications with a remote test operations system or with other network elements.

Maintenance includes using self-diagnostic capabilities within the DSI module and the capabilities of the customer's NT1 (Network Termination 1). The DMS-10 performs link maintenance functions using capabilities of the DSI module, NT1s at the customers' premises, and existing DMS-10 test equipment (for example, the Integrated Bit Error Rate Tester (IBERT) pack). Protocol analysis must be performed using external operating company-provided test equipment. Maintenance equipment enables a link to be tested from a DMS-10 maintenance position and provides the capability for fault detection, fault isolation, and other OAM&P functions.

PRI testing is organized into two major tasks: performance monitoring and testing. Performance monitoring detects PRI faults and testing isolates the cause of the faults.

Performance monitoring

PRI performance is monitored for transmission errors at Layer 1, for transmission errors, service disruptions and protocol errors at Layer 2, and for service disruptions and protocol errors at Layer 3. Layer 1 and Layer 2 performance monitoring is performed by the DSI module. Layer 3 performance monitoring is performed by the CPU software.

Layer 1 performance monitoring This performance monitoring assesses physical-layer transmission performance of the physical medium between the NT1 and the NT6X50 Dual DS-1 Interface card (U-loop). This monitoring, along with NT1 self-test capability, determines whether the cause of a fault is likely to be in the network or in the customer-provided equipment.

The DSI module implements this monitoring using the following standard digital line signal features:

- monitoring for bipolar violations or monitoring for extended superframe cyclic redundancy check (CRC) error events
- monitoring for loss-of-frame or change-of-frame alignment

The DSI performs the following monitoring functions using thresholds configured by operating company personnel on a per-digital span basis:

- generating outgoing CRC code and monitoring for incoming CRC error indications
- counting and storing CRC-based block errors, errored seconds, and severely error seconds (usually three errors per second) separately for each direction of transmission
- storing thresholds for each of these performance parameters and sending alerts when thresholds are exceeded
- maintaining alarm/status information based on line unit failures, loss of synchronization word, loss of signal, NT1 power status, and NT1 test mode status

Layer 2 performance monitoring This performance monitoring entails the following:

- Layer 2 transmission performance monitoring, which monitors the transmission performance between the CPE and the DS-1 termination at the DSI module. The assessment is based on Layer 2 frame errors (detected through the frame check sequence field) and the number of frames retransmitted.
- Counting layer 2 service disruptions caused by received-frame-buffer overflows and data-link-layer resets (caused by excessive transmission errors or certain protocol abnormalities such as receiving a frame with invalid sequence number).
- Counting layer 2 protocol abnormalities or all D-channel protocol abnormalities occurring at layer 2 (between the DSI module and the D-channel). These abnormalities include, for example, disconnected mode frame received in response to a set asynchronous balanced mode extended frame, or, invalid sequence number in the received frame.

Layer 3 performance monitoring This performance monitoring entails the following:

- protocol violations not associated with an allocated call reference cause a counter to be incremented. When this counter exceeds a designated threshold limit, service disruptions on the interface result.
- counting errors associated with a call. When a threshold limit is exceeded, the call is dropped.

Testing

In-service performance monitoring identifies faults in the transmission system. Testing, described in the following paragraphs, isolates the cause of the fault in the DSI module, the span, or CLASS II equipment.

Digital testing This group of tests includes loopback testing through the Bit Error Rate Testing (BERT) facility, in-service and out-of-service testing of the DSI module.

Loopback testing is performed by activating a loopback test point at a specified loopback device, transmitting test data to the loopback, and analyzing the test data returned. In the DMS-10 NI-2 PRI, near-end loopback test points are provided within the DSI module. Far-end testing is performed using a dialable loopback test point at the NT2 (Network Termination 2). The loopback test points include a channel loopback at the NT4T24 pack, a payload loopback test point within the NT4T24 pack, a payload loopback test point within the NT6X50 pack, and a line loopback test point within the NT6X50 pack.

Transmission testing The ISDN PRI transport facilities (that is, the T-1 carrier) are tested through the following methods:

- test lines, used to provide simple tones and terminations, and to provide marginal signaling and transmission tests
- T-1 carrier analyzer, used to test and monitor T-1 carrier systems, and which may be used during installation, fault isolation, in-service testing, and trouble-shooting of T-1 carrier systems

ISDN testing The operating company may choose to provide an ISDN PRI test set for testing and trouble-shooting PRI problems. In addition, a protocol analyzer may be used to analyze National ISDN protocols on a PRI.

Alarms

Alarms and alarm messages are generated when the performance level of the PRI degrades or if it becomes unusable for an ISDN call. Alarms are generated during scheduled background testing or during DS-1 line monitoring/auditing.

The DSI module monitors for red alarms (loss of signal), yellow alarms (remote alarms), and blue alarms (alarm indication signal). When an alarm condition is recognized, the DMS-10 software pegs an alarm counter. When the alarm counter crosses a designated threshold, the alarm condition is reported to operating company personnel.

Recovery management

A wide variety of system failures can disrupt calls, block new calls, inhibit resource availability, and degrade service to the end user. The treatment given to the end user as a result of these failures depends on the current state of the call and the type of problem.

System Reload Only stable two-party calls remain up during a system reload (SYSLOAD). After the DMS-10 switch completes loading and starts initialization, the DS-30A interface packs (NT4T04), or Network Interface packs (NT8T04), are polled to determine their connection status. When the initialization completes, connections are rebuilt and a query message is sent to each PRI interface asking for the current call state of the Class II equipment. Calls are then rebuilt or dropped in accordance with the call state indicated in the response. A SYSLOAD may cause billing data to be lost.

A SYSLOAD has no effect on a stable call. A call cannot be dropped if an end user attempts to disconnect when the DMS-10 switch is reloading, although the Class II equipment does drop the call after the reloading is complete. Likewise, the Class II equipment cannot originate a call until after the system has completed reloading.

A SYSLOAD has no effect on the DSI module or on the signaling/synchronization from the DSI module to the NT1 at the customer's premises.

Initialization (warm start) Calls are treated in the same manner as during a SYSLOAD. During initialization, however, each DSI module is queried for the firmware version it is running. Billing data is lost if Protected Call Store is affected by the initialization.

PRI U-loop failure (loss of synchronization) This type of failure occurs due either to a faulty Dual DS-1 Interface card, a faulty NT1, or a fault on the span (for example, an open or shorted loop in the T-1 carrier).

If the loss is due to the Dual DS-1 Interface card (NT6X50), the Span Interface Controller card (NT4T24) reports the loss and an alarm is raised. The NT1 attempts to regain synchronization. If synchronization cannot be regained, operating company personnel must intervene.

Loss of power Any loss of power to any of the subsystems results in an immediate loss of frame synchronization in the specific interface. The DCI shelf is powered through redundant power supplies, so only a total power loss (loss of both power supplies) results in calls being dropped.

Exceeding product capacity (congestion) Congestion is most likely to be caused by Class II equipment (for example, an intelligent peripheral with short call holding times using all available channels) and not by ISDN PRI trunks.

Line load control (LLC) LLC is used in extreme emergencies to restrict originating service to subscribers designated “essential users,” such as police and fire departments, hospitals, and government agencies. LLC does not apply to ISDN PRI.

Sparing There is no sparing of equipment associated with an ISDN PRI call. PRI calls associated with faulty equipment are dropped.

Section 7: Index

Numbers-

DMS-10 Family

600-Series Generics

General Description

NTP number: NTP 297-3601-100
Release: 07.01
For Generic 602.20
Status: Standard
Date: August 2006